A System Dynamic Approach for Evaluating the Effect of Shocking News on Stock Market

- Case Study: Volkswagen's Scandal

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requirements for Master of Philosophy

System Dynamics

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GEO-SD351

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Acknowledgments

Dedicated to my love and my daughter, both in my heart forever.

And thanks to everyone who helped me on the way here...

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Abstract

This research aims to analyze the effect of a sudden event or surprising news (like scandals) about a company. A shocking event can occur in any aspect, at any time in a company. Positive or negative, a surprising phenomenon affects the company's income, profit, reliability, brand image, and other areas. Among all the consequences, the effect of such an emerging incident is evaluated on the company's stock price.

The case study of this research comes from Volkswagen (VW) automaker group in which a scandal raised in 2015, called Diesel Gate. The Scandal's effect on the VW's stock price was worse than that of the financial crisis in 2008 and the Covid-19 era.

The underlying methodology for analyzing the case study is System Dynamic Modelling. Causal Loop Diagram (CLD) is the main technique for evaluating the Scandal's effect on the stock price of VW. The final model can describe the interrelationships of the underlying variables and other system elements in an acceptable way.

The focus of this study for spotlighting the shock in the stock price of VW, is on Fundamental Analysis of VW stock price. In addition, Technical Analysis does a small part of modeling the system. In fundamental analysis, the core concept of the model is based on sentiment analysis, behavioral finance, branding image, and perception of stock attractiveness by customers.

The model's findings show a high level of dependencies among those mentioned factors in the stock price mechanism. Investors' persuasion on the fundamental value of the stock price will drop drastically as the scandal leaks. The lost portion of the stock price is more significant than imposed fines and the compensation cost of such a phenomenon. Fortunately, the proposed model can describe the mechanism/problem occurring in the stock price in a good way and able to follow the market perception of the stock price. The model links the market's sentimental effects and psychological reactions to the 50% dropdown of the stock price. Those mental features of the *stock market*[1] survive the stock price from falling even more down at the end of reviving period of the stock price.

The research covers the fundamental effects comprehensively, but not the technical side in depth. Technical analysis can be an exciting ground for the following researchers who are eager to spotlight the market's pricing mechanism more than the sentiment analysis.

[1] Note: There are two terms for STOCK in this research: *1) Stock Market;* *2) Stock and Flow*

Chapter 1: INTRODUCTION

Background and Problem Definition

It is a normal event in the automotive industry to hear about recalling cars produced by a brand to solve a couple of serious problems/errors in their systems. It can happen locally, nationally, or globally, and almost has happened for every company in their lifetime.

There are two kinds of shocking news about a company in this industry (or generally in other branches). The first one is something that releases about a technical error in some parts or systems of an automobile. Some of the well-known examples for the first category are errors in braking systems of Toyota cars in 2011 and the other one, is the series fault in the battery system of General Motors products in 2018. In both examples, the source of the phenomenon has root in technical errors (in the physical products of a company).

The second part of a shocking event in a company can happen due to a non-technical drawback in the products. Primarily, when they are related to the human being's behavior/decision that has happened intentionally. Orally, this kind of information is called Scandal. A scandal is defined by the Cambridge dictionary in this way: "*A public feeling of shock and solid moral disapproval*[2]".

On the top of the list of such a scandal in automotive industry is Volkswagen DieselGate in 2015 and Carlos Ghosn's financial scandal in Renault-Nissan Group in 2017. In both cases, a human being's decision taken by a top manager (or a group of stakeholders), leads not only to a situation that causes a massive reaction by the customers/market but also costs the company much more than it seems to be as a direct cost of the event. In the former case, VW lost a considerable part of the market value (almost half the price of each share in the stock market).

In this research, the role of the VW scandal (DieselGate) is evaluated by the System Dynamic approach to get a comprehensive insight into the underlying factors/elements in the case. DieselGate refers to a cheating process in which the gauging tools/systems for measuring the emission of VW cars were calculated and shown at a significantly more minor level than reality (up to 40 times smaller).

For more than two decades, Volkswagen has held its place as one of the biggest car sellers in the world. Toyota, General Motors, and VW have been on the top list regarding the number of sold cars in a year[3].

VW's Dieselgate was detected in 2014 by West Virginia University and announced publicly in September 2015, rooted in a couple of months before[4]. The announcement of a scandal was a great shock not only for customers (who had bought those defective cars) but also for all the VW shareholders in the stock market and other stakeholders and companies in the industry. Furthermore, even governments that had applied their strategies based on the previous emission results of VW products had to change their policies (for example in Norway).

Nowadays, VW is an active and agile company in producing electric cars. However, before the scandal leakage, VW's R&D department focused on developing diesel cars. VW tried to show that their

[2] https://dictionary.cambridge.org/dictionary/english/scandal
[3] https://en.wikipedia.org/wiki/List_of_manufacturers_by_motor_vehicle_production
[4] https://www.emissionscandal.com/volkswagen

products are green enough to be a solution/response for Global Green Awareness (GGA) raised a couple of years before. When Tesla, the leading electric car seller globally, developed its first versions of electric cars, it seems that VW chose the wrong approach for responding to the GGA.

Cheating in the monitoring tools and systems hid that some of the VW car passenger models emitted up to 40 times the case of Nitrogen Oxides. Operationally this phenomenon costs VW billions of Euros, including recalling almost 500,000 cars in the USA, direct fines and charges, and even some settlements to customers, even seven years later (May 2022). Moreover, it affects the whole automotive industry, the green movement in fossil fuel cars, and those governmental and environmental policymakers based on the previous emission reports.

As a result, dozens of direct and indirect costs and elements are effective in this case. From a financial viewpoint, those effects can be measured by the bills and invoices related to this matter and the portion of lost value in the stock market.

In this research, the central affected aspect of the company (in the case of the Scandal) that was selected to investigate is VW's stock price. The history of VW's stock price is shown in Figure 1.1 (weekly price in euros over time).

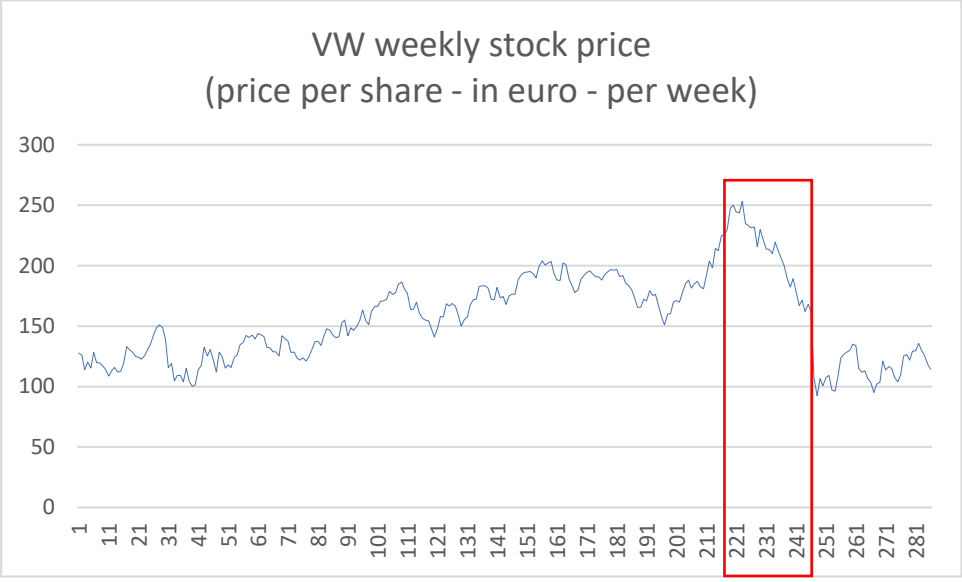

Figure 1. 1: Weekly price of VW in euro, starting in the first week in 2011, ending in July 2016

Source from Finance.yahoo.com

The horizontal axis represents the week numbers starting from the first week in 2011 and ending on June 20, 2016. The vertical axis shows the price of each VW stock in the stock market. In the week #221 to #241 (Jul. & Sep. 2015), it was the proper time to spotlight the scandals effectual on the stock price (the red rectangle). During this catastrophic period, the market price of VW stock dramatically dropped by almost 50%, an absolute nightmare for investors.

It is worthy to discuss one of the other aspects of the business side of the Scandal, which is sales. The DieselGate happened in 2015, and the stock price dropped drastically. But what about VW's sales and market share in the same period?

In Figure 1.2, the number of yearly sold passenger cars for the top 5 best sellers can be seen. Surprisingly, at the time of the scandal announcement in 2015, there was no sign of dropping in sold cars by VW.

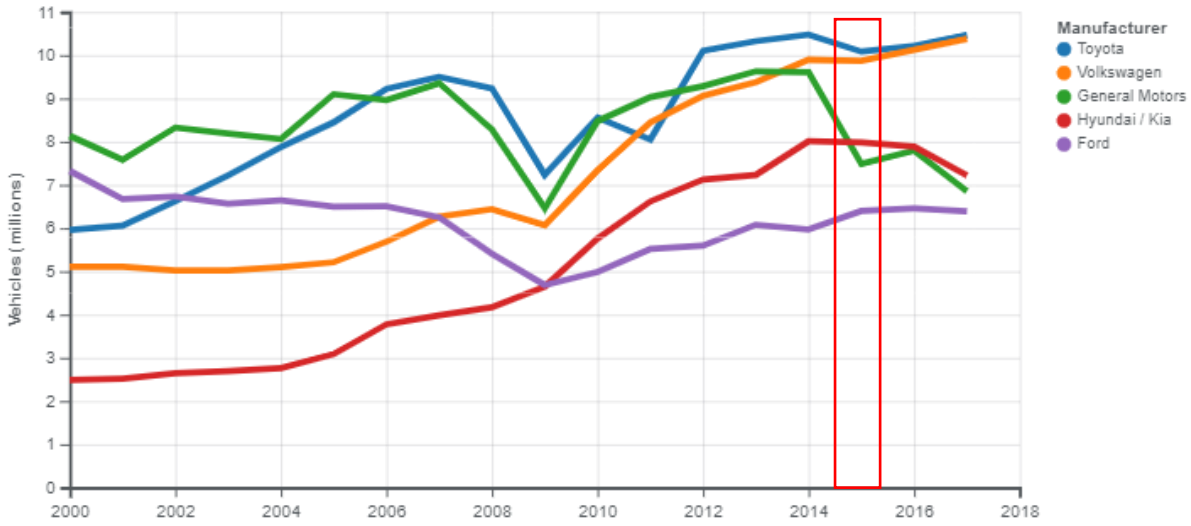

Figure 1. 2: Number of cars sold by the top 5 biggest sellers each year.

Source: Wikipedia, originally from oica.net

Also, the revenue of VW did not drop (even though it slightly increased) in the year of the DieselGate. There are some relevant factors/reasons for such behavior. Furthermore, the following sections will be discussed.

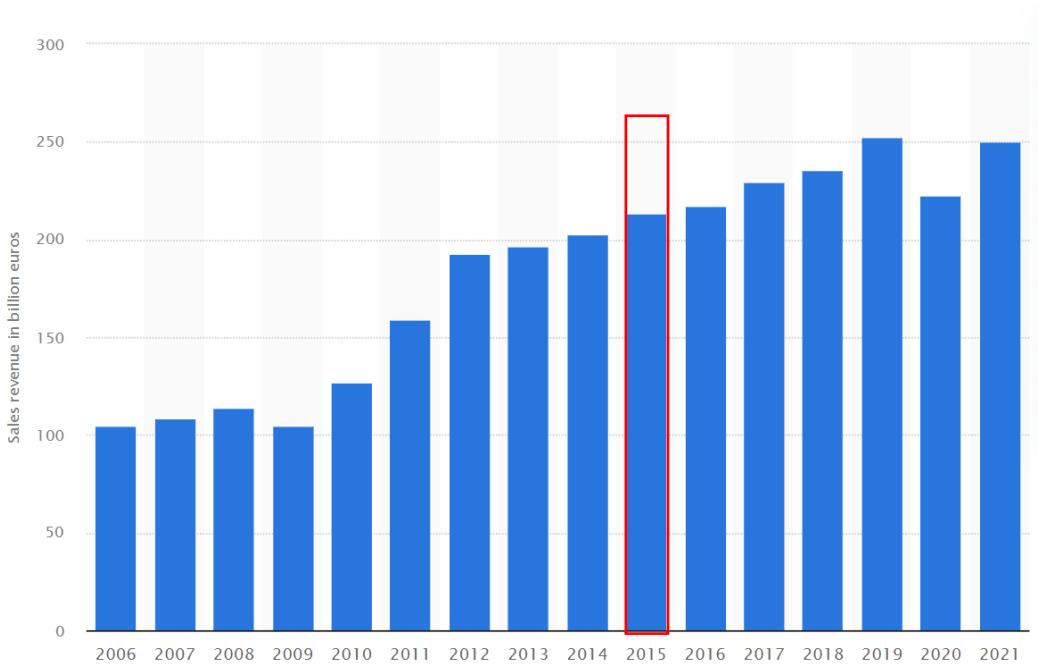

Figure 1. 3: Yearly sales revenue in billion euros by VW.

source from statista.com

As a result, the research focuses on the effect of DieselGate on VW's stock price, not on revenue or the number of sold cars (or market share).

Research Objectives

This research tries to analyse a significant period in the history of Volks Wagen in the automotive industry, in which a shocking scandal was released. The author follows and captures some of the underlying factors that affect the stock price of VW in that period (mid-2015). Evaluating those relevant elements comes from the System Thinking concept and System Dynamics tools.

Although at the very first beginnings, it is expected to see a shocking downward trend towards bankruptcy in the sales side of the company, surprisingly, the effect of such a scandal just can be noticed in the stock market. Modelling a system for replicating the reference mode and finding the main reasons for occurring the mentioned dropdown is the main goal of the research.

Research Questions

The main questions of the research can be sorted in this way:

- What is the source of such a scandal in VW?
- What is the main area for searching the effect of the Scandal?
- How can we measure the effect of shocking news on the stock market?
- Which group of stakeholders gets the most effects from such a scandal?
- How can mitigate the effect of the Scandal?
- What is the best approach for responding to a Global Awareness?

At the end of the research and through those relevant sections on the way to the end, the author tries to find reliable, analytical, and logical answers to the mentioned questions.

Chapter 2: PROBLEM HYPOTHESIS

Literature Review

The main issue for analyzing and investigating by this research is the Scandal (DieselGate) raised in VW and affects its success process. Furthermore, the case study has been chosen to be Volkswagen.

The DieselGate has been studied in various researches and has attracted the attention of researchers both in theory and practice. Hachenberg et al. (2018) investigated the role and effect of DieselGate in other European countries. Besides, for implications of unaccounted and future emissions for cars, research was performed by Brand (2016). Jong and Linde (2022) analyzed the effect of DieselGate in the intra-industry and focused on the role German's media in this case. Because they believed the effect of the scandal shifted from a single company (VW) to an industry-wide crisis.

By focusing on the psychological side of the stock market, several theories can be found that cover the area of sentiment analysis of the market. The main reference for this section of the research is Behavioral Finance book by Statman (2008). Silva and Klotzle (2019) analyzed the phenomenon of Herding behavior and contagion in the cryptocurrency market. Also, Kabir and Shakur (2018) studied the evidence of the Herding effect on the Asian and Latin stock markets.

The other attractive area for the psychological aspect of the market is Halo Effect, which is used in the other knowledge areas. In this area, the book named "The art of thinking clearly" by Dobelli (2013), was an outstanding source for human-being sentiment analysing. Abid and Sekrafi (2021) investigated the role of the Halo effect on CO2 emission in developed and developing countries. Bschaden et al. (2022) worked on the sustainability halo effect and its importance on food production. Another noticeable research on the Halo effect was done by Nicolau et al. (2020) to evaluate this phenomenon in the hotel and tourism market. For a complete review of the literature history in the case of behavioral finance, the review paper of Sinha (2015) is used in this project.

Guo et al. (2018) focused on the concept of Greenwashing from a legitimacy perspective. The effect of brand positioning on the relationship between the type of green message and brand evaluation was investigated by Da Luz et al. (2020). Wheeler et al. (2015) considered consumer brand rejection of Green and Non-Green Brands.

Simao and Lisboa (2017) evaluated the effect of Green Branding and Green Marketing in the Toyota case study. "Green Branding and Eco-Innovations for Evolving a Sustainable Green Marketing Strategy" by Sarkar (2012) is one of the other concrete bases to struct the current study.

From the System Dynamic approach, Sakas et al. (2015) evaluated the effect of the competitive advantages of Facebook on Brand Awareness. This paper can be used as the primary source for the model building process. Also, Fadil (2015) assessed the effect of Viral Marketing on the branding process through System Dynamics. Above all, a master's thesis from MIT Sloan School of Management helped to build the model of this project in a more structured way (Leika (2013)). The developed model in the latter reference, was a remarkable ground for SD modeling of Behavioral Finance.

Research Methodology

As mentioned before, the System Dynamics approach (SD) has been employed in this research for modeling, simulating, and replicating the reference mode. Modeling based on a causal loop diagram is the main ground for the author to build up the investigation process regarding the reference mode.

Since the SD concept was developed in the 1950s by Jay W. Forrester, thousands of researches have been performed in a broad knowledge area using a system thinking approach and SD methodology. Sterman (2000) has defined it, simply as:

"System Dynamics is a method to enhance learning in complex systems."

The main idea for the investigation is a fundamental analysis of the stock market and behavioral finance approach. So, a significant part of the model is related to dozens of qualitative variables, and the research captures the psychological interactions of different elements in the market.

A relatively short part of the model highlights the technical analysis and designs a structure for that section. The combination of technical and fundamental analysis can make up investors' perception of the market price of each share.

Data Collection

For the data gathering step in this research, publicly available data sources have been used. Almost all the data comes from financial sources: the stock market data for finding of VW's weeklystock price, the yearly published profit and loss statement by VW, and the yearly balance sheet of VW. As a result, all kinds of financial data used in the model are generally and publicly available on VW Annual Reports and financial data centers.

In addition, some of the collected data come from other sources, and they were mentioned in the context by referring to those references (statista.com, oica.net, Etc). This kind of data comes from market data statistics, which is extracted initially from sales data from worldwide car sellers. Moreover, no primary data were collected for this research, and only public data was used.

Model Overview

As mentioned before, the basis of the model for simulating the stock price is behavioral finance and its characteristics. From a fundamental perspective, the primary psychological factor of the model for simulating the market behavior is *Aggregated Attractiveness of Stock.* This element covers and aggregates all the underlying sub-models that build up the primary model of fundamental stock pricing.

On the other hand, this research also covers some aspects of technical analysis. For this corner of the model, historical stock price data is considered to figure out another aspect of the pricing model.

Moreover, VW's Branding and *Brand Image Development* is the next effective attribute of the company in shaping the pricing model. This side of the model has been considered in accordance to fundamental analysis. It is rooted in *the Innovation, Quality, and Differentiation Image* section of the model to reflect the role of modern technology in the Goodwill effect.

More details will be de presented in the following sections.

Model Characteristics

Following the previous section, the CLD of the model and some of the required information about the model are presented and discussed in this part. In Figure 2.1, the highest level of CLD that is the base

for model development process, can be seen. Regardless of the exogenous variables for representing stock attractiveness, there are three feedback loops in the model (R1, R2, and B1).

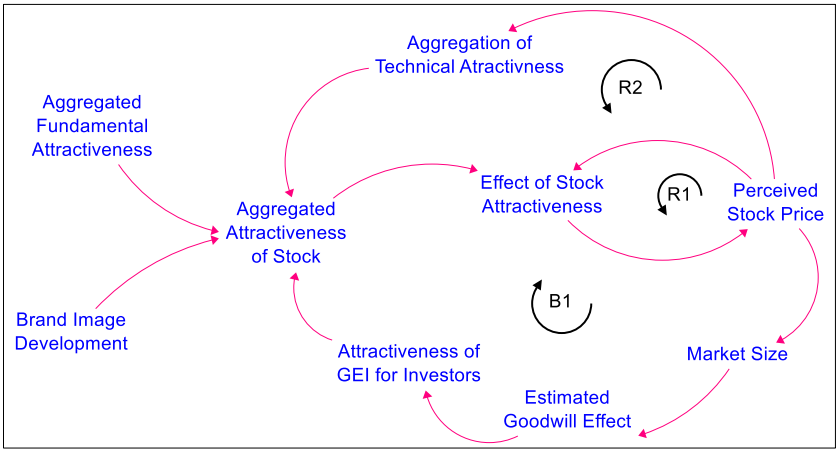

Figure 2. 1: CLD of the primary model for stock market pricing.

