

Gaps in Measurements of the Costs of Quality: Revisiting the Volkswagen Emission Scandal After Seven Years

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This study examines the costs associated with Volkswagen's diesel emission cheating scandal. This study views the incident as a failure in quality, thus, the costs borne by VW are the costs of quality (COQ). So far, different estimates of the COQ have been suggested at different times because of the contingent nature of the litigations. As most of the pending litigations faced by VW have been resolved over the past seven years, this study revisits the scandal to evaluate the gap between two contrasting approaches, accounting-based and market-based. The cumulative COQ derived from VW financial reports varies between \$31.5 billion and \$44.8 billion by the end of 2021. However, these figures are below what was reflected in the market, \$60.0 billion, when VW settled most litigations in the U.S. This study confirms a large gap, ranging from \$15.2 billion to \$28.5 billion, between the two measures. This study concludes the gap is likely to be associated with the opportunity costs arising from the scandal, which are ignored in financial reporting.

Keywords: cost of quality (COQ), Volkswagen scandal, market-based estimation

INTRODUCTION

The primary objective of this study is to measure and compare the costs of quality failures (COQ) derived from two distinctive approaches: accounting-based and market-based. This study explores the COQ associated with the Volkswagen (VW) diesel emission scandal. This study views the costs borne by VW from its failure to meet the quality requirement (or emission level) imposed by the EPA as COQ. More specifically, they are “external failure costs” among four distinctive types of quality costs, i.e., prevention, appraisal, and internal and external failure, identified in the extant literature (Carnerud, 2018; Juran, 1967; & van Kemenade & Hardjono, 2019).

While the accounting-based model has widely been used to measure the COQ, the market-based approach has also been used as an alternative measure to approximate the COQ. VW reported the costs as “expenses” based on IFRS in its annual reports, but one significant methodological weakness embedded in the conventional accounting-based model is that it is likely to underestimate the true costs of the scandal. Like other companies, VW counted cash outlays resulting from the incident under the current financial reporting standards, thus, all the visible costs associated with the incident are counted in its financial reporting, but not the invisible costs such as opportunity costs associated with the scandal.

One issue related to the measurement of the COQ is how to view such opportunity costs arising from the scandal, which are not counted as expenses in the financial reports. Such opportunity costs were absent from the financial reporting. Examples of the hidden costs recognized in the extant literature are the loss in sales and market share (Chiadamrong, 2003; Krishnan, 2006; Schiffauerova & Thompson, 2006) due to the sales ban imposed by multiple countries after the breakout of the scandal and the damage to the VW brand and its reputation (Freeman, Kearney, & Lederman, 2012; Rhee & Haunshild, 2006). For instance, VW was not allowed to sell its new diesel models and its 2.0-liter diesel vehicles until the company got a final approval in January 2017. Such loss in sales due to the ban were reflected in VW's income statement as a reduction of sales, but it was not counted as a diesel-related expense in the financial statements.

The focus of this study is to determine the magnitude of the gap between two measures and to identify plausible reasons to explain the gap. This study first estimates the COQ based on the accounting model that is believed to capture the visible costs that arose from the scandal. For comparison, this study also approximates the COQ based on the market-based model that is believed to capture the hidden costs omitted by the accounting-based approach. The market-based model generally assumes that given the semi-strong and strong-form of information efficiency in the U.S. financial markets that all the information relevant to the valuation, including a new set of information available in the market, will be immediately reflected in the valuation process. Therefore, any changes that occurs in the company's market capitalization surrounding a specific corporate event represent the net effects of the event on the future free cash flows and their corresponding discount rate. This study conjectures that the changes in market capitalization (loss in the VW case) along the diesel emission scandal is the COQ borne by the company.

BRIEF HISTORY OF THE VW'S DIESEL EMISSION SCANDAL

VW developed its diesel engine in 2006 hoping that its diesel engines would meet stricter U.S. emissions standards. Selling its diesel vehicles was an important strategic goal and its new engine was the cornerstone of a new initiative to market themselves as "clean diesel" to customers in the U.S. However, suspicions on the accuracy of the emission levels of various diesel engines manufactured by multiple automobile companies began in April 2012. In fact, a report from the International Council on Clean Transportation (ICCT) unveiled that the actual fuel consumption of vehicles across Europe was about 25% higher than written on the sales sticker (ICCT 2012). Table 1 lists key events along the developments of the VW's diesel scandal in the U.S., and other countries over 2012-2021 period.

The emission cheating associated with VW diesel engines was highlighted with another ICCT report in May 2014 (ICCT 2014). It revealed that VW's diesel cars emit far more nitrogen oxide than allowed. VW initially denied the results from this report and formed a task force to investigate the emissions of its diesel cars. In December 2014, VW offered a voluntary recall of about 500,000 vehicles in the US, but the CARB performed follow up tests that found that the repairs were insufficient.

In August 2015, the US Environmental Protection Agency (EPA) announced that it would not certify VW's 2016 diesel cars until the company explained the discrepancies. In September 2015, the EPA made a public notice of the violation of the Clean Air Act (CAA) against VW on its 2.0-liter diesel cars, alleging that VW illegally installed a cheating device to bypass emission tests (EPA, 2015). The EPA made another public notice of violation against VW on its 3.0-liter diesel cars and SUVs sold worldwide in November 2015.

The scandal brought about multiple litigations in the US and other countries. In January 2016, the Department of Justice (DoJ) filed a civil complaint on behalf of the EPA for alleged violations of the CAA (DoJ, 2016a). In March 2016, the Federal Trade Commission (FTC) also filed civil complaints for false advertising (FTC, 2016a). In June 2016, FTC announced that VW spent 14.7 billion to settle allegations of cheating emissions tests and deceiving customer on its 2-liter vehicles (FTC, 2016b). In December 2016, VW admitted that there had been manipulations of diesel emission tests on its 3-liter vehicles (DoJ, 2016b). Consequently, VW recalled a total of 11 million diesel cars sold worldwide, including 482,000 2-liter vehicles (FTC, 2016b) and 83,000 3-liter vehicles sold in the U.S. This figure exceeds Toyota's recall of

10 million cars in 2009 due to problem with their accelerator (Jensen & Tabuchi, 2014), thus, making it the largest in history by a single automobile company.

TABLE 1
KEY DATES OF VW EMISSION SCANDAL IN U.S.: 2012-2021

Date	Key Events of the Emission Scandal
Pre-Scandal Period: 4/4/2012 ~ 4/30/2014	
4/4/2012	ICCT report on discrepancy between type-approval and real consumption.
4/30/2014	The EPA and CARB received ICCT study about showing that VW diesel emissions.
Period 1 (ICCT report, VW's internal prove, DoJ lawsuits): 5/201/2014 ~ 9/17/2015	
5/30/2014	ICCT reported in-use emissions testing results of light-duty diesel cars in the U.S.
10/13/2014	ICCT reported real-world exhaust emissions from modern diesel cars.
12/1/2014	VW met with the CARB and began a recall of about 500,000 vehicles in the U.S.
1/12/2015	DoJ, on behalf of EPA/CBP filed