Description and characteristics of the loops

R1: A small reinforcing feedback loop for describing and capturing the effect of the long-term history of the stock price on the Perceived Stock Price. Based on sentiment analysis of the stock market, it was decided to get feedback from almost six months of historical data (i.e., 24 weeks / 4 weeks per month = 6 months). Although it is a minor feedback loop in the model, its role is to consider the long-term memory of the stock price on the perceived price.

R2: The other reinforcing feedback loop in the CLD calls for Technical Analysis of the market. Generally, the short-term movement in stock price tends to follow another movement in the same direction. If the market goes down in the previous period (the previous week in this model), then the stock price continues in that way, at least for one significant period (a week). In other words, investors do not dare to move against the market trend.

Nevertheless, why the stock price does not continue to go downward (upward) for several periods in a row? The response relies on the fact that in the absence of a shocking (positive) event or news, the stock price fluctuates over a long-term trend (a positive trend for stock markets and a neutral trend for Forex market). As a result, some movements to higher price levels would be compensated with the opposite market shifts in the mid-term horizon. However, in the VW's case study, there is a significant reason for having several negative periods (negative weekly return) due to DieselGate.

In contrast to R1, which is a little reinforcing feedback loop (for the long-term effect of price), the second one is a significant feedback loop but focuses on the short-term memory of stock price. Both R1 and R2 have a role in replicating the effect of the Technical Analysis of the VW stock attractiveness.

B1: The only balancing feedback loop in the CLD is the one for shaping the structure of the Goodwill Effect in the stock market, that is defined in this part. Every company in its Balance Sheet refers to Intangible Assets (under the section: Noncurrent Assets). This kind of property represents Branding, Goodwill, and other intangible assets. In this research, it is called Goodwill Effect in general.

The B1 loop acts in this way: the higher level of VW stock price, the lower attractiveness of the stock for investors in case of the Goodwill effect. On the other hand, as the stock is traded at a lower price due to the loss of the Goodwill effect, then the VW's stock seems more attractive to customers (technically called under-priced stock). It means that they expect higher prices, due to reviving the Brand. Interestingly, if the damage to the Brand is not so hard, then it is possible to expect that surviving by the Goodwill effect comes into reality.

In this case study, the effect of DieselGate on the dropdown of the VW stock price contributes to a decrease in intangible assets (Goodwill and Brand) rather than that of fines, compensation costs, Etc. As a result, one of the significant effects of DieselGate can be traced to the Goodwill area.

So far, the central concept of the model has been described in terms of feedback loops. In the following sections of this chapter, more details on the model and its variables are coming.

DT

A DT of 1/5 (fractional) is used for running the model. Because of the weekly price of the stock market, weekly time units in Stella Architect are suitable for modeling timing. Also, because of 5 working days in a week in the stock market, DT is 1/5. In this way, using DT in any part of the model represents a daily repetition of the event in every time unit (one week). Moreover, Euler's integration method is employed for running the model.

Calibration

All the parameters of the model have been calibrated regarding the reference mode. The main criterion for calibrating is matching the stock price behavior (reference mode) as much as possible, considering the minimum error. More clarification about calibration and the error calculation comes in the next chapter.

Time Horizon

As mentioned in previous sections, this research tries to go through a specified era in the market history of VW, in which the DieselGate has been raised. For such reason, it is necessary to go back in time enough to start the analysis. So, more than four years of weekly data have been assigned for replicating the reference mode (2011-2015, before the scandal).

On the other hand, the reference mode continued for a couple of periods after the Scandal. So, before and after the time that the shocking news raises, the model needs a relatively long spectrum of data for a better and more reliable analysis (plus one year after the scandal).

Regarding a conceptual viewpoint from the financial area, it is essential to distinguish the role of different practical elements in each time horizon in the stock market. In this case, for focusing on the effect of DieselGate on VW's stock price, other factors/news must be considered in detail (or be filtered out by choosing a smaller time horizon).

In other words, in the time horizon of the DieselGate in this research (2011-2016), there is no other significant news/phenomenon around VW (Figure 2.1). However, in 2009 (financial crisis) and 2020 (COVID-19), there were two considerable shocks (called GAP in the financial area) in the stock price of

VW. As a result, we decided to choose a time horizon with no effect from those mentioned remarkable events (the red rectangle in the graph).

Figure 2. 2: A snapshot of a more extensive time horizon than VW's DieselGate era.

Source from Finance.yahoo.com

Model Boundary

As mentioned in the previous section, the time horizon has been limited to a period in which there is no effect of other essential elements on the stock price. It means that it has been assumed that the only aspect for capturing the shock in the stock price is the Scandal. Moreover, there are no effects of the financial crisis, pandemic era, rescission, war, and sanctions (both for VW and the automotive industry).

Other assumptions include the fact that the market is efficient, based on the Efficient Market theory (Fama (1970) and that there is no hidden information for the investors. In other words, the stock's attractiveness is related to the nature of the news in the market, which leads to a change in the stock price.

From a stock pricing perspective, it has been assumed that there is no hidden viewpoint for investors and shareholders due to the company's maturity. Furthermore, they can rely on the Goodwill effect of the VW's brand.

The psychological aspect of the market and investors' mental movement and sentiment have an essential role in market movements. The mentioned effects are the focus of the research for analyzing the stock price of VW in the scandal era.

Model Validation

The guideline proposed by Barlas (1996) and Sterman (2000) in this modeling research is used for model validation. Based on the proposed procedure for validation, the practical aspect of the model

and the usefulness of the structure for replicating the reference mode is the most crucial criterion to follow.

According to Barlas's flowchart for model validation, the process performs through an iterative structure. It is done in this order:

- *Perform Theoretical Direct Structure Tests*,
- *Perform Empirical Direct Structure Tests*,
- *Perform Structure-Oriented Behaviour Tests*,
- *Perform Behaviour Pattern Tests*,
- *Communicate the Results and Start Implementation.*

These repetitive steps are executed in every run to get the final model in the way to replicate the reference mode effectively and for the right reason (cause and effect concept). In practice, the process begins with the development step, followed up by testing, and validating. The model gets some revisions in the next round, retests the revised model, and is finally revalidated again. As mentioned, the final model should be capable of simulating the historical data with the minimum error level and does the simulation for a reasonable cause and effect structure. The currently developed model has passed the process until producing the final acceptable behavior.

The next chapter presents more details about analyzing the underlying key variables (and their intercorrelation).

The mentioned repetitive steps in this section should be executed about the attributes of the model and include the following sub-category:

- Structure Confirmation,
- Parameter Confirmation,
- Extreme Conditions,
- Dimensional Consistency,
- Behavior Sensitivity,
- Behavioral Validity,

This chapter covers the information, description, and documentation of the validation sub-category.

Model Structure and Confirmation

Following the previous section of this chapter, rest of the details about the model and description of other elements are presented. In the first step, those three feedback loops have been described. The other main variables and sections of the model are shown in CLD and Stock and Flow Diagram (SFD).

In Figure 2.3, the main internal and external variables for structuring the model can be seen. The left side of the diagram contains the structure behind the curtain for simulating *Aggregated Fundamental Attractiveness* and *Brand Image Development*. These latter two variables are the internal section presented in the high-level SLD (Figure 2.1). Initially, they are fed by some elements in the second layer: *Expected Future Loss*, *Expected Future Growth*, *Innovation, Quality, and Differentiation Image.* These three elements have an essential role in reflecting on DieselGate.

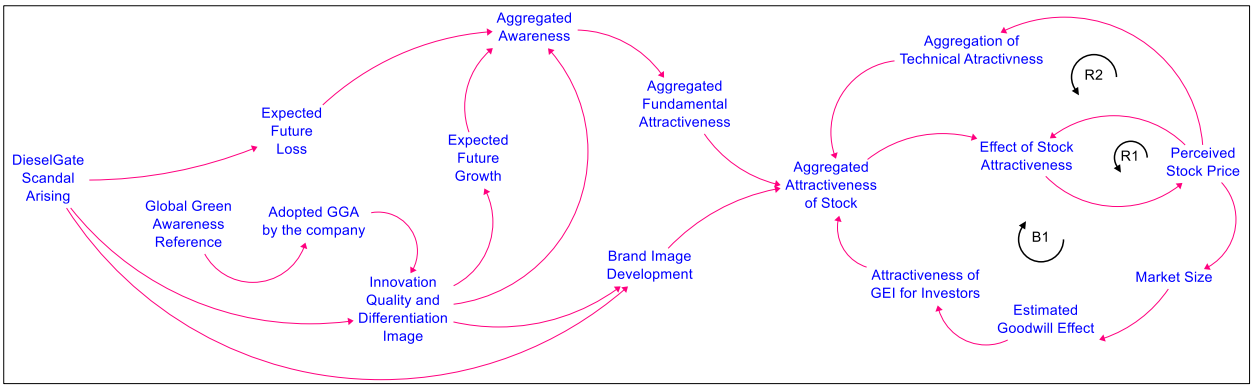

Figure 2. 3: A broader view of CLD with more details using exogenous variables.

The role of the DieselGate Scandal in the model can be traced on the down-left hand side of the diagram (Figure 2.3), named *DieselGate Scandal Arising*. This variable has been rooted in the response of VW to the Global Green Awareness, which is a global environmental expectation from society against the automotive industry.

The phenomenon of Scandal arising causes a severe negative effect on Branding and Differentiation Image and is shocking news for Expected Future Loss.

In Figure 2.4, all the sections containing variables, stocks, and flows and the underlying relationships are depicted in one view. Also, on the down-right side of the diagram, the behavior of reference mode replication of the reference model can be seen in one view. The latter diagram will show in the next chapter in more detail.

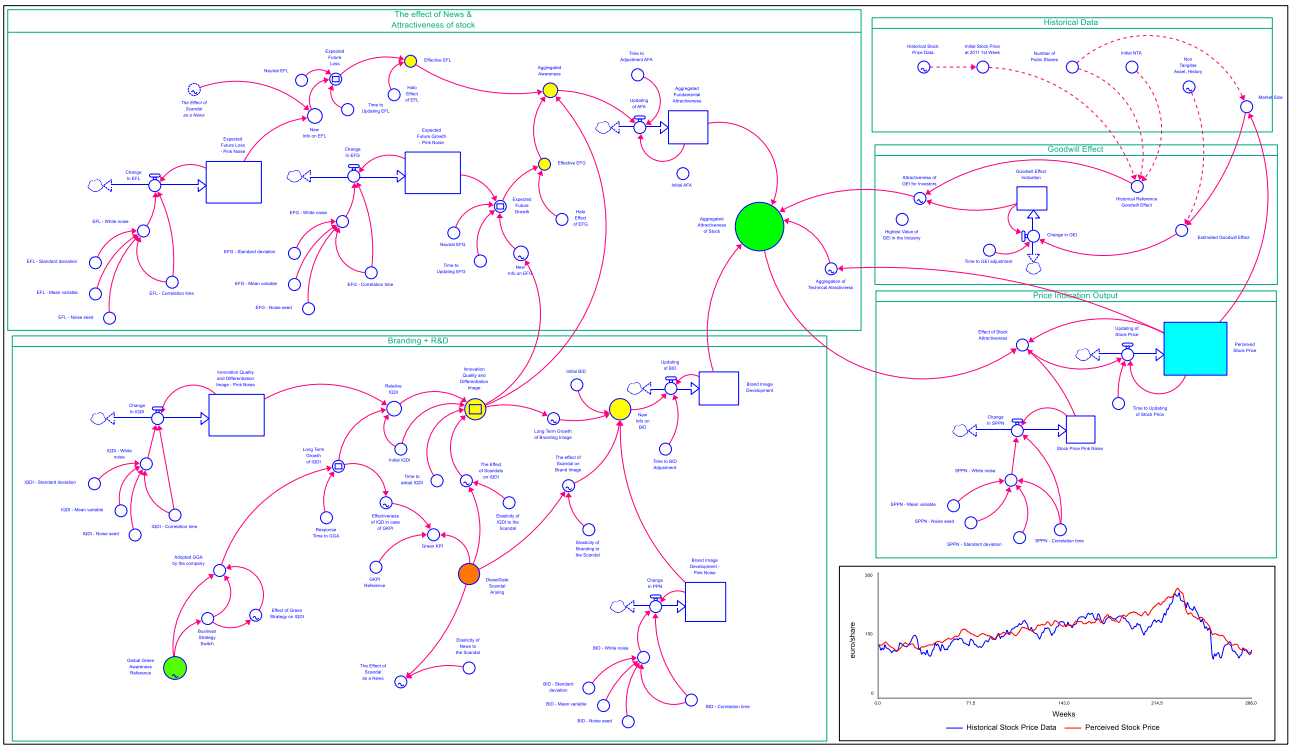

Figure 2. 4: Overall view of the developed model in the research.

In the following diagrams, every model part is described in more detail.

One of the repetitive structures of the base model that works as an auxiliary sector for producing noise in the system is demonstrated in Figure 2.5.

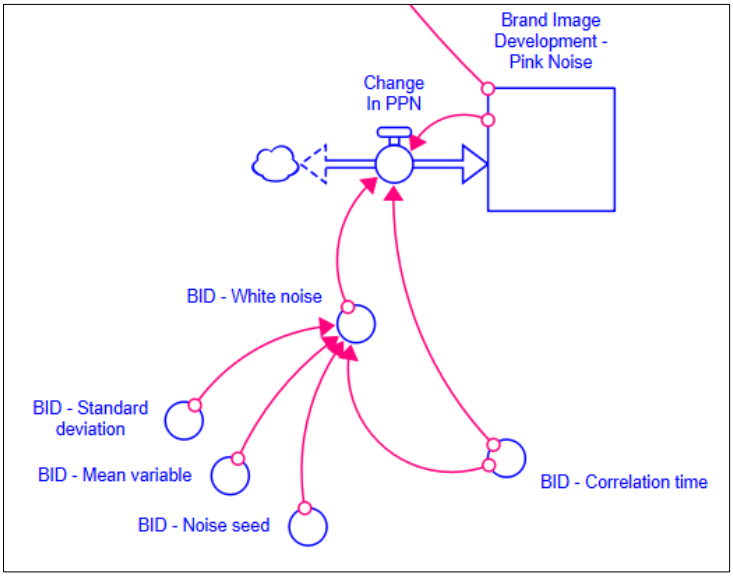

Figure 2. 5: Detailed view of the general model, section: Pink Noise Structure.

This is an auxiliary section for Branding Image Development (BID), in which a pink noise is generated to simulate the actual fluctuation in the related section. This structure is a generic suggestion for any behavior that shows some evidence of fluctuations (Sterman, 2000). Pink noise refers to a behavior that serves some level of positive correlation among different periods (different stock prices in this research). When there is no such correlation among those periods, it can be called White Noise. We can see random fluctuations around a Mean Variable with a positive Standard Deviation.

This structure is used in every other part of the model that shows such a fluctuation in the reference behavior of the stock market. All the variables and formulas in this structure come from Sterman's model. The parameters and the equations are defined in the reference. Moreover, for adopting the model in this research, just some calibrations have been performed. In the absence of the pink noise structure, the model cannot replicate the characteristics of the reference model.

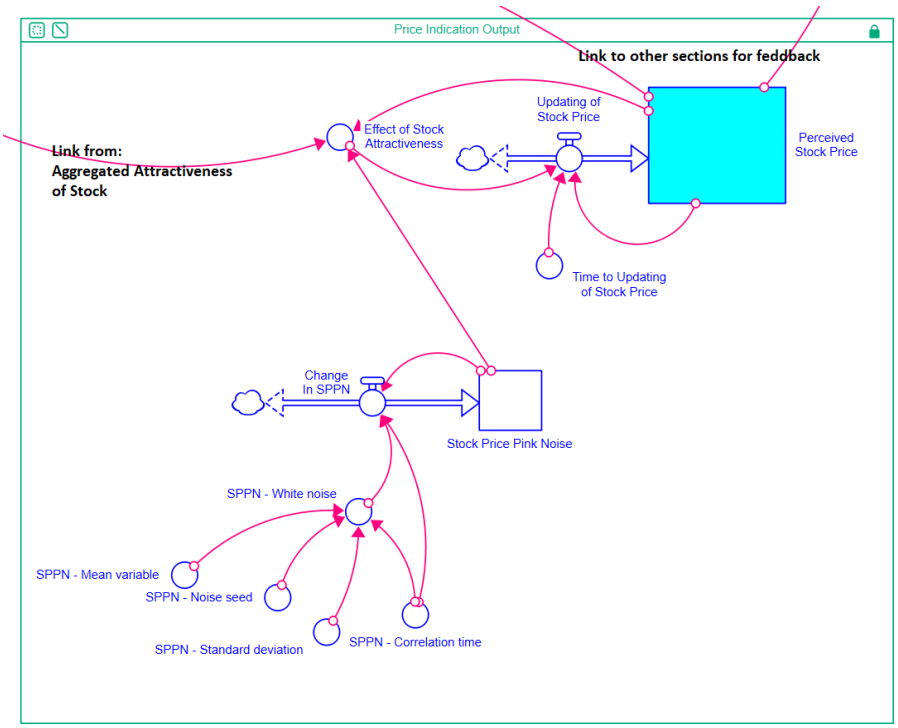

Figure 2. 6: Detailed view of the general model, section: Price Indication Output.

In Figure 2.7, the Goodwill effect and historical data used in the model are demonstrated. This section contains the required financial/business data for calculating Net Tangible Asset in the time horizon of the simulation, data about the historical stock price, market size, number of public shares, Etc. Based on such information, the Goodwill effect of the VW stocks can be estimated for the mentioned B1 loop.

The most critical element in this part of the model is Goodwill Effect Ratio (GER). Simply, Goodwill can be defined as the difference value/money paid for a business in an acquisition process and the net properties of the acquired business. This ratio deviates from zero to a positive number and is calculated in this way (based on the principle of the financial statement):

GER= (Non-Tangible Asset)/ Market Size = (Market Size – Net Tangible Asset)/ Market Size

The range of this ratio is different for each industry and should be compared to the industry's average. For example, in the high-tech industry, it ranges up to 60%, which is much more than that of production-based companies (e.g., VW). This research focuses on the automotive industry and especially on the stock price of VW. So, the range of GER in this research is different from that of a high-tech company (e.g., for AOL Company in 2002, GER= 61%)[5].

Based on the financial data of VW, at the start of 2011, the ratio was 31% which is slightly high for a company in the automotive industry. It means that the company's market value is vulnerable to shocking news and probably could lose some part of its goodwill effect.

[5] fool.com

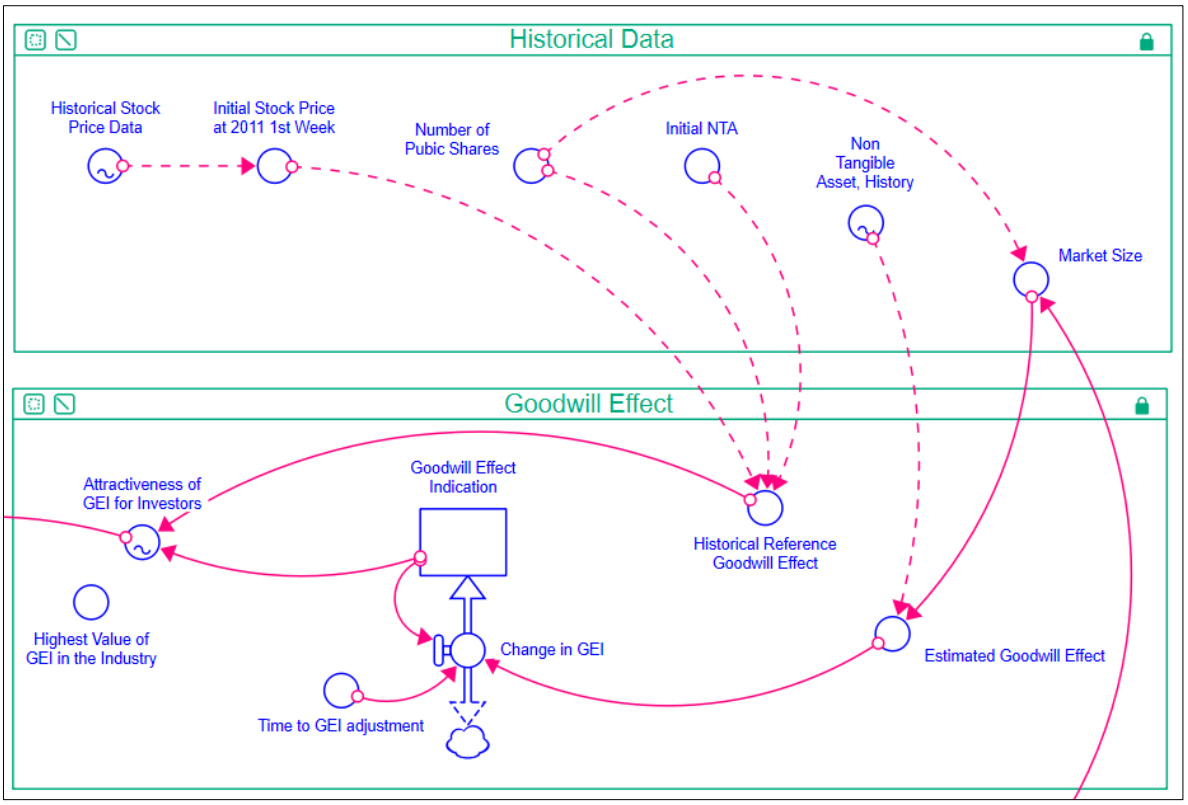

Figure 2. 7: Detailed view of the general model, section: Goodwill Effect and Historical Data.

The higher level of Goodwill leads to a lower attraction of the stock for investors and vice versa. In this section, a mechanism for capturing the perception of the Goodwill effect is used. The rest of the characteristics will be described in Table 2.1.

In Figure 2,8, the main elements that indicate Global Green Awareness, the base for the Scandal, Branding Image, and Innovation (R&D).

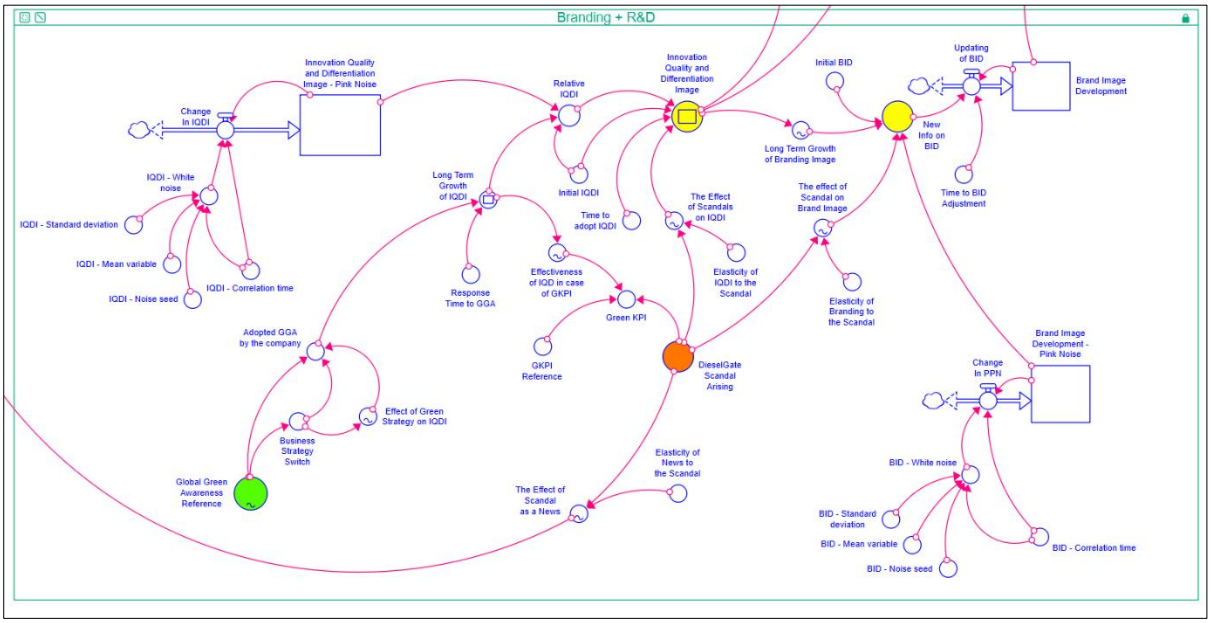

Figure 2. 8: Detailed view of the general model, section: Branding and R&D.

In the absence of GGA, there is no ground for DieselGate; because it was a strategical response to GGA. Due to Global Warming and GGA, a green movement by the automotive industry emerged at the beginning of the 2010s. It could come into reality as an innovation (like electric cars by Tesla in 2013) or a GreenWashing (GW) to compensate for the green movement. Let us simply assume that VW decided on the latter approach, although nowadays, VW has a reasonably wide range of alternatives for electric cars for the customers.

Ultimately, GW led to DieselGate and had a severe effect on the Innovation and Differentiation Image of VW and the Brand Image Development of the business. On top of that, it was shocking news for feeding the Expected Future Loss as a negative impact.

In the following diagram, Expected Future Loss (EFL), Expected Future Gain (EFG), and the Integration of all the cognitive elements of the model can be seen (Figure 2.9).

This section chooses the traditional factor multiplication approach for aggregated elements. In Other Words, if there are four elements (A, B, C, and D) for integration, then the result of integration would be:

Aggregated effect= *[A*B*C*D]^(1/4)*

All the integration elements in this model have been defined as equal to 1 unit in a neutral situation. In this way, the effect of extreme values is considered reasonable.

EFL is rooted in the Scandal directly, and it has a considerably high effect on the Stock Attractiveness. EFG is fed by Innovation and Differentiation Image and not directly from the Scandal because the negative aspect of the news attracts more attention than the positive side.

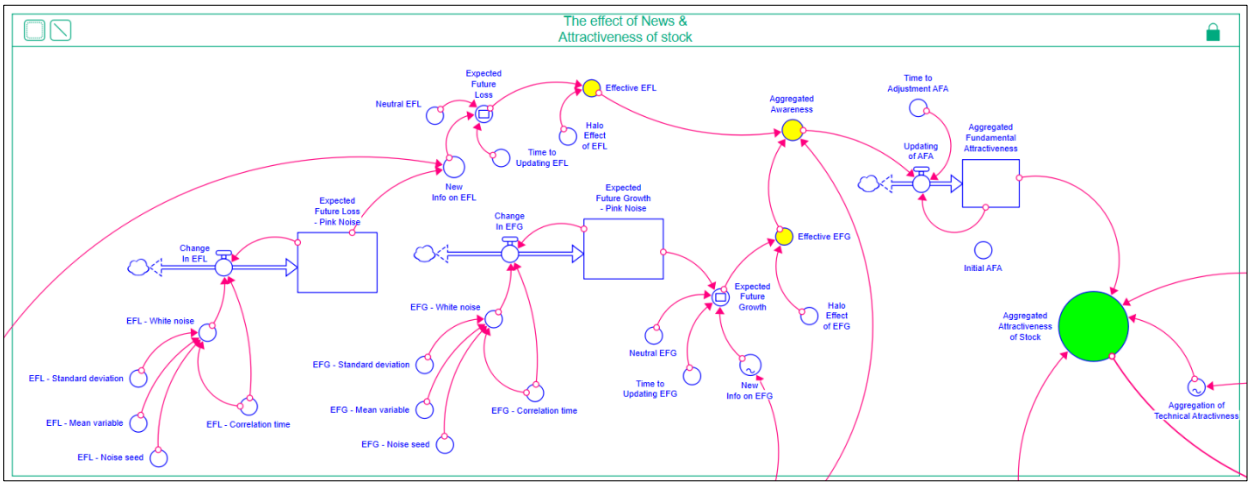

Figure 2. 9: Detailed view of the general model, section: Aggregated Attractiveness of Stock.

All the mentioned sectors of the model and how they interact in the simulation process led to the behavior presented briefly and will be discussed in more detail in the next chapter. From the practical side of the project, the model is helpful in capturing the effect of underlying elements to result in an intended behavior for VW stock price.

Model Parameters and Confirmation

In this section, all the exogenous parameters have been listed in Table 2.1. These parameters act as a foundation for the model replicating the reference mode.

Table 2. 1: List of exogenous parameters in the model.

Row	Parameter name	Parameters value	Unit	References/Notes
1	BID - Correlation time	2	Week	Sterman, 2000; with adjustment
2	BID - Mean variable	1	dmnl	Sterman, 2000; with adjustment
3	BID - Noise seed	1	dmnl	Sterman, 2000; with adjustment
4	BID - Standard deviation	0,05	dmnl	Sterman, 2000; with adjustment
5	EFG - Correlation time	1	week	Sterman, 2000; with adjustment
6	EFG - Mean variable	1	dmnl	Sterman, 2000; with adjustment
7	EFG - Noise seed	1	dmnl	Sterman, 2000; with adjustment
8	EFG - Standard deviation	0,05	dmnl	Sterman, 2000; with adjustment
9	EFL - Correlation time	1	week	Sterman, 2000; with adjustment
10	EFL - Mean variable	1	dmnl	Sterman, 2000; with adjustment
11	EFL - Noise seed	1	dmnl	Sterman, 2000; with adjustment
12	EFL - Standard deviation	0,05	dmnl	Sterman, 2000; with adjustment
13	The elasticity of Branding to the Scandal	1	dmnl	The maximum amount for being affected by the Scandal -
14	The elasticity of IQDI to the Scandal	1	dmnl	The maximum amount for being affected by the Scandal
15	The elasticity of News to the Scandal	1	dmnl	The maximum amount for being affected by the Scandal
16	GKPI Reference	1	dmnl	Normalizing the variable for the start of the simulation
17	Halo Effect of EFG	1	dmnl	Normalizing the variable for the start of the simulation
18	Highest Value of GEI in the Industry	0,3	dmnl	Based on the financial data on the companies in the industry
19	Initial AFA	1	dmnl	Normalizing the variable for the start of the simulation
20	Initial BID	1	dmnl	Normalizing the variable for the start of the simulation
21	Initial IQDI	1	dmnl	Normalizing the variable for the start of the simulation
22	Initial NTA	22194000000	euro	VW Financial Statement
23	IQDI - Correlation time	1	week	Sterman, 2000; with adjustment
24	IQDI - Mean variable	1	dmnl	Sterman, 2000; with adjustment
25	IQDI - Noise seed	1	dmnl	Sterman, 2000; with adjustment
26	IQDI - Standard deviation	0,05	dmnl	Sterman, 2000; with adjustment
27	Neutral EFG	1	dmnl	Normalizing the variable for the start of the simulation
28	Neutral EFL	1	dmnl	Normalizing the variable for the start of the simulation
29	Number of Public Shares	539000000	share	From VW financial Statements
30	Response Time to GGA	24	week	About six months is considered for R&D innovations to respond to GA – new green technologies, innovations, and patents
31	SPPN - Correlation time	4	week	Sterman, 2000; with adjustment
32	SPPN - Mean variable	1	dmnl	Sterman, 2000; with adjustment
33	SPPN - Noise seed	1	dmnl	Sterman, 2000; with adjustment

34	SPPN - Standard deviation	0,02	dmnl	Sterman, 2000; with adjustment
35	Time to Adjustment AFA	1	week	The minimum time for adjustment of the variable is required: one week
36	Time to adopt IQDI	1	week	The minimum time for adjustment of the variable is required: one week
37	Time to BID Adjustment	1	week	The minimum time for adjustment of the variable is required: one week
38	Time to GEI adjustment	1	week	The minimum time for adjustment of the variable is required: one week
39	Time to Updating EFG	1	week	The minimum time for adjustment of the variable is required: one week
40	Time to Updating EFL	1	week	The minimum time for adjustment of the variable is required: one week
41	Time to Updating Stock Price	1	week	The minimum time for adjustment of the variable is required: one week.

Extreme Conditions

For evaluating the model equations, all the formulas in the elements were tested and controlled in extreme conditions. They passed the test and produced logical output in terms of exaggerated situations. In most of the sensitivity diagrams in the following sections (and an appendix section), the ranges of the variables are being set to meet the extreme condition. In all scenarios, the behavior of the model remains in a reasonable area, and there is no evidence of extreme fluctuation.

Dimensional Consistency

According to the equations, all the model elements have been checked to be dimensionally consistent. As a result, there is no error in equations, dimensions, and relationships of different elements. The fact that the model is constructed based on psychological and mental concepts leads to several "dimensionless" elements in the model. In any case, the cognitive factors should be normalized and scaled in a way to be able to evaluate their interconnection through the simulation.

Sensitivity Testing

Every SD model is subjected to pass Sensitivity Testing. For this reason, every eternal variable should be considered in the test. In the developed model, there are several external variables to cooperate with the internal elements in the modeling process. In this section, some of the sensitivity tests are presented for the most critical variables, and the rest of the results can be seen in the appendix. The reference behavior for executing the test is *Perceived Stock Price* in the model.

Time to Updating of Stock Price,

In the minor feedback loop R1 (Figure 2.1), there is a time variable for updating the attractiveness of the stock based on the perceived price in the short-term history. This is a time element in the Information Delay structure and can postpone the process of price updating. The behavior of the

model in the case of reference mode replication is depicted in Figure 2.10, and the range of sensitivity testing is presented in Table 2.2. Note that the highlighted value in the table presents the value of the parameter in the base run.

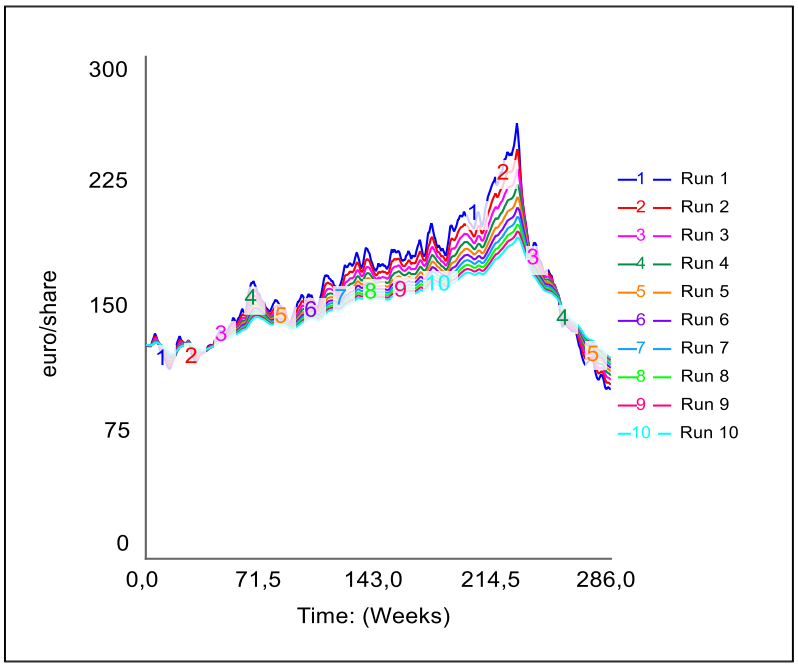

Figure 2. 10: Sensitivity of simulated results on Time to Updating of Stock Price.

In the diagram, as the Time for Updating increases, the behavior of the model shows some evidence of delay in the updating process. As a result, the diagram is smoother than the base run (run number 1). In other words, a lower high-point of the price and a higher low-point in the diagram can be seen (literature comes from technical analysis in finance).

Table 2. 2: Range of values for "Time to Updating of Stock Price" in sensitivity testing.

Run #	1	2	3	4	5	6	7	8	9	10
Variable value (week)	1	2	3	4	5	6	7	8	9	10

The values in the table somehow contain the extreme conditions.

SPPN-Standard Deviation,

As mentioned, the noise in the stock piece is a remarkable attribute of every kind of asset, regardless of the timeframe. It can be noticed in a five-second timeframe in the Forex market, to the monthly price of the VW stock market. In this model, this fact has an essential role in the structure of model behavior and leads to a shape that is reasonably based on historical data.

Figure 2.11 shows the result of sensitivity analysis for Standard Deviation in the Stock Price Pink Noise.

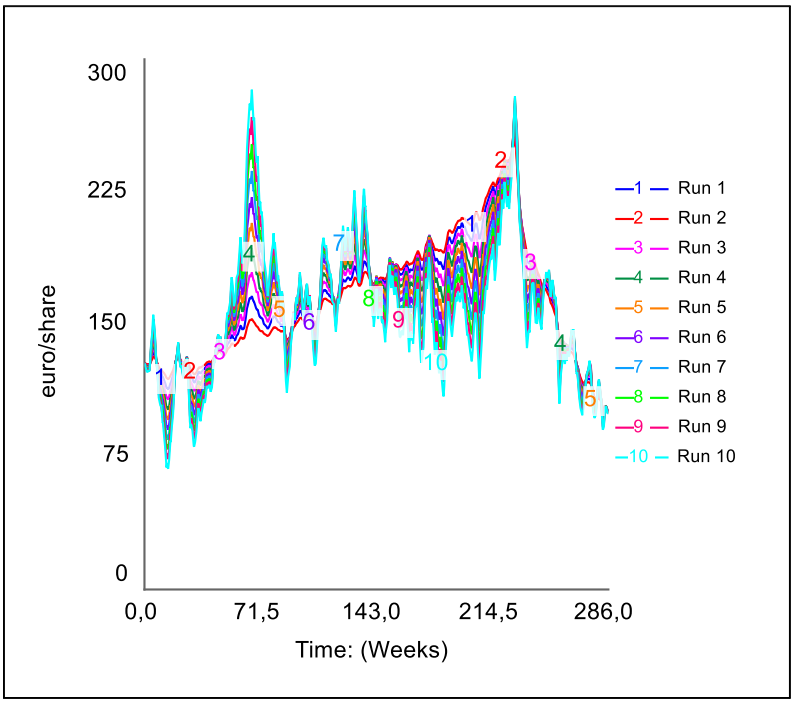

Figure 2. 11: Sensitivity of simulated results on SPPN-Standard Deviation.

As was expected, the model behavior represents more fluctuations in the case of a more significant standard deviation in the Pink Noise. In Table 2.3, the range of values for the variable in the sensitivity analysis is presented, and the value of the base run is highlighted.

Table 2. 3: Range of values for "SPPN-Standard Deviation" in sensitivity testing

Run #	1	2	3	4	5	6	7	8	9	10
Variable value (Standard deviation)	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	0.1

In any case, this part of the model is based on the concept of Pink Noise Structure (Sterman, 2000), and the range of underlying variables were calibrated before by the reference.

Moreover, there are other four sections in the model that use the Pink Noise structure. However, their effect is weaker than the one presented here (the model behavior is not so sensitive to their changes). The result of the sensitivity analysis for those sectors can be fined in the appendix.

Halo Effect of EFL and EFG,

The Halo effect is used for detecting and measuring the difference between the power of the negative and positive side of news on the cognitive analysis. To obtain better results, they are evaluated in a unified diagram, and step by step, the effect of sensitivity testing can be captured.

In Figure 2.12, the result of the reference mode simulation is presented in case of changes in the Halo effect of the Scandal. The more significant the Halo effect of the Scandal, the more exaggerated reaction by the investors. It means more shocking and sensitive movements from the market stakeholders are expected in the higher level of Halo effect.

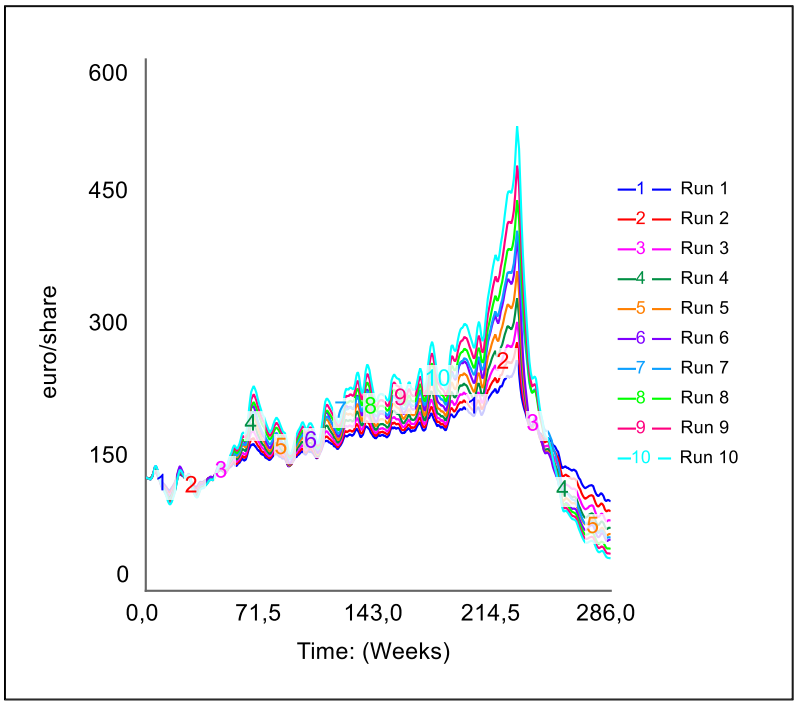

Figure 2. 12: Sensitivity of simulated results on Halo Effect of EFL and EFG

The higher pick just before the Scandal can be attributed to the fact that the customers and investors overestimated the market value of the VW stock due to GreenWashing. However, as soon as the Scandal was raised, the falling of the stock price would be even more rigorous in terms of the more considerable Halo Effect.

Again, in a separate table, the selected range for changing the values of Hallo Effect variables can be seen in Table 2.4, and the value for the base run has been highlighted. In the base run, the Halo effect of EFG is slightly more significant (1.2) than that of EFG (1)

Table 2. 4: Range of values for both "Halo Effect of EFL" and "EFG" in sensitivity testing.

Run #	1	2	3	4	5	6	7	8	9	10
Variable value (Halo Effect)	1	2	3	4	5	6	7	8	9	10

The elasticity of Branding to the Scandal

The elasticity of the Brand in the Scandal is an essential part of the model. Conceptually, a scandal has a different effect on the different sentiments of the market. In this model, three different sources for adopting the elasticity concept have been selected, and in this section, its effect on the Branding Image is analyzed.

In Figure 2.13, the sensitivity of the stock price in terms of different Elasticity values is considered. The Branding sector of the model is in the spotlight and the values. The changing range starts from zero and ends up at one, as was defined in the concept of elasticity. Simply, it covers the test of extreme values for this parameter.

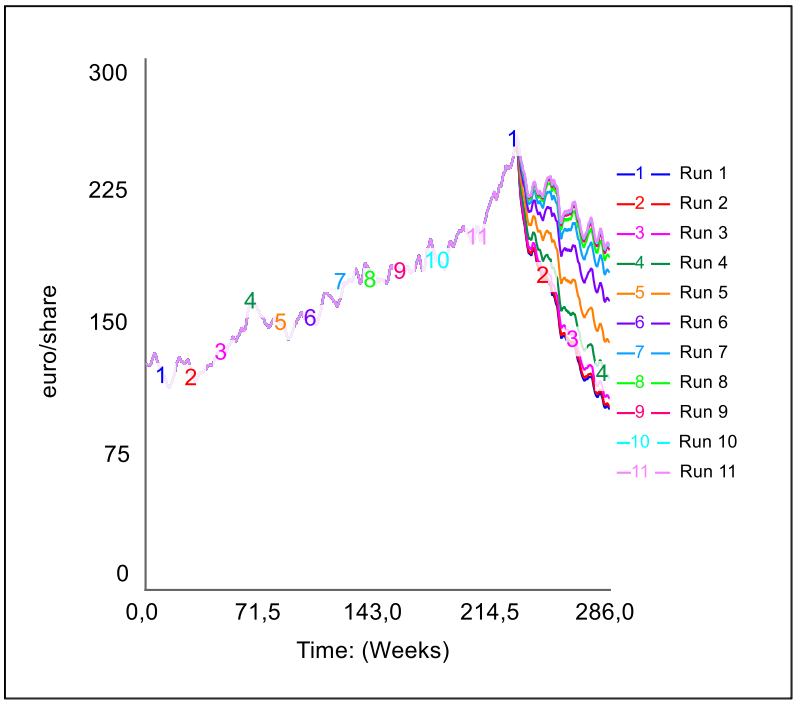

Figure 2. 13: Sensitivity of simulated results on Elasticity of Branding to the Scandal

The fact that a higher level of elasticity of Branding presents more negative effects from the Scandal can be inferred from the diagram. In the case of zero value for elasticity of Branding, the reason for dropping in the stock price relies upon the elasticity of other sectors. If all the elasticity variables in the model are equal to zero, then the stock price will not be sensitive to the Scandal. The results of this part can be found in the next chapter, as well as in the appendix.

Like the other charts in this section, he selected a range for changing the values of Elasticity of Branding to the Scandal variable presented in Table 2.5, and the value for the base run was highlighted.

Table 2. 5: Range of values for "Elasticity of Branding to the Scandal" in sensitivity testing.

Run #	1	2	3	4	5	6	7	8	9	10	11
Variable value (Halo Effect)	1	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1	0

Behaviour Validation

After performing sensitivity analysis on the model variable against the model behavior, in this part, another attribute of model behavior is considered, which is Behavior Validation. This evaluation is a crucial step in the model validation process. For this reason, Error analysis of the model in case of simulating the reference mode is performed, and the result is presented.

In Table 2.6, the criteria of Mean Square Error (MSE) and Root Mean Squared Deviation of simulated data are presented. These values show the overall error of the simulation process while it is compared to the historical data. The values are not in the absolute scale (calculated based on the relative error).

Table 2. 6: MSE and RMSE of simulated data (the stock price of VW)

Criterion	Value
MSE	0,0257198
RMSE	0,0128599

The formulas and criteria for error analysis are derived from Freund's Mathematical Statistics (2004). In Figure 2.13, the histogram of the Relative Error and Absolute Error is demonstrated and can be compared with the behavior of both reference mode and historical data. The relevant formula for calculating the errors is presented here:

Relative Error= (Historical data – Simulated data)/(Historical data)

Absolute Error= | Historical data – Simulated data |

In the top diagram, the unit of graphs are (euro) and can be depicted together. Nevertheless, the bottom diagram has different units and is presented separately.

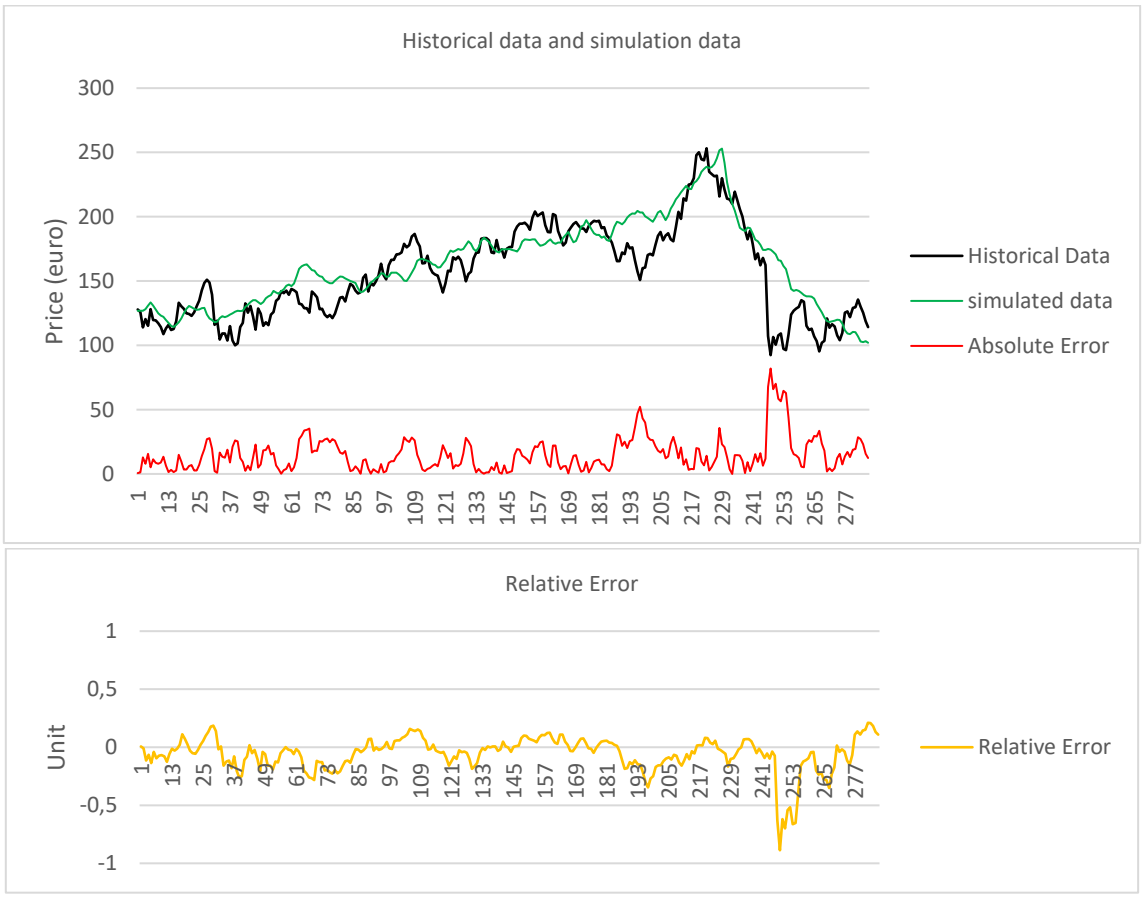

Figure 2. 14: Simultaneous comparison of Errors, Simulated data, and Absolute Data.

Neglecting some parts in which the data does not match perfectly (and cause gig error), the reference mode was replicated reasonably in most parts of the diagram.

Chapter 3: PROBLEM ANALYSIS

Domains and Borders

In the boundaries section of the previous chapter, a basic framework of the research was presented briefly. In the current section, other layers of borders will be discussed.

The model covers the technical analysis side of the market trading in a narrow approach. In other words, not all the practical elements of technical analysis have been included in the research. There is much room for considering this aspect in more detail and more depth.

Sentiment analysis of the market requires a wide range of knowledge, including behavioral finance, psychological analysis of market stakeholders (especially investors), knowledge of other industry sectors, and the market's economic condition.

In this case study, the role of an internal phenomenon is studied in the behavior of the market against VW, which is reflected in a good way in the stock price of VW. Nevertheless, the mentioned Scandal itself had a significant impact on the other companies in the same industry, in other correlated industries, generally on the economy and Branding of the German industry, and finally on the global movement of global society in terms of Global Green Awareness. As a result, the effect of DieselGate on the mentioned external elements is out of the boundary of the model in the research.

It is noticeable that for a better consideration of the Scandal, the influence of other factors in the breakdown of VW in case of stock price (in mid-2015) is neglected. Moreover, if there are other practical elements in the real world (about this case study), future studies could cover them.

Also, it has been assumed that any kind of Scandal in the real world in any branch would be detected, and there is no way toward success through cheating. So, the primary variable for detecting the Scandal is vital in analyzing the stock price behavior. In any case, if there is no effect of cheating yet, then there is no scandal yet. Nevertheless, as soon as it comes into existence, then there is no room for GreenWashing!

Model Calibration

All the parameters, stocks, graphical functions, and initial values should be calibrated to get the best result for replicating the reference mode. There is no room for calibrating in case of external values, historical data, and imported variables. The fundamental values and historical data are used and imported into the model as they are, without any adjustment.

The tool for running the model and simulating the behavior in this research is Stella Architect (isee Systems, 2022). For calibration of the model, there are two approaches to choose from: automated calibration by Stella Architect software and manual calibration. The latter approach is selected to do the calibration in this study.

In performing the calibration process, the effect of any essential variables (for example, those that affect *Aggregated Attractiveness of Stock*) should be considered separately in the absence of the others. By doing so, the role of a selected variable can be investigated logically and individually. In the next step, all the essential variables in the selected section affect the model behavior simultaneously to check and control their role aggregately.

The main criterion for manual calibration is to pursue the minimum of Least Square Error while simulating the reference mode. However, as it is done manually in this research, the criterion is controlled not analytically and just by the eyesight when the replicated behavior approaches the historical data.

Model Results

In this section, all the intermediary variables that play a role in the primary variable of the model, as well as the final sector for replicating the price of VW stock, are considered in detail.

Perceived Stock Price

The purpose of the model is to spotlight the historical data (VW stock price) and try to replicate by Perceived Stock Price of VW (by simulating). The result is demonstrated in Figure 3.1 and shows that the model can reasonably simulate the historical data acceptably. Nevertheless, does the model do that for the right reasons? It has been discussed in the Hypothesis chapter, and now it is under the testing criterion.

Figure 3. 1: VW's weekly stock price historical data and the simulated results.

The pink noise oscillation structure can produce moderate fluctuations around an average trend in stock price. However, these fluctuations do not straightforwardly match the stock price's actual movements. For this reason, there are some gaps between the simulated price (Perceived Stock price) and the historical data in the diagram. Nevertheless, using the calibration, it has tried to replicate the actual data acceptably.

Aggregated Attractiveness of Stock

As mentioned at the beginning of the section, the parameter *Aggregated Attractiveness of Stock* plays a significant role in simulation in the previous diagram.

In Figure 3.2, four variables are merged into one united element named *Aggregated Attractiveness of Stock.* Those variables are:

- Aggregated Fundamental Attractiveness
- Brand Image Development
- Aggregation of Technical Attractiveness
- The attractiveness of Goodwill Effect Indication (GEI) for Investors.

All the variables have been defined to have fluctuated around 1 unit, and all are Dimensionless since they are cognitive variables. They have defined and controlled to move upward and downward by around 50% of their value. The aggregation of these variables shapes the overall attractiveness of the stock market from an investor's perspective. The integration formula has discussed in the previous chapter. By multiplying the approach for such an integration, the role of extreme conditions can be easily captured (in comparison to that of a simple average). Moreover, to normalize the final effect after integration, the method of n^{th} *rooted* is used to modify the effect of multiplication.

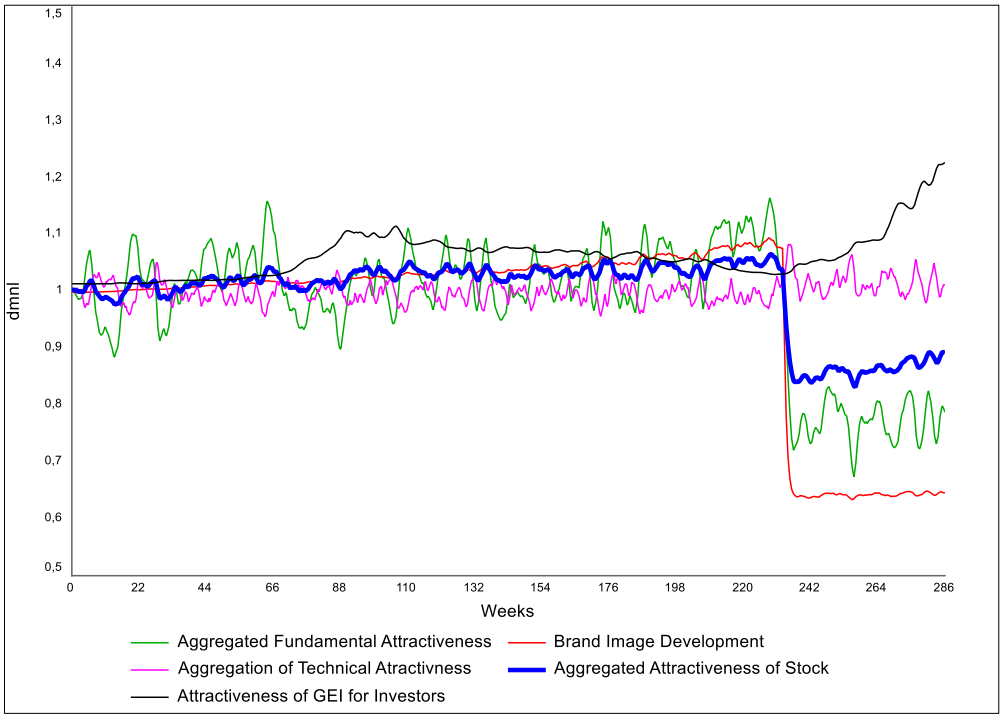

Figure 3. 2: the behavior of Aggregated Attractiveness of Stock and its influential variables.

The blue line in the above diagram represents the aggregation of the other four variables.

After integration, the result of the variable is shown by the thick blue line. As expected, it moves among the underlying variables. After arising the Scandal, the behavior of those variables is quite different.

Aggregated Fundamental Attractiveness: Fundamental analysis of the stock market is one of the most critical aspects of the model, governed by three different variables and stocks: 1. Innovation Quality and Differentiation Image, 2. Effective EFG, and 3. Effective EFL. This integration part is presented in the following sections. This variable's effectivity is less than that of Brand Image but still one of the highest levels among these four variables. Because the Scandal imposes lots of operational costs and

fines for compensation, it leads to a lower prediction of seasonal profit. The latter fact causes a severe drop in the fundamental attractiveness of the stock.

Brand Image: It developed with a significant impact from the Scandal in 2015, the most extreme effect. Because as soon as a scandal is raised in a company, the first corner that gets affected negatively is the company's Brand structure. Moreover, the company can lose its reputation severely. Nevertheless, it is essential to check the Elasticity of Branding in the Scandal. In the absence of a noticeable elasticity, the adjustment of the branding value would be moderate. Also, the oscillation of the Branding graph is not as robust as the others and shows a more stable behavior. On the other hand, VW's most challenging part of the attractive elements to be recovered is its Branding Image. It is a long process to recover the Branding value after such a scandal.

Aggregation of Technical Attractiveness: This part of the model tries to simulate the effect of price movement in a brief trading timeframe (one period in this case). Based on the diagram, this part of the integration does not affect by the Scandal.

But why? From a technical analysis viewpoint, the market always serves an excellent potential for technical traders. They just try to detect the trend correctly, then follow the trend. As a result, in any kind of market status, technical investors find an exciting position to make a profit (downward or upward movement). Briefly, it can be stated that the elasticity of technical attractiveness of the Scandal is almost zero, leading to the minimum affectivity of DieselGate.

The attractiveness of Goodwill Effect for Investors: All the previous integration elements negatively or negatively impact the stock attractiveness. Nevertheless, Goodwill Effect has the role of compensation in the time of the Scandal arising and serves as a positive feeling for investors.

But how? A downward movement in the stock market (due to the Scandal) indicates that the VW stock will be under-priced and is considered a good option for investment. The lower the price, the more attractiveness. The company has billions of physical assets and is capable of making a profit, even in the short-term time horizon. This element is the essential factor in stopping the movement toward bankruptcy.

In Figure 3.3, the model behavior in the absence of the GoodWill Effect is presented.

Figure 3. 3: Reference mode in the absence of GoodWill, without any extra calibration.

It seems that regardless of the GoodWill effect, the stock price loses some of its attractiveness and would be traded under-priced. Even after some more calibration for replicating the reference mode before the Scandal (Figure 3.4), the behavior after DieselGate would be lower than the reference mode (under-priced).

Figure 3. 4: Reference mode in the absence of GoodWill, with re-calibration.

In other words, by deleting the effect of Goodwill in the model, the balancing loop (B1) will be deleted, and the model cannot replicate the surviving process of the stock price at the end of the simulation. By doing so, the company will be bankrupt soon, and the market value even meets lower levels.

As a result, logically, the role of the Goodwill effect is an essential structure in balancing the stock price after the Scandal.

Aggregated Fundamental Attractiveness

Behind the previously mentioned variable (*Aggregated Attractiveness of Stock*), another element integrates the other three factors to shape the final attractiveness of the stock. The variable is called *Aggregated Awareness* and is constructed in the same way as the latter integrated process. This variable is the primary input for *Aggregated Fundamental Attractiveness*, stocked in an information delay structure. However, in this corner of the model, there are three variables for integration and can be calculated as:

Aggregated Effect= *[A*B*C]^(1/3)*

Again, to normalize the final effect after integration, the method of n^{th} *rooted* is used to modify the effect of multiplication.

In Figure 3.5, the behavior of all three variables, along with the integrated one. The blue line in the diagram represents the aggregation of the other three variables. Following up in this sub-section, more details about each variable are coming.

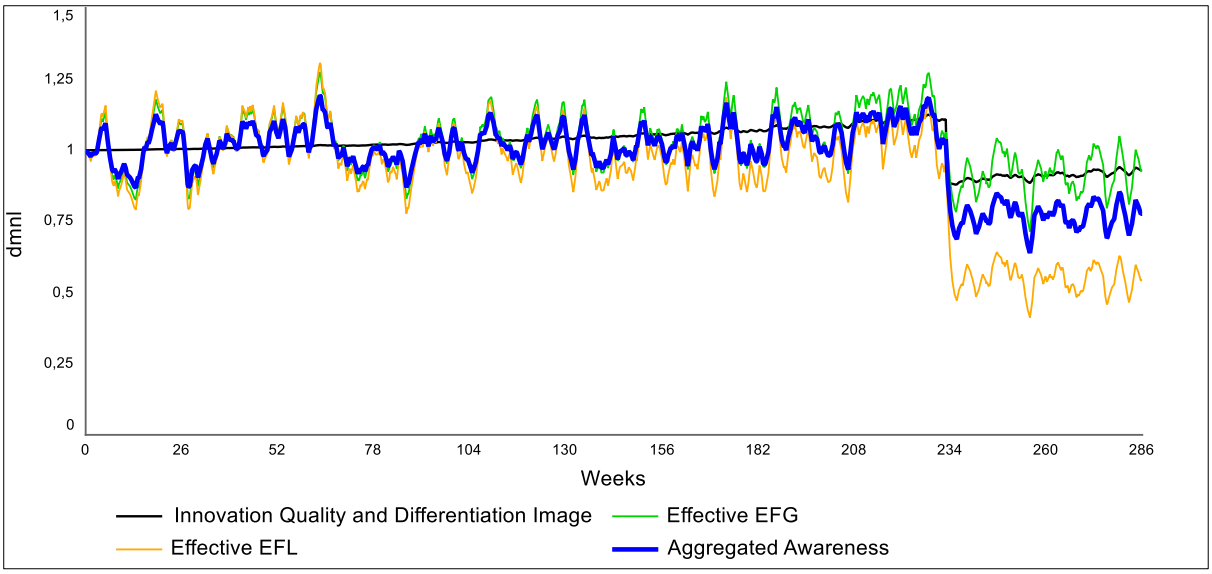

Figure 3. 5: the behavior of Aggregated Awareness and its influential variables.

The Effective Expected Future Loss: This factor gat impact from the Scandal directly, based on the calibrated elasticity. It means that in the case of full elasticity, the Scandal invokes this variable in such a way to warn the investors that a severe expected loss is about to come soon. Another critical fact in this side of the model is the *Halo Effect of EFL*.

The Halo Effect was detected in a psychological evaluation by Rosenthal and Jacobs in 1968. The Halo Effect is a psychological and cognitive bias in which customers believe in a phenomenon based on their perception of other events (Nicolau et al., (2020)). Simply, it indicates that the perception of people about a specific attribute of a phenomenon can bias and affect their judgment about the other events or another attribute of the former phenomenon. In the financial area, the Halo effect of an event (the Scandal in this case) can bias and amplify investors' perception of the effect of an event. As a result, the scale and impact of the Scandal are considered much more than the actual condition. This biased perception eventually amplifies the shocking effect of the Scandal and leads to the dropping down of the stock price more than its actual effect.

In this variable, the Halo effect is more than that of a normal situation (one unit), and here it has been estimated as 1.2. So, the Scandal's effect on the EFL is higher than normal conditions (in reality). Also, in the diagram, the highest impact of the variables is contributed to the Effective EFL. In other words, it tends to overestimate the intensity of the event and touch the exaggerated borders of the phenomenon.

The Effective Expected Future Growth: In contrast to the latter mentioned variable, this one does not directly affect by the Scandal. It is fed by the *innovation Quality and Differentiation Image variable* since it carries the positive side of the news (not the negative aspect). As a result, it has been rooted in the technological side of the business to reflect the positive pulse of future growth.

The Halo effect for this variable is at the standard level (one unit). So, there is no evidence of exaggeration in the EFG characteristics. The behavior of this variable in the diagram shows the mentioned logic and serves as a moderate shock on the stock price.

Innovation Quality and Differentiation Image (IQDI)

The last part of the relevant factors in this sector comes from the Research and Development department of the company (R&D). This sub-section provides every response to the external awareness from the company's society. Above that, all the company's activities for making the Brand outstanding (from a technological aspect) and differentiating it from other competitors are done by the R&D department. Like the Branding Image, this part of the model shows somewhat a constant trend over time and does not fluctuate like the other elements in the diagram.

Spotlighting more details in the underlying sub-section (figure 3,6) gives extra information about the structure of this essential section of the model. Gradually arising the Global Green Awareness requires a strategic decision to invest in the relevant part of the company to respond to the expectation. This strategical movement in the baseline of the business leads to a stable framework for pursuing the public interest unless a scandal arises.

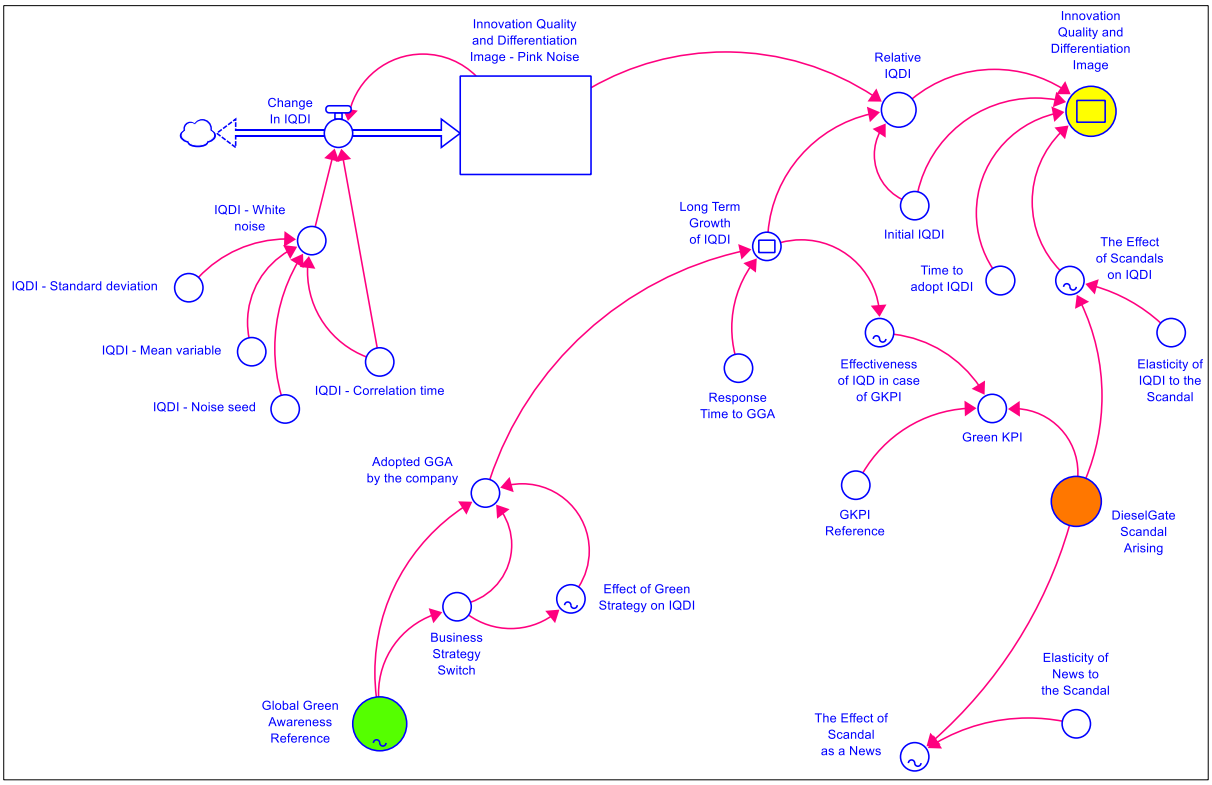

Figure 3. 6: Detail elements in the sub-section of IQDI.

The Scandal directly impacts the IQDI variable regarding elasticity (as mentioned in the previous sections). It decreases the pace of IQDI towards sustainable growth and slows down the approval process of the Brand by the customers and investors. The role of the R&D department on Branding and the effect of elasticity of shocking news will be discussed in chapter number 4.

Moreover, there is a Pink Noise replication structure in this corner of the model to provide a moderate fluctuation in the process of IQDI. Also, to control the company's performance, a primary Key Performance Indicator (KPI) has been defined.

Chapter 4: POLICY AND IMPLEMENTATION

Overview

Generally, this research project attempted to spotlight the historical data of VW group stock price between 2011 and 2016 and replicate the reference mode through the model. The future of the stock price is out of the model boundary. Furthermore, the model must be adjusted and calibrated to cover more periods in the time series.

The model does not cover an approach for the policymaking step because the only way to prevent such a scandal is to stop GreenWashing. In the absence of GreenWashing, the stock price goes toward higher and higher price levels, resulting in more and more attractiveness and market share (Figure 4.1).

Figure 4. 1: The stock price trend in the absence of DieselGate.

From the theoretical side of the problem, it is easy to make the products more productive and effective in case of fuel consumption instead of GreenWashing. Nevertheless, it is not as easy from a practical viewpoint. It requires a detailed plan for technological development projects and billions of USD for investing in those projects.

Investment in R&D and technological projects are the essential factors for being a pioneer in the industry. Especially if there is an issue like awareness of Global Warming, then the importance of investment in development and new technologies is the highest priority for the company. In Figure 4.2, the role of the R&D department budget can be compared to that of advertisement in the automotive industry.

As a pioneer company in the electric car sector, Tesla has the higher budget in R&D (somehow, investment in R&D) but the lowest budget for advertisement. This fact contrasts with the other companies in the branch in the diagram: on average, their R&D budget is doubled of advertising budget. As a result, the only way to respond to the need for new technology and Global Awareness is to be more innovative, not be pretended as innovative.

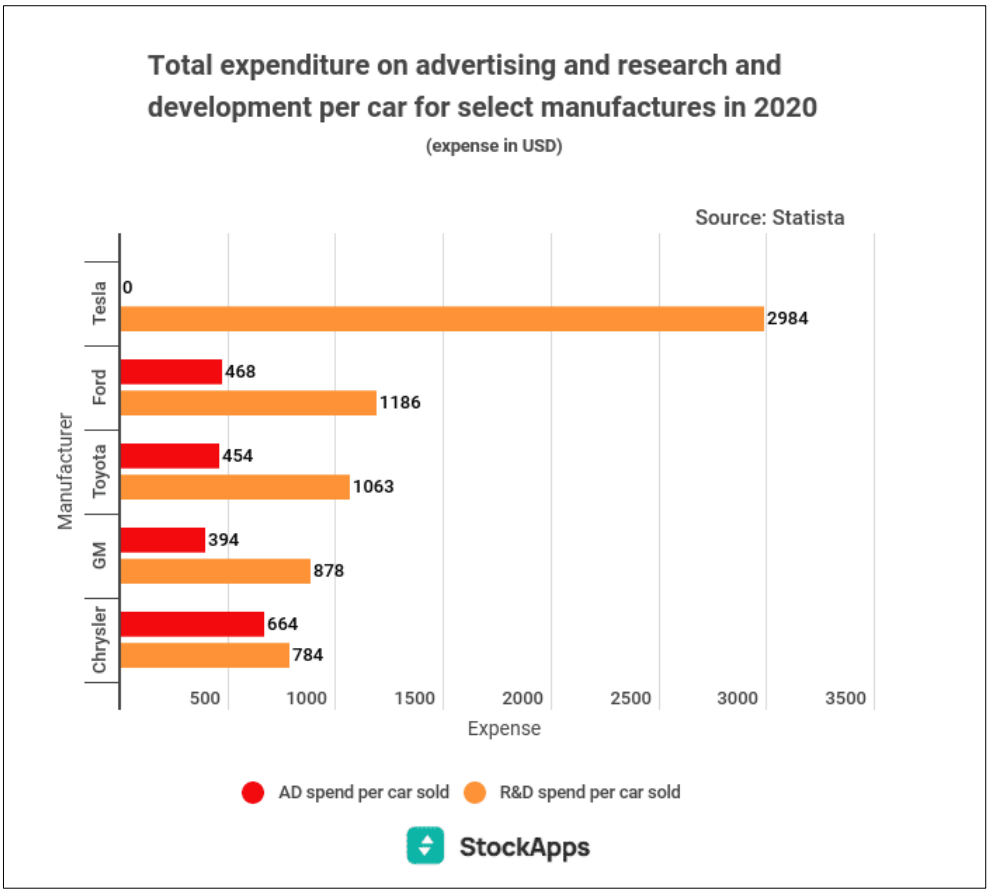

Figure 4. 2: A comparison between R&D and Advertisement budgets in the automotive industry.

Source: StockApps.come

This is the fact that the model has been structured based upon: the *Innovation Quality and Differentiation Image* is the most crucial factor to cope with the Global Awareness and leads to a Branding Image.

On the other hand, after the Scandal, the management needs to take responsibility for all the opposing sides of the phenomenon. By doing so, the risk of going down to lower prices (bankruptcy) would be less. Moreover, the company can survive the recession due to the Scandal. The reaction of VW's top managers to the Scandal can be considered a practical strategy but, at the same time, could be regarded as not a practical approach because the VW stock price was unable to touch the highest price before the Scandal, even after six years (it happened in 2021). It is not a short-term or mid-term process to recover the Brand Imaging after such a scandal.

Theoretical and Practical Implementation

The developed model in this project research can be used in similar situations where shocking news affects a company. The news could be from any internal or external sources, whether the company is responsible for the situation or not.

For using the model in comparable conditions, checking the elasticity of the company on the event/scandal is the most critical criterion. Because the Scandal does not affect the core activities of the business brutally, then the elasticity of the company is very weak and sometimes is neglectable.

In this case study, the DieselGate is directly correlated to the core activity of VW, which is producing a more efficient car as a response to the Global Green Awareness. As a result, the Scandal's effect on the attractiveness of VW to investors is even more than that of COVID-19 in 2020.

For better evaluation of elasticity in a scandal, another example of shocking news on a company is presented here. on April 9, 2017, a video was whirled on social media of dragging a passenger on an overbooked flight[6]. Due to this shocking phenomenon, United Airlines faced a scandal called "re-accommodation-gate."[7]. After a couple of hours, the CEO of United Airlines did not even try to apologize formally to save the company's reputation. It is usually expected to see a negative shock in its stock price in this situation. Nevertheless, what happened in reality? In Figure 4.3, the diagram of the weekly stock price of United Airlines is shown, and the period in which the Scandal happened is noticeable in 2017.

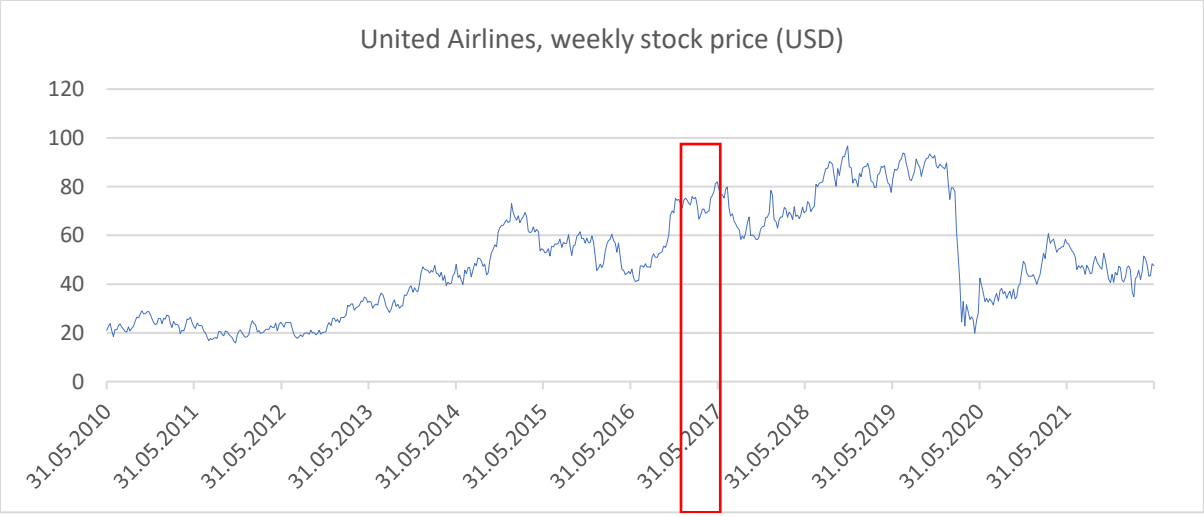

Figure 4. 3: The weekly stock price of United Airlines (USD)

Interestingly, there is no evidence of dropping in the stock price, in contrast to that of VW. But why? The keynote in “re-accommodation-gate” is that the elasticity of United Airlines on the Scandal is almost zero. Although the company's core activity is to transport the passengers, the only guaranteed thing is the lowest price: *Always the Best Flight Deals*.

On the company's home page, the company's core responsibilities can be seen: *“Are you searching for the lowest price on United Airlines flights for your next holiday?”*[8]

It can be indicated that its customers are looking forward to the best deal instead of the best quality. As a result, the Scandal can not be a source of shock to the stock price, and the elasticity can be neglected.

On the other hand, there are not many competitors for United Airlines in the airline industry, and there is no risk of customer migration to the other companies.

[6] United Airlines Customer Dragging Drama, forbes.com
[7] United Airlines scandal, qz.com
[8] Book cheap United Airlines flights on eDreams.com

These two mentioned factors on the “re-accommodation-gate” are entirely far from that of the DieselGate. Both in the case of the company's core activity and the alternative competitors for taking attention of the customers. So, the reaction of the market to these scandals is entirely different.

Besides, the model can be used in any problem or case with evidence of shock in the system (historical data). Several factors have essential roles in shaping behavior. Generally, the model has been developed to spotlight the psychological and mental aspects of the problems. However, the model can be applied to technical problems if the underlying variables could be treated the same way these cognitive variables have been treated.

Model limitations

Regarding the underlying problem in the history of VW stock price, this research tried to capture some of the causes that have a principal role in such behavior. So, behavioral finance has been selected as the main structure for modeling. And a fundamental aspect of technical analysis.

Considering the timeframe of the model, it can be possible to use a shorter timespan for covering more aspects of technical analysis because this model used weekly data for analyzing the stock price trend. Nevertheless, on the other hand, a smaller timeframe serves much more complexity to the model structure and the calibration steps.

Notably, the model does not consider any external factor that leads to such behavior but the raising of DieselGate. As a result, the catastrophic shock to the VW stock price in mid-2015 is supposed to be a phenomenon like Tech-Bubble in the 2000s, in which the High-Tech industry lost most of its value in the stock market. Before the Scandal, the company's shares were over-priced, and the market found the accurate price of each share by raising the Scandal (due to not any quick movement for recovering the price).

Another aspect is that the company did not adjust the value of non-tangible assets after the Scandal. It serves as a potential contrast between the perception of the market and that of the company itself because the model results show that the Scandal has a significant impact on the non-tangible assets of the company and not the physical side. The reaction of the company does not indicate such reasoning.

Besides, the model does not cover any strategy or policy suggestion for recovering the stock price after the Scandal more quickly. Not also, any sort of policy implementation step in the modeling process for preventing such a scandal. In other words, the model tried to replicate the historical data. Moreover, the only way not to have another scandal in the future is not to GreenWahnig!

Last but not least, in this model, the concept of elasticity was considered just on the positive side, and it does not cover the negative elasticity. So, if some news has different effectiveness (positive and negative, simultaneously) on the company, then the negative side of elasticity should be defined and modeled.

Suggestions for Future research

Regarding the characteristics of the model in the research, every other aspect outside the model boundary can be considered a potential topic for future research. The boundaries of the model have been discussed in the previous chapters and include:

- The effect of the Scandal on the other companies in the automotive industry,
- The enormous impact of DieselGate on Germany's economy,
- The role of the Scandal on the strategic policies for governments,
- Possibilities of using of Agent-Based Modelling approach to investigate market movements,
- Checking the evidence of other external sources for such a downward movement in price,
- The role of policymaking in the era after the Scandal for quickly recovering the price,
- In terms of the Elasticity of the Brand to the Scandal, it would be interesting to introduce the negative values for elasticity for capturing the positive effects of the news as well.
- Trying to model the technical analysis side of the problem at a higher level, considering that a basic sub-model has been used in this sector,

The options mentioned above can be considered a base for broader modeling of the DieselGate Scandal and other shocking events for other companies.

Chapter 5: DISCUSSION AND CONCLUSIONS

This research project tried to analyze and model the effect of the DieselGate Scandal on the VW group. Interestingly, the stock price of VW represented the highest level of effectiveness by the Scandal, neither sales side nor market share. As a result, the model was developed based on the concept of stock price and its background in psychological, sentiment, and cognitive. In other words, the focus of the model was on the Fundamental Analysis of the market to investigate the shock on the VW's Stock price, as well as an essential structure for capturing the Technical Analysis side.

The results indicated that the model was capable of replicating the reference mode and simulating the problem based on the developed SD model. Moreover, the assumptions about the causes of such a model behavior due to the Scandal seemed to be correct. It means that the model did the replicating process for the right reason and selected those correct areas for simulating the problem.

Regarding the feedback loops, there were three main loops in the model, and their roles defined the interactions between different sectors/forces in the model to move the price up or down. After the Scandal, two reinforcing feedback loops pushed the company towards bankruptcy, and the third loop (balancing) mitigated the power of the reinforcing ones. The outcome of interactions between those loops resulted in a severe shock in the stock price as the Scandal raised. Moreover, after a while, it ended up surviving the company from bankruptcy.

The Validation section of the thesis covered all the necessary tests and checks that are needed for developing a reliable model. Besides, sensitivity analysis was done on all the external variables to control their effect on the model behavior. Also, formulation, calibration, extreme testing, and other validation steps were executed to be sure that the model works reasonably and is robust.

The model limitations section and those mentioned implications criteria can help the practitioner to implement the model in other cases regarding some adjustments. For the research side, the model can be a basic model to analyze the effect of shocking news on the stock market and detect those different loops that shape the stock market behavior. For sure, the model deserves several comments, adjustments, editions, and re-development for being able to be a reliable structure for facing the challenges of the Behavioral Finance area.

Deep knowledge of sentiment analysis and understanding of the power of the practical elements in the stock market can help developers to analyze this kind of problem in a company. Qualitative modeling, which was the main idea of this research, requires noticeable capabilities of the mentioned backgrounds. Although it seems to be easier to model a qualitative phenomenon, at the same time, it is more challenging and deserves comprehensive knowledge of both the psychological and technical sides of the problem. This model was able not only to handle some attributes of the technical/quantitative side of DieselGate but also cover those main cognitive viewpoints of the model.

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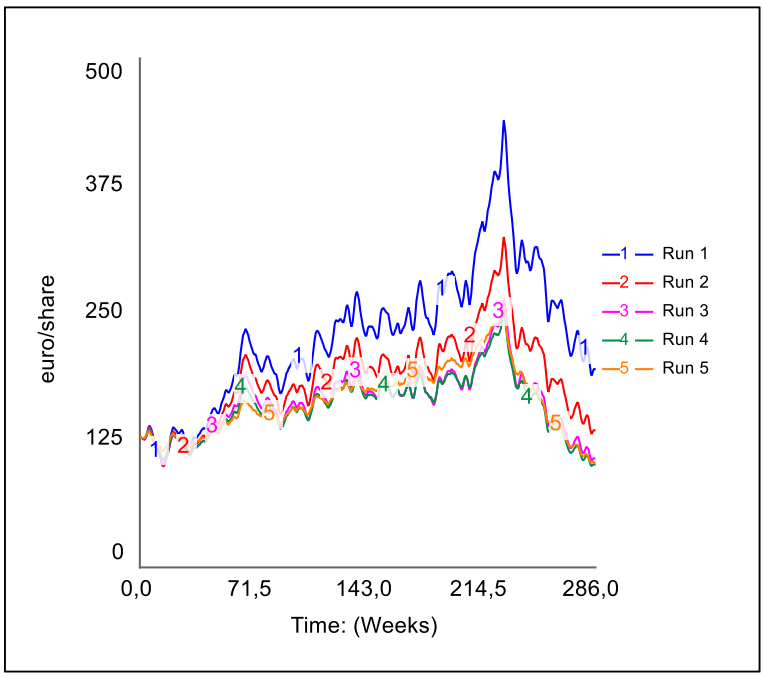
Appendices

Complementary Results of Sensitivity Testing

Follow up by previous chapters, sensitivity of other external variables is tested and explained in this section.

Standard Deviations of Pink Noise Structure,

As mentioned in the Sensitivity analysis section, there are four sectors in the model that contains the Pink Noise structure (excluding the one that was covered in that section). The effect of those four structures is presented in one diagram and can be seen in Figure App.1. As it can be seen, the bigger the standard deviation is, the more fluctuations and more extreme conditions are.



App1. 1: Sensitivity of simulated results on Standard Deviations of Pink Noise Structure (4 sections).

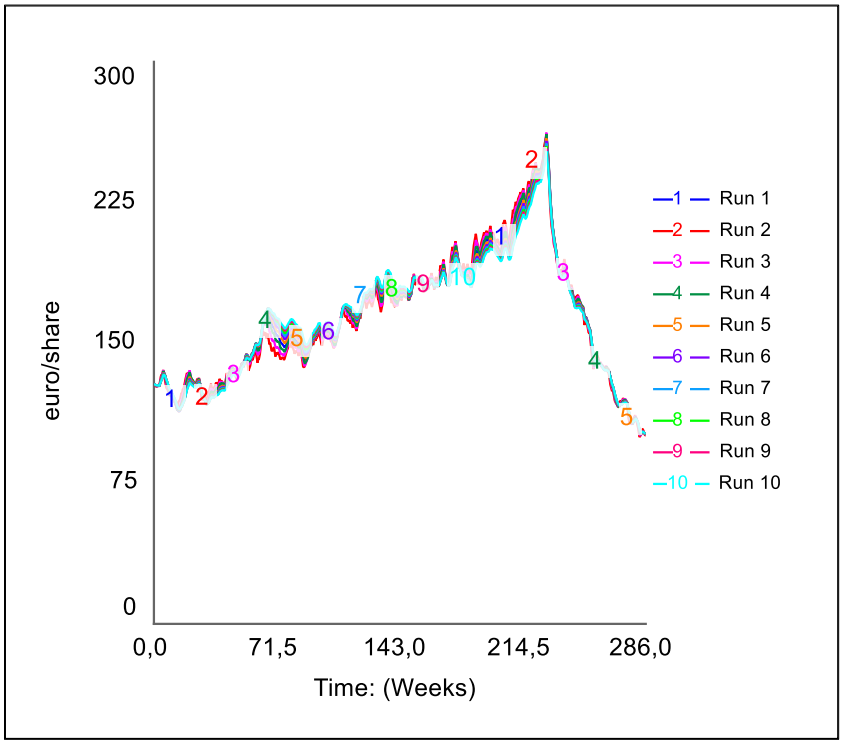
In table App1.2, the range of the input variable for the variable can be found. The value of the base run is highlighted.

App1. 2: Range of values for "Standard Deviations of Pink Noise Structure" in sensitivity testing.

Run #	1	2	3	4	5
Standard Deviation	0.05	0.2	0.3	0.4	0.5

SPPN-Correlation Time,

The next variable is the SPPN-Correlation Time, which is a time adjusting variable in the Pink Noise structure. As it is shown in the diagram, the model behaviour is not so sensitive to this variable and deviation from the reference mode can be neglected.



App1. 3: Sensitivity of simulated results on SPPN-Correlation Time.

In table App1.4, the range for the time is defined and the base run value is highlighted.

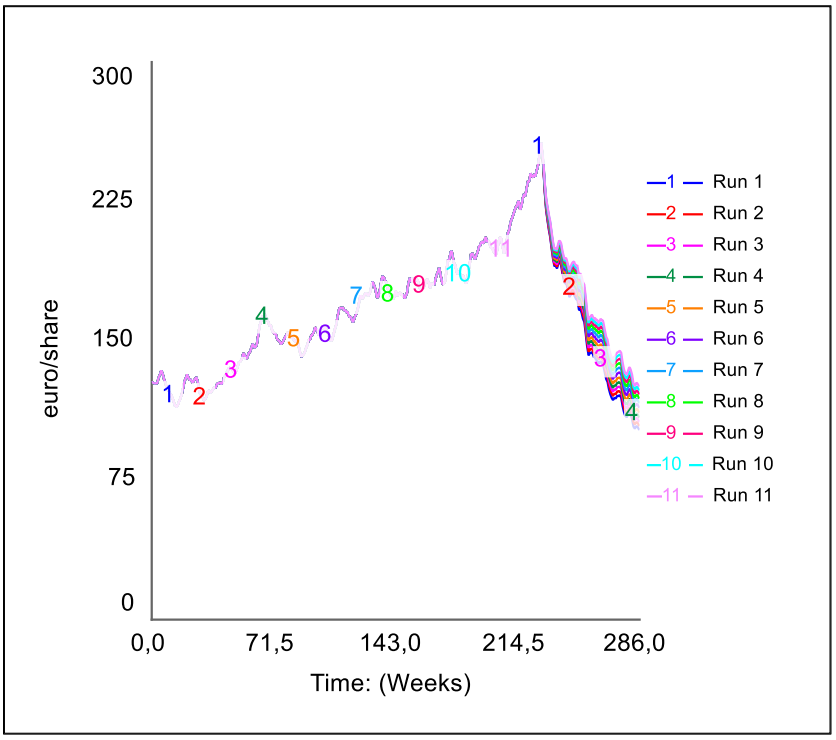
App1. 4: Range of values for "SPPN-Correlation Time" in sensitivity testing.

Run #	1	2	3	4	5	6	7	8	9	10
Variable value (week)	1	2	3	4	5	6	7	8	9	10

Elasticity of IQDI to the Scandal,

IQDI is affected by the scandal regarding the value of *Elasticity of IQDI to the Scandal.* The term of elasticity defines the power of effectiveness of scandal on the IQDI.

As it can be distinguished by the graph (App1.5), lower level of elasticity leads to a more moderate reaction of the market to the scandal. The last run (#11) is in the highest position in the graph and indicates smaller amount of shock to the stock price. The fact that there is still some evidence of falling movement in the price after the scandal, is related to the effect of the other active variable in the model.



App1. 5: Sensitivity of simulated results on Elasticity of IQDI to the Scandal

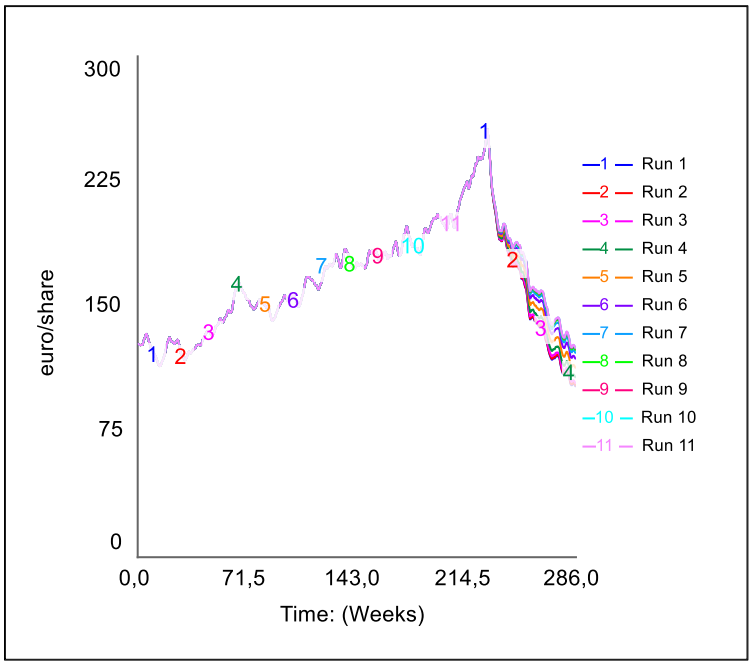
Again, in table App1.5, the selected range for sensitivity analysis is presented. The highlighted number indicates the value of the parameter in the base run.

App1. 6: Range of values for "Elasticity of IQDI to the Scandal" in sensitivity testing.

Run #	1	2	3	4	5	6	7	8	9	10	11
Variable value (unit)	1	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1	0

Elasticity of News to the Scandal,

Referring to the description of the previous variable, the structure and analysis is the same. The graph and the related table can be seen in App 1.7 and App1.8, respectively.



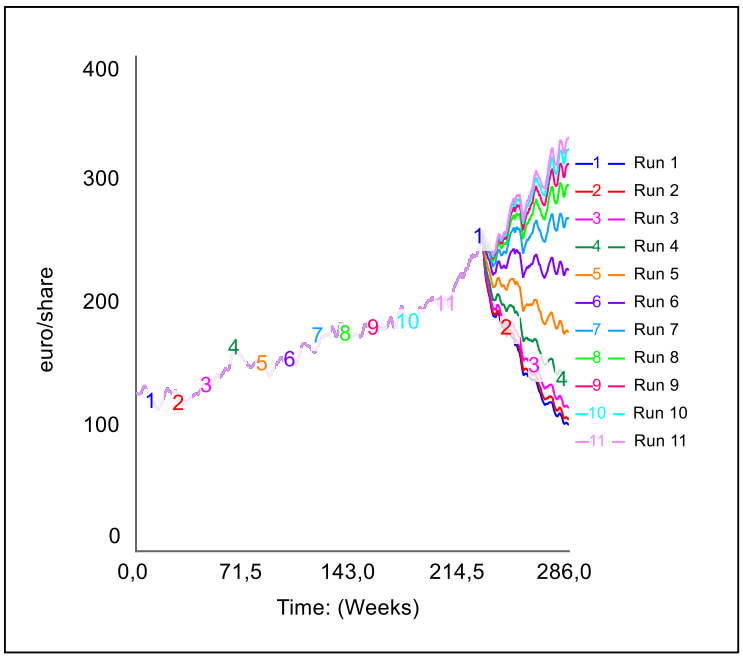
App1. 7: Sensitivity of simulated results on Elasticity of News to the Scandal

App1. 8: Range of values for "Elasticity of News to the Scandal" in sensitivity testing.

Run #	1	2	3	4	5	6	7	8	9	10	11
Variable value (unit)	1	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1	0

Sensitivity of simulated results on deviation for all Elasticity variables (3 elements),

Here the overall effect of those three elements that have Elasticity would be tested together.



App1. 9: Sensitivity of simulated results on deviation for all Elasticity (3 elements)

As it is described, in case of zero elasticity for those three variables, the model behaviour would be independent of the scandal and follow its increasing trend, just like before DieselGate.

App1. 10: Range of values for Elasticity in sensitivity testing.

Run #	1	2	3	4	5	6	7	8	9	10	11
Variable value (unit)	1	0,9	0,8	0,7	0,6	0,5	0,4	0,3	0,2	0,1	0

SPPN - Mean variable,

This variable is defined to control the average value of fluctuations. As a result, it should be constant, and no sensitivity analysis is performed. This is a common approach for all the variables that have the role of normalizing the effect (most of the time equals, 1)

The other external variables that are not in this sensitivity test section represented no change in the case of sensitivity analysis. So, the result of the model is not sensible to those variables (e.g., Noise Seed).

Formulas and calculations:

	Equation	Properties	Units	Documentation	Annotation
Top-Level Model:					
Aggregated_Fundamental_Attractiveness(t)	Aggregated_Fundamental_Attractiveness(t - dt) + (Updating_of_AFA) * dt	INIT Aggregated_Fundamental_Attractiveness = Initial_AFA	dmnl		NON-NEGATIVE
Brand_Image_Development(t)	Brand_Image_Development(t - dt) + (Updating_of_BID) * dt	INIT Brand_Image_Development = Initial_BID	dmnl		NON-NEGATIVE
"Brand_Image_Development_-_Pink_Noise"(t)	"Brand_Image_Development_-_Pink_Noise"(t - dt) + (Change_In_PPN) * dt	INIT "Brand_Image_Development_-_Pink_Noise" = 1	dmnl		NON-NEGATIVE
"Expected_Future_Growth_-_Pink_Noise"(t)	"Expected_Future_Growth_-_Pink_Noise"(t - dt) + (Change_In_EFG) * dt	INIT "Expected_Future_Growth_-_Pink_Noise" = 1	dmnl		NON-NEGATIVE
"Expected_Future_Loss_-_Pink_Noise"(t)	"Expected_Future_Loss_-_Pink_Noise"(t - dt) + (Change_In_EFL) * dt	INIT "Expected_Future_Loss_-_Pink_Noise" = 1	dmnl		NON-NEGATIVE
Goodwill_Effect_Indication(t)	Goodwill_Effect_Indication(t - dt) + (Change_in_GEI) * dt	INIT Goodwill_Effect_Indication = Historical_Reference_Goodwill_Effect	dmnl		NON-NEGATIVE

"Innovation_Quality_and_Differentiation_Image_-_Pink_Noise"(t)	"Innovation_Quality_and_Differentiation_Image_-_Pink_Noise"(t - dt) + (Change_In_IQDI) * dt	INIT "Innovation_Quality_and_Differentiation_Image_-_Pink_Noise" = 1	dmnl		NON-NEGATIVE
Perceived_Stock_Price(t)	Perceived_Stock_Price(t - dt) + (Updating_of_Stock_Price) * dt	INIT Perceived_Stock_Price = Initial_Stock_Price_at_2011_1st_Week	euro/share		NON-NEGATIVE
Stock_Price_Pink_Noise(t)	Stock_Price_Pink_Noise(t - dt) + (Change_In_SPPN) * dt	INIT Stock_Price_Pink_Noise = 1	dmnl		NON-NEGATIVE
Change_In_EFG	("EFG_-_White_noise"-"Expected_Future_Growth_-_Pink_Noise")/"EFG_-_Correlation_time"		1/week		
Change_In_EFL	("EFL_-_White_noise"-"Expected_Future_Loss_-_Pink_Noise")/"EFL_-_Correlation_time"		1/week		
Change_in_GEI	(Estimated_Goodwill_Effect - Goodwill_Effect_Indication)/Time_to_GEI_adjustment		Per Week		
Change_In_IQDI	("IQDI_-_White_noise"-"Innovation_Quality_and_Differentiation_Image		1/week		

	_- _Pink_Noise")/ "IQDI_- _Correlation_time"				
Change_In_PPN	("BID_- _White_noise"- "Brand_Image_Development_- _Pink_Noise")/ "BID_- _Correlation_time"		dmnl/week		
Change_In_SPPN	("SPPN_- _White_noise"- Stock_Price_Pink_Noise)/ "SPPN_- _Correlation_time"		1/week		
Updating_of_AFA	(Aggregated_Awareness- Aggregated_Fundamental_Attractiveness)/Time_to_Adjustment_AFA		1/week		
Updating_of_BID	(New_Info_on_BID - Brand_Image_Development)/Time_to_BID_Adjustment		1/week		
Updating_of_Stock_Price	(Effect_of_Stock_Attractiveness- Perceived_Stock_Price)/ Time_to_Updating_of_Stock_Price		euro/share/ Weeks		
Adopted_GGA_by_the_company	Global_Green_Awareness_Reference* Business_Strategy_Switch*Effe		dmnl		

	ct_of_Green_Strategy_on_IQDI				
Aggregated_Attractiveness_of_Stock	(Brand_Image_Development* Aggregated_Fundamental_Attractiveness* Attractiveness_of_GEI_for_Investors* Aggregation_of_Technical_Atractivness)^(1/4)		dmnl		
Aggregated_Awareness	(Innovation_Quality_and_Differentiation_Image * Effective_EFG* Effective_EFL) ^(1/3)		dmnl		
Aggregation_of_Technical_Atractivness	GRAPH(HISTORY(Perceived_Stock_Price; TIME-1)/ Perceived_Stock_Price) Points: (0,8500, 0,8500), (0,8800, 0,8800), (0,9100, 0,9100), (0,9400, 0,9400), (0,9700, 0,9700), (1,0000, 1,0000), (1,0300, 1,0300), (1,0600, 1,0600), (1,0900, 1,0900), (1,1200, 1,1200), (1,1500, 1,1500)		dmnl		

Attractiveness_of_GEI_for_Investors	GRAPH(Historical_Reference_Goodwill_Effect - Goodwill_Effect_Indication) Points: (-3,000, 2,98661429815), (-2,700, 2,96402758008), (-2,400, 2,90514825364), (-2,100, 2,76159415596), (-1,800, 2,46211715726), (-1,500, 2,000), (-1,200, 1,53788284274), (-0,900, 1,23840584404), (-0,600, 1,09485174636), (-0,300, 1,03597241992), (0,000, 1,01338570185)		dmnl		
"BID_-_Correlation_time"	2		Week		
"BID_-_Mean_variable"	1		dmnl		
"BID_-_Noise_seed"	1		dmnl		
"BID_-_Standard_deviation"	0,05		dmnl		
"BID_-_White_noise"	"BID_-_Mean_variable" + "BID_-_Standard_deviation" * (24*("BID_-_Correlation_time")/DT)^0,5 *		dmnl		

	UNIFORM(-1 ; 1 ; "BID_-_Noise_seed")				
Business_Strategy_Switch	IF Global_Green_Awareness_Reference > 0,2 THEN 1 ELSE 0,5		dmnl	It seems that the Business strategy has replied to the GGA at the start of this study. https://www.cleanenergywire.org/factsheets/dieselgate-timeline-car-emissions-fraud-scandal-germany https://environmentaldefence.ca/volkswagen-dieselgate-timeline/	
DieselGate_Scandal_Arising	1 + STEP(1; 228) {1 is the neutral value of scandal, and 2 is the activation level of scandal. This range will be adjusted with elasticity}		dmnl	2014 May 1: US researchers at the University of West Virginia discover that certain VW diesel cars emit up to 40 times the permissible levels of harmful nitrogen oxide when tested on the road. 2015 September 18: The US Environmental Protection Agency accuses VW of duping diesel emissions tests using so-called "defeat devices". https://techxplore.com/news/2019-09-vw-dieselgate-fraud-timeline-scandal.html https://environmentaldefence.ca/volkswagen-dieselgate-timeline/	

Effect_of_Green_Strategy_on_IQDI	GRAPH(Business_Strategy_Switch) Points: (0,000, 0,0001), (0,100, 0,000105), (0,200, 0,00011), (0,300, 0,000115), (0,400, 0,00012), (0,500, 0,000125), (0,600, 0,00013), (0,700, 0,000135), (0,800, 0,00014), (0,900, 0,000145), (1,000, 0,00015)		dmnl		
Effect_of_Stock_Attractiveness	Stock_Price_Pink_Noise* Aggregated_Attractiveness_of_Stock* MEAN (HISTORY(Perceived_Stock_Price; TIME-16); HISTORY(Perceived_Stock_Price; TIME-15); HISTORY(Perceived_Stock_Price; TIME-14); HISTORY(Perceived_Stock_Price; TIME-13); HISTORY(Perceived_Stock_Price; TIME-12); HISTORY(Perceived_Stock_Price; TIME-11); HISTORY(Perceived_Stock_Price; TIME-10);		euro/share		

	HISTORY(Perceived_Stock_Price; TIME-9); HISTORY(Perceived_Stock_Price; TIME-8); HISTORY(Perceived_Stock_Price; TIME-7); HISTORY(Perceived_Stock_Price; TIME-6); HISTORY(Perceived_Stock_Price; TIME-5); HISTORY(Perceived_Stock_Price; TIME-4); HISTORY(Perceived_Stock_Price; TIME-3); HISTORY(Perceived_Stock_Price; TIME-2); HISTORY(Perceived_Stock_Price; TIME-1))				
Effective_EFG	Expected_Future_Growth^ Halo_Effect_of_EFG		dmnl		
Effective_EFL	Expected_Future_Loss^ Halo_Effect_of_EFL		dmnl		
Effectiveness_of_IQD_in_case_of_GKPI	GRAPH(Long_Term_Growth_of_IQDI) Points: (0,002, 1,00334642546), (0,0022, 1,00899310498), (0,0024, 1,02371293659), (0,0026, 1,05960146101), (0,0028, 1,13447071069)		dmnl		

	, (0,003, 1,2500), (0,0032, 1,36552928932), (0,0034, 1,44039853899), (0,0036, 1,47628706341), (0,0038, 1,49100689502), (0,004, 1,49665357454)				
"EFG_-_Correlation_time"	1		week		
"EFG_-_Mean_variable"	1		dmnl		
"EFG_-_Noise_seed"	1		dmnl		
"EFG_-_Standard_deviation"	0,05		dmnl		
"EFG_-_White_noise"	"EFG_-_Mean_variable" + "EFG_-_Standard_deviation" * (24*("EFG_-_Correlation_time")/DT)^0,5 * UNIFORM(-1 ; 1 ; "EFG_-_Noise_seed")		dmnl		
"EFL_-_Correlation_time"	1		week		
"EFL_-_Mean_variable"	1		dmnl		
"EFL_-_Noise_seed"	1		dmnl		

"EFL_-_Standard_deviation"	0,05		dmnl		
"EFL_-_White_noise"	"EFL_-_Mean_variable" + "EFL_-_Standard_deviation" * (24*("EFL_-_Correlation_time")/DT)^0,5 * UNIFORM(-1 ; 1 ; "EFL_-_Noise_seed")		dmnl		
Elasticity_of_Branding_to_the_Scandal	1 {Elasticity can be from 0 to 1. In this case, the effect of scandal is very strong and can ruin all the good image of the Brand, so it equals to 1}		dmnl	Based on the branding values and the concentration/reputation of the company on the scandal subject, the elasticity could be total (+1) or null (0). But not possible to have a negative effect.	
Elasticity_of_IQDI_to_the_Scandal	1 {Elasticity can be from 0 to 1. In this case, the effect of scandal is very strong and can ruin all the good image of the Brand, so it equals to 1}		dmnl		
Elasticity_of_News_to_the_Scandal	1 {Elasticity can be from 0 to 1. In this case, the effect of scandal is very strong and can ruin all the good image of the Brand, so it equals to 1}		dmnl		
Estimated_Goodwill_Effect	("Non_Tangible_Asset,_History"*10^9)/ Market_Size {Goodwill / Market Size}		dmnl		

Expected_Future_Growth	SMTH1(New_Info_on_EFG*"Expected_Future_Growth_-_Pink_Noise"; Time_to_Updating_EFG; Neutral_EFG)		dmnl		DELAY CONVERTER
Expected_Future_Loss	SMTH1(New_Info_on_EFL; Time_to_Updating_EFL; Neutral_EFL)		dmnl		DELAY CONVERTER
GKPI_Reference	1		dmnl		
Global_Green_Awareness_Reference	GRAPH(TIME {Starting at the first week of 2011 - Can be considered as the start of Global Green Awareness}) Points: (0,0, 0,200), (1,16078431373, 0,202352941176), (2,32156862745, 0,204705882353), (3,48235294118, 0,207058823529), (4,6431372549, 0,209411764706), (5,80392156863, 0,211764705882), (6,96470588235, 0,214117647059),		dmnl		

	(8,12549019608, 0,216470588235), (9,2862745098, 0,218823529412), (10,4470588235, 0,221176470588), (11,6078431373, 0,223529411765), (12,768627451, 0,225882352941), (13,9294117647, 0,228235294118), (15,0901960784, 0,230588235294), (16,2509803922, 0,232941176471), (17,4117647059, 0,235294117647), (18,5725490196, 0,237647058824), (19,7333333333, 0,240), (20,8941176471, 0,242352941176), (22,0549019608, 0,244705882353), (23,2156862745,				

	0,247058823529), (24,3764705882, 0,249411764706), (25,537254902, 0,251764705882), (26,6980392157, 0,254117647059), (27,8588235294, 0,256470588235), (29,0196078431, 0,258823529412), (30,1803921569, 0,261176470588), (31,3411764706, 0,263529411765), (32,5019607843, 0,265882352941), (33,662745098, 0,268235294118), (34,8235294118, 0,270588235294), (35,9843137255, 0,272941176471), (37,1450980392, 0,275294117647), (38,3058823529,				

	0,277647058824), (39,4666666667, 0,280), (40,6274509804, 0,282352941176), (41,7882352941, 0,284705882353), (42,9490196078, 0,287058823529), (44,1098039216, 0,289411764706), (45,2705882353, 0,291764705882), (46,431372549, 0,294117647059), (47,5921568627, 0,296470588235), (48,7529411765, 0,298823529412), (49,9137254902, 0,301176470588), (51,0745098039, 0,303529411765), (52,2352941176, 0,305882352941), (53,3960784314, 0,308235294117				

	8), (54,5568627451, 0,310588235294), (55,7176470588, 0,312941176471), (56,8784313725, 0,315294117647), (58,0392156863, 0,317647058824), (59,2, 0,320), (60,3607843137, 0,322352941176), (61,5215686275, 0,324705882353), (62,6823529412, 0,327058823529), (63,8431372549, 0,329411764706), (65,0039215686, 0,331764705882), (66,1647058824, 0,334117647059), (67,3254901961, 0,336470588235), (68,4862745098, 0,338823529412),				

	(69,6470588235, 0,341176470588), (70,8078431373, 0,343529411765), (71,968627451, 0,345882352941), (73,1294117647, 0,348235294118), (74,2901960784, 0,350588235294), (75,4509803922, 0,352941176471), (76,6117647059, 0,355294117647), (77,7725490196, 0,357647058824), (78,9333333333, 0,360), (80,0941176471, 0,362352941176), (81,2549019608, 0,364705882353), (82,4156862745, 0,367058823529), (83,5764705882, 0,369411764706), (84,737254902,				

	0,371764705882), (85,8980392157, 0,374117647059), (87,0588235294, 0,376470588235), (88,2196078431, 0,378823529412), (89,3803921569, 0,381176470588), (90,5411764706, 0,383529411765), (91,7019607843, 0,385882352941), (92,862745098, 0,388235294118), (94,0235294118, 0,390588235294), (95,1843137255, 0,392941176471), (96,3450980392, 0,395294117647), (97,5058823529, 0,397647058824), (98,6666666667, 0,400), (99,8274509804, 0,402352941				

	6), (100,988235294 , 0,404705882353), (102,149019608 , 0,407058823529), (103,309803922 , 0,409411764706), (104,470588235 , 0,411764705882), (105,631372549 , 0,414117647059), (106,792156863 , 0,416470588235), (107,952941176 , 0,418823529412), (109,11372549, 0,421176470588), (110,274509804 , 0,423529411765), (111,435294118 , 0,425882352941), (112,596078431 , 0,428235294118), (113,756862745 , 0,430588235294), (114,917647059 ,				

	0,432941176471), (116,078431373, 0,435294117647), (117,239215686, 0,437647058824), (118,4, 0,440), (119,560784314, 0,442352941176), (120,721568627, 0,444705882353), (121,882352941, 0,447058823529), (123,043137255, 0,449411764706), (124,203921569, 0,451764705882), (125,364705882, 0,454117647059), (126,525490196, 0,456470588235), (127,68627451, 0,458823529412), (128,847058824, 0,461176470588), (130,007843137, 0,463529411765),				

	(131,168627451, 0,465882352941), (132,329411765, 0,468235294118), (133,490196078, 0,470588235294), (134,650980392, 0,472941176471), (135,811764706, 0,475294117647), (136,97254902, 0,477647058824), (138,133333333, 0,480), (139,294117647, 0,482352941176), (140,454901961, 0,484705882353), (141,615686275, 0,487058823529), (142,776470588, 0,489411764706), (143,937254902, 0,491764705882), (145,098039216, 0,494117647059), (146,258823529				

	, 0,496470588235), (147,419607843, 0,498823529412), (148,580392157, 0,501176470588), (149,741176471, 0,503529411765), (150,901960784, 0,505882352941), (152,062745098, 0,508235294118), (153,223529412, 0,510588235294), (154,384313725, 0,512941176471), (155,545098039, 0,515294117647), (156,705882353, 0,517647058824), (157,866666667, 0,520), (159,02745098, 0,522352941176), (160,188235294, 0,524705882353), (161,349019608,				

	0,527058823529), (162,509803922, 0,529411764706), (163,670588235, 0,531764705882), (164,831372549, 0,534117647059), (165,992156863, 0,536470588235), (167,152941176, 0,538823529412), (168,31372549, 0,541176470588), (169,474509804, 0,543529411765), (170,635294118, 0,545882352941), (171,796078431, 0,548235294118), (172,956862745, 0,550588235294), (174,117647059, 0,552941176471), (175,278431373, 0,555294117647), (176,439215686				

	, 0,557647058824), (177,6, 0,560), (178,760784314, 0,562352941176), (179,921568627, 0,564705882353), (181,082352941, 0,567058823529), (182,243137255, 0,569411764706), (183,403921569, 0,571764705882), (184,564705882, 0,574117647059), (185,725490196, 0,576470588235), (186,88627451, 0,578823529412), (188,047058824, 0,581176470588), (189,207843137, 0,583529411765), (190,368627451, 0,585882352941), (191,529411765, 0,588235294117				

	8), (192,690196078 , 0,590588235294), (193,850980392 , 0,592941176471), (195,011764706 , 0,595294117647), (196,17254902, 0,597647058824), (197,333333333 , 0,600), (198,494117647 , 0,602352941176), (199,654901961 , 0,604705882353), (200,815686275 , 0,607058823529), (201,976470588 , 0,609411764706), (203,137254902 , 0,611764705882), (204,298039216 , 0,614117647059), (205,458823529 , 0,616470588235), (206,619607843 , 0,618823529412),				

	(207,780392157, 0,621176470588), (208,941176471, 0,623529411765), (210,101960784, 0,625882352941), (211,262745098, 0,628235294118), (212,423529412, 0,630588235294), (213,584313725, 0,632941176471), (214,745098039, 0,635294117647), (215,905882353, 0,637647058824), (217,066666667, 0,640), (218,22745098, 0,642352941176), (219,388235294, 0,644705882353), (220,549019608, 0,647058823529), (221,709803922, 0,649411764706), (222,870588235				

	, 0,651764705882), (224,031372549, 0,654117647059), (225,192156863, 0,656470588235), (226,352941176, 0,658823529412), (227,51372549, 0,661176470588), (228,674509804, 0,663529411765), (229,835294118, 0,665882352941), (230,996078431, 0,668235294118), (232,156862745, 0,670588235294), (233,317647059, 0,672941176471), (234,478431373, 0,675294117647), (235,639215686, 0,677647058824), (236,8, 0,680), (237,960784314, 0,682352941				

	6), (239,121568627 , 0,684705882353), (240,282352941 , 0,687058823529), (241,443137255 , 0,689411764706), (242,603921569 , 0,691764705882), (243,764705882 , 0,694117647059), (244,925490196 , 0,696470588235), (246,08627451, 0,698823529412), (247,247058824 , 0,701176470588), (248,407843137 , 0,703529411765), (249,568627451 , 0,705882352941), (250,729411765 , 0,708235294118), (251,890196078 , 0,710588235294), (253,050980392 ,				

	0,712941176471), (254,211764706, 0,715294117647), (255,37254902, 0,717647058824), (256,533333333, 0,720), (257,694117647, 0,722352941176), (258,854901961, 0,724705882353), (260,015686275, 0,727058823529), (261,176470588, 0,729411764706), (262,337254902, 0,731764705882), (263,498039216, 0,734117647059), (264,658823529, 0,736470588235), (265,819607843, 0,738823529412), (266,980392157, 0,741176470588), (268,141176471, 0,74352941176				

	5), (269,301960784, 0,745882352941), (270,462745098, 0,748235294118), (271,623529412, 0,750588235294), (272,784313725, 0,752941176471), (273,945098039, 0,755294117647), (275,105882353, 0,757647058824), (276,266666667, 0,760), (277,42745098, 0,762352941176), (278,588235294, 0,764705882353), (279,749019608, 0,767058823529), (280,909803922, 0,769411764706), (282,070588235, 0,771764705882), (283,231372549, 0,774117647059),				

	(284,392156863,0,776470588235), (285,552941176,0,778823529412), (286,71372549,0,781176470588), (287,874509804,0,783529411765), (289,035294118,0,785882352941), (290,196078431,0,788235294118), (291,356862745,0,790588235294), (292,517647059,0,792941176471), (293,678431373,0,795294117647), (294,839215686,0,797647058824), (296,0,0,800)				
Green_KPI	(1-DieselGate_Scandal_Arising)* Effectiveness_of_IQD_in_case_of_GKPI/ GKPI_Reference		dmnl		

Halo_Effect_of_EFG	1		dmnl		
Halo_Effect_of_EFL	1,2 {Halo Effect: Behavioral Finance Book, P 132}		dmnl		
Highest_Value_of_GEI_in_the_Industry	0,3		dmnl		
Historical_Reference_Goodwill_Effect	Initial_NTA/(Initial_Stock_Price_at_2011_1st_Week*Number_of_Pubic_Shares)		dmnl		
Historical_Stock_Price_Data	GRAPH(TIME) Points: (0,0, 127,8), (1,00350877193, 125,8), (2,00701754386, 114,0), (3,01052631579, 120,4), (4,01403508772, 115,3), (5,01754385965, 128,2), (6,02105263158, 119,7), (7,02456140351, 119,4), (8,02807017544, 117,1), (9,03157894737, 114,3), (10,0350877193, 108,7), (11,0385964912, 113,1), (12,0421052632, 115,9), (13,0456140351, 112,0), (14,049122807, 112,7),		euro/share		

	(15,0526315789, 118,6), (16,0561403509, 133,0), (17,0596491228, 130,4), (18,0631578947, 128,4), (19,0666666667, 124,9), (20,0701754386, 124,4), (21,0736842105, 122,8), (22,0771929825, 125,6), (23,0807017544, 130,3), (24,0842105263, 134,9), (25,0877192982, 142,8), (26,0912280702, 148,6), (27,0947368421, 151,0), (28,098245614, 148,8), (29,101754386, 139,4), (30,1052631579, 115,9), (31,1087719298, 119,3), (32,1122807018, 104,6), (33,1157894737, 109,2), (34,1192982456, 109,2), (35,1228070175, 103,8), (36,1263157895, 115,0), (37,1298245614, 103,8), (38,1333333333, 100,1), (39,1368421053, 101,6),				

	(40,1403508772, 114,3), (41,1438596491, 117,4), (42,1473684211, 132,5), (43,150877193, 125,3), (44,1543859649, 130,6), (45,1578947368, 122,3), (46,1614035088, 112,1), (47,1649122807, 128,6), (48,1684210526, 124,7), (49,1719298246, 115,3), (50,1754385965, 117,9), (51,1789473684, 115,8), (52,1824561404, 124,0), (53,1859649123, 126,0), (54,1894736842, 134,5), (55,1929824561, 136,4), (56,1964912281, 142,2), (57,2, 140,7), (58,2035087719, 142,5), (59,2070175439, 139,3), (60,2105263158, 143,9), (61,2140350877, 142,8), (62,2175438596, 141,3), (63,2210526316, 132,4), (64,2245614035, 131,9), (65,2280701754				

	, 128,9), (66,2315789474 , 128,8), (67,2350877193 , 125,4), (68,2385964912 , 141,9), (69,2421052632 , 139,9), (70,2456140351 , 137,4), (71,249122807, 128,2), (72,2526315789 , 128,4), (73,2561403509 , 123,8), (74,2596491228 , 121,8), (75,2631578947 , 123,7), (76,2666666667 , 121,2), (77,2701754386 , 124,6), (78,2736842105 , 130,9), (79,2771929825 , 137,1), (80,2807017544 , 137,6), (81,2842105263 , 134,1), (82,2877192982 , 141,7), (83,2912280702 , 147,9), (84,2947368421 , 146,4), (85,298245614, 142,6), (86,301754386, 140,4), (87,3052631579 , 141,3), (88,3087719298 , 152,5), (89,3122807018 , 155,1), (90,3157894737				

	, 141,9), (91,3192982456, 148,6), (92,3228070175, 146,6), (93,3263157895, 149,9), (94,3298245614, 154,4), (95,3333333333, 163,6), (96,3368421053, 154,5), (97,3403508772, 151,3), (98,3438596491, 162,3), (99,3473684211, 166,4), (100,350877193, 166,5), (101,354385965, 170,6), (102,357894737, 171,0), (103,361403509, 172,1), (104,364912281, 178,9), (105,368421053, 176,1), (106,371929825, 177,9), (107,375438596, 184,6), (108,378947368, 186,6), (109,38245614, 180,6), (110,385964912, 177,0), (111,389473684, 163,8), (112,392982456, 164,1), (113,396491228, 169,8), (114,4, 160,3), (115,403508772, 156,6),				

	(116,407017544, 155,0), (117,410526316, 154,4), (118,414035088, 147,8), (119,41754386, 141,0), (120,421052632, 148,1), (121,424561404, 158,0), (122,428070175, 157,6), (123,431578947, 168,4), (124,435087719, 166,6), (125,438596491, 168,9), (126,442105263, 166,3), (127,445614035, 159,1), (128,449122807, 149,9), (129,452631579, 155,6), (130,456140351, 157,3), (131,459649123, 167,4), (132,463157895, 172,0), (133,466666667, 172,3), (134,470175439, 182,8), (135,473684211, 183,3), (136,477192982, 183,4), (137,480701754, 181,6), (138,484210526, 172,1), (139,487719298, 171,8), (140,49122807, 181,9),				

	(141,494736842, 173,3), (142,498245614, 174,6), (143,501754386, 168,1), (144,505263158, 175,2), (145,50877193, 176,5), (146,512280702, 176,5), (147,515789474, 188,4), (148,519298246, 192,4), (149,522807018, 194,5), (150,526315789, 194,7), (151,529824561, 195,3), (152,533333333, 193,4), (153,536842105, 189,9), (154,540350877, 199,3), (155,543859649, 204,0), (156,547368421, 200,5), (157,550877193, 202,1), (158,554385965, 203,4), (159,557894737, 193,3), (160,561403509, 188,1), (161,564912281, 187,9), (162,568421053, 202,1), (163,571929825, 201,0), (164,575438596, 189,0), (165,578947368, 183,6),				

	(166,58245614, 177,8), (167,585964912, 179,9), (168,589473684, 188,6), (169,592982456, 191,7), (170,596491228, 194,4), (171,6, 195,8), (172,603508772, 193,2), (173,607017544, 190,8), (174,610526316, 190,8), (175,614035088, 188,1), (176,61754386, 192,9), (177,621052632, 195,0), (178,624561404, 196,9), (179,628070175, 196,4), (180,631578947, 196,9), (181,635087719, 191,0), (182,638596491, 191,9), (183,642105263, 185,4), (184,645614035, 183,5), (185,649122807, 180,0), (186,652631579, 173,1), (187,656140351, 165,5), (188,659649123, 165,5), (189,663157895, 172,1), (190,666666667, 170,9), (191,670175439				

	, 179,4), (192,673684211, 175,5), (193,677192982, 176,3), (194,680701754, 166,3), (195,684210526, 157,6), (196,687719298, 150,9), (197,69122807, 160,0), (198,694736842, 160,4), (199,698245614, 170,1), (200,701754386, 171,1), (201,705263158, 169,9), (202,70877193, 177,9), (203,712280702, 185,2), (204,715789474, 188,1), (205,719298246, 181,6), (206,722807018, 185,3), (207,726315789, 187,1), (208,729824561, 182,5), (209,733333333, 180,9), (210,736842105, 191,8), (211,740350877, 203,8), (212,743859649, 198,3), (213,747368421, 214,3), (214,750877193, 212,6), (215,754385965, 225,0), (216,757894737				

	, 225,5), (217,761403509, 229,9), (218,764912281, 247,8), (219,768421053, 250,1), (220,771929825, 244,6), (221,775438596, 243,8), (222,778947368, 253,2), (223,78245614, 235,0), (224,785964912, 233,1), (225,789473684, 231,4), (226,792982456, 232,0), (227,796491228, 215,7), (228,8, 229,9), (229,803508772, 221,0), (230,807017544, 213,9), (231,810526316, 213,4), (232,814035088, 210,0), (233,81754386, 219,4), (234,821052632, 212,7), (235,824561404, 205,8), (236,828070175, 200,0), (237,831578947, 189,8), (238,835087719, 182,4), (239,838596491, 189,1), (240,842105263, 178,9), (241,845614035, 166,9),				

	(242,849122807, 171,4), (243,852631579, 162,2), (244,856140351, 167,9), (245,859649123, 162,4), (246,863157895, 107,3), (247,866666667, 92,4), (248,870175439, 106,6), (249,873684211, 100,6), (250,877192982, 107,7), (251,880701754, 109,3), (252,884210526, 97,2), (253,887719298, 96,3), (254,89122807, 108,4), (255,894736842, 123,8), (256,898245614, 126,9), (257,901754386, 128,6), (258,905263158, 130,0), (259,90877193, 135,1), (260,912280702, 133,8), (261,915789474, 115,1), (262,919298246, 111,9), (263,922807018, 112,9), (264,926315789, 106,9), (265,929824561, 103,2), (266,933333333, 95,2),				

	(267,936842105, 102,1), (268,940350877, 103,6), (269,943859649, 121,0), (270,947368421, 113,7), (271,950877193, 116,5), (272,954385965, 114,8), (273,957894737, 107,7), (274,961403509, 103,9), (275,964912281, 109,7), (276,968421053, 125,4), (277,971929825, 126,4), (278,975438596, 121,8), (279,978947368, 129,2), (280,98245614, 129,6), (281,985964912, 135,6), (282,989473684, 130,2), (283,992982456, 125,4), (284,996491228, 118,8), (286,0, 114,3)				
Initial_AFA	1		dmnl		
Initial_BID	1		dmnl		
Initial_IQDI	1		dmnl		
Initial_NTA	22,194*10^9 {22,194 Billion Dollar at 2011}		euro		
Initial_Stock_Price_at_	HISTORY(Historical_Stoc		euro/share		

2011_1st_Week	k_Price_Data;TIME=1)				
Innovation_Quality_and_Differentiation_Image	(The_Effect_of_Scandals_on_IQDI)* SMTH1(Relative_IQDI; Time_to_adopt_IQDI; Initial_IQDI)		dmnl		DELAY CONVERTER
"IQDI_-_Correlation_time"	1		week		
"IQDI_-_Mean_variable"	1		dmnl		
"IQDI_-_Noise_seed"	1		dmnl		
"IQDI_-_Standard_deviation"	0,05		dmnl		
"IQDI_-_White_noise"	"IQDI_-_Mean_variable" + "IQDI_-_Standard_deviation" * (24*("IQDI_-_Correlation_time")/DT)^0,5 * UNIFORM(-1 ; 1 ; "IQDI_-_Noise_seed")		dmnl		
Long_Term_Growth_of_Branding_Image	GRAPH(Innovation_Quality_and_Differentiation_Image) Points: (1,0000, 0,00005), (1,0500, 0,00006), (1,1000, 0,00007), (1,1500, 0,00008), (1,2000,		dmnl		

	0,00009), (1,2500, 0,0001), (1,3000, 0,00011), (1,3500, 0,00012), (1,4000, 0,00013), (1,4500, 0,00014), (1,5000, 0,00015)				
Long_Term_Growth_of_IQDI	SMTH1 ((Adopted_GGA_by_the_company); Response_Time_to_GGA)		dmnl		DELAY CONVERTER
Market_Size	Number_of_Public_Shares* Perceived_Stock_Price		euro	https://www.fool.ca/investing/what-is-market-cap/#:~:text=Market%20cap%20is%20the%20total%20value%20of%20a,to%20buy%20every%20share%20in%20a%20company%E2%80%99s%20stock. https://companiesmarketcap.com/volkswagen/marketcap/ start at 2011.01.01: 68,9 B $	
Neutral_EFG	1		dmnl		
Neutral_EFL	1		dmnl		
New_Info_on_BID	((Initial_BID+ (RAMP(Long_Term_Growth_of_Branding_Image)* "Brand_Image_		dmnl		

	Development_-_Pink_Noise")/DT))* The_effect_of_Scandal_on_Brand_Image				
New_Info_on_EFG	GRAPH(Innovation_Quality_and_Differentiation_Image {RANDOM(1, 1.3)+ STEP (0.8, 90)+ STEP (0.8, 210)}) Points: (0,9000, 0,9000), (0,9600, 0,9600), (1,0200, 1,0200), (1,0800, 1,0800), (1,1400, 1,1400), (1,2000, 1,2000), (1,2600, 1,2600), (1,3200, 1,3200), (1,3800, 1,3800), (1,4400, 1,4400), (1,5000, 1,5000)		dmnl		
New_Info_on_EFL	"Expected_Future_Loss_-_Pink_Noise" * The_Effect_of_Scandal_as_a_News		dmnl		
"Non_Tangible_Asset,_History"	GRAPH(TIME { The graphical data of NTA history can be seen in Graphical Function		euro		

	section. Numbers are in Billion $ }) Points: (0,0, 17,4), (1,0, 17,4), (2,0, 17,7), (3,0, 17,9), (4,0, 18,2), (5,0, 18,5), (6,0, 18,8), (7,0, 19,0), (8,0, 19,3), (9,0, 19,6), (10,0, 19,8), (11,0, 20,1), (12,0, 20,4), (13,0, 20,6), (14,0, 20,9), (15,0, 21,2), (16,0, 21,5), (17,0, 21,7), (18,0, 22,0), (19,0, 22,3), (20,0, 22,5), (21,0, 22,8), (22,0, 23,1), (23,0, 23,4), (24,0, 23,6), (25,0, 23,9), (26,0, 24,2), (27,0, 24,4), (28,0, 24,7), (29,0, 25,0), (30,0, 25,2), (31,0, 25,5), (32,0, 25,8), (33,0, 26,1), (34,0, 26,3), (35,0, 26,6), (36,0, 26,9), (37,0, 27,1), (38,0, 27,4), (39,0, 27,7), (40,0, 28,0), (41,0, 28,2), (42,0, 28,5), (43,0, 28,8), (44,0, 29,0), (45,0, 29,3), (46,0,				

	29,6), (47,0, 29,8), (48,0, 30,1), (49,0, 30,4), (50,0, 30,7), (51,0, 30,9), (52,0, 31,2), (53,0, 32,3), (54,0, 33,4), (55,0, 34,6), (56,0, 35,7), (57,0, 36,8), (58,0, 37,9), (59,0, 39,0), (60,0, 40,2), (61,0, 41,3), (62,0, 42,4), (63,0, 43,5), (64,0, 44,6), (65,0, 45,8), (66,0, 46,9), (67,0, 48,0), (68,0, 49,1), (69,0, 50,2), (70,0, 51,4), (71,0, 52,5), (72,0, 53,6), (73,0, 54,7), (74,0, 55,8), (75,0, 57,0), (76,0, 58,1), (77,0, 59,2), (78,0, 60,3), (79,0, 61,4), (80,0, 62,6), (81,0, 63,7), (82,0, 64,8), (83,0, 65,9), (84,0, 67,0), (85,0, 68,2), (86,0, 69,3), (87,0, 70,4), (88,0, 71,5), (89,0, 72,6), (90,0, 73,8), (91,0, 74,9), (92,0, 76,0), (93,0, 77,1), (94,0, 78,1), (95,0, 78,1), (96,0,				

	78,1), (97,0, 78,1), (98,0, 78,1), (99,0, 78,1), (100,0, 78,1), (101,0, 78,1), (102,0, 78,1), (103,0, 78,1), (104,0, 78,1), (105,0, 78,1), (106,0, 78,1), (107,0, 78,1), (108,0, 78,1), (109,0, 78,1), (110,0, 78,1), (111,0, 78,1), (112,0, 78,1), (113,0, 78,1), (114,0, 78,1), (115,0, 78,1), (116,0, 78,1), (117,0, 78,1), (118,0, 78,1), (119,0, 78,1), (120,0, 78,1), (121,0, 78,1), (122,0, 78,1), (123,0, 78,1), (124,0, 78,1), (125,0, 78,1), (126,0, 78,1), (127,0, 78,1), (128,0, 78,1), (129,0, 78,1), (130,0, 78,1), (131,0, 78,1), (132,0, 78,1), (133,0, 78,1), (134,0, 78,1), (135,0, 78,1), (136,0, 78,1), (137,0, 78,1), (138,0, 78,1), (139,0, 78,1), (140,0, 78,1), (141,0, 78,1), (142,0, 78,1), (143,0, 78,1), (144,0, 78,1), (145,0, 78,1), (146,0,				

	78,1), (147,0, 78,1), (148,0, 78,1), (149,0, 78,1), (150,0, 78,1), (151,0, 78,1), (152,0, 78,1), (153,0, 78,1), (154,0, 78,1), (155,0, 78,1), (156,0, 78,1), (157,0, 78,1), (158,0, 78,1), (159,0, 78,1), (160,0, 78,1), (161,0, 78,1), (162,0, 78,1), (163,0, 78,1), (164,0, 78,1), (165,0, 78,1), (166,0, 78,1), (167,0, 78,1), (168,0, 78,1), (169,0, 78,1), (170,0, 78,1), (171,0, 78,1), (172,0, 78,1), (173,0, 78,1), (174,0, 78,1), (175,0, 78,1), (176,0, 78,1), (177,0, 78,1), (178,0, 78,1), (179,0, 78,1), (180,0, 78,1), (181,0, 78,1), (182,0, 78,1), (183,0, 78,1), (184,0, 78,1), (185,0, 78,1), (186,0, 78,1), (187,0, 78,1), (188,0, 78,1), (189,0, 78,1), (190,0, 78,1), (191,0, 78,1), (192,0, 78,1), (193,0, 78,1), (194,0, 78,1), (195,0, 78,1), (196,0,				

	78,1), (197,0, 78,1), (198,0, 78,1), (199,0, 78,1), (200,0, 78,1), (201,0, 78,1), (202,0, 78,1), (203,0, 78,1), (204,0, 78,1), (205,0, 78,1), (206,0, 78,1), (207,0, 78,1), (208,0, 78,1), (209,0, 78,0), (210,0, 77,9), (211,0, 77,8), (212,0, 77,7), (213,0, 77,6), (214,0, 77,5), (215,0, 77,4), (216,0, 77,3), (217,0, 77,2), (218,0, 77,1), (219,0, 77,0), (220,0, 76,9), (221,0, 76,8), (222,0, 76,7), (223,0, 76,6), (224,0, 76,5), (225,0, 76,4), (226,0, 76,3), (227,0, 76,2), (228,0, 76,1), (229,0, 76,0), (230,0, 75,9), (231,0, 75,8), (232,0, 75,7), (233,0, 75,6), (234,0, 75,5), (235,0, 75,4), (236,0, 75,3), (237,0, 75,2), (238,0, 75,1), (239,0, 75,0), (240,0, 74,9), (241,0, 74,8), (242,0, 74,7), (243,0, 74,6), (244,0, 74,5), (245,0, 74,4), (246,0,				

	74,3), (247,0, 74,2), (248,0, 74,1), (249,0, 74,0), (250,0, 73,9), (251,0, 73,8), (252,0, 73,7), (253,0, 73,6), (254,0, 73,5), (255,0, 73,4), (256,0, 73,3), (257,0, 73,2), (258,0, 73,1), (259,0, 73,0), (260,0, 72,9), (261,0, 72,8), (262,0, 72,7), (263,0, 72,6), (264,0, 72,5), (265,0, 72,4), (266,0, 72,3), (267,0, 72,2), (268,0, 72,1), (269,0, 72,0), (270,0, 71,9), (271,0, 71,8), (272,0, 71,7), (273,0, 71,6), (274,0, 71,5), (275,0, 71,4), (276,0, 71,3), (277,0, 71,2), (278,0, 71,1), (279,0, 71,0), (280,0, 70,9), (281,0, 70,8), (282,0, 70,7), (283,0, 70,6), (284,0, 70,5), (285,0, 70,4), (286,0, 70,3)				
Number_of_Pubic_Shares	539*10^6 {539 Million shares on market}		share	https://companiesmarketcap.com/volkswagen/marketcap/ https://www.fool.ca/investing/what-is-market-cap/#:~:text=Market%20cap%20is%20the%20total%20value%20of%20a,to%20buy%20ev	

				ery%20share%20in%20a%20company%E2%80%99s%20stock.	
Relative_IQDI	Initial_IQDI+ 1/DT*(RAMP(Long_Term_Growth_of_IQDI)) * "Innovation_Quality_and_Differentiation_Image_-_Pink_Noise"		dmnl		
Response_Time_to_GGA	24		week		
"SPPN_-_Correlation_time"	4		week		
"SPPN_-_Mean_variable"	1		dmnl		
"SPPN_-_Noise_seed"	1		dmnl		
"SPPN_-_Standard_deviation"	0,02		dmnl		
"SPPN_-_White_noise"	"SPPN_-_Mean_variable" + "SPPN_-_Standard_deviation" * (24*("SPPN_-_Correlation_time")/DT)^0,5 * UNIFORM(-1 ; 1 ; "SPPN_-_Noise_seed")		dmnl		
The_Effect_of_Scandal_as_a_News	GRAPH((DieselGate_Scandal_Arising^ Elasticity_of_News_to_the_Scandal) -1) Points: (0,000, 0,99732285963)		dmnl		

	, (0,100, 0,992805516015), (0,200, 0,981029650729), (0,300, 0,952318831191), (0,400, 0,892423431452), (0,500, 0,8000), (0,600, 0,707576568548), (0,700, 0,647681168809), (0,800, 0,618970349271), (0,900, 0,607194483985), (1,000, 0,60267714037)				
The_effect_of_Scandal_on_Brand_Image	GRAPH((Diesel Gate_Scandal_ Arising^ Elasticity_of_Branding_to_the_Scandal) - 1) Points: (0,000, 0,99732285963), (0,100, 0,992805516015), (0,200, 0,981029650729), (0,300, 0,952318831191), (0,400, 0,892423431452), (0,500, 0,8000), (0,600, 0,707576568548), (0,700, 0,647681168809), (0,800, 0,618970349271), (0,900, 0,607194483985), (1,000, 0,60267714037)		dmnl		
The_Effect_of_Scandals_on_IQDI	GRAPH((Diesel Gate_Scandal_ Arising^		dmnl		

	Elasticity_of_IQDI_to_the_Scandal) - 1 {Because it was against the R&D achievement, The Highest Effect on VW }) Points: (0,000, 1,0000), (0,100, 0,9800), (0,200, 0,9600), (0,300, 0,9400), (0,400, 0,9200), (0,500, 0,9000), (0,600, 0,8800), (0,700, 0,8600), (0,800, 0,8400), (0,900, 0,8200), (1,000, 0,8000)				
Time_to_Adjustment_AFA	1		week		
Time_to_adopt_IQDI	1		week		
Time_to_BID_Adjustment	1		week		
Time_to_GEI_adjustment	1		week		
Time_to_Updating_EFG	1		week		
Time_to_Updating_EFL	1		week		
Time_to_Updating_of_Stock_Price	1		week		

Total	Count	Including Array Elements
Variables	97	97

Sectors	5	
Stocks	9	9
Flows	9	9
Converters	79	79
Constants	42	42
Equations	46	46
Graphicals	12	12
Macro Variables	20	

Run Specs	
Start Time	0
Stop Time	286
DT	1/5
Fractional DT	True
Save Interval	0,2
Sim Duration	1
Time Units	Weeks
Pause Interval	0
Integration Method	Euler
Keep all variable results	True
Run By	Run
Calculate loop dominance information	True
Exhaustive Search Threshold	1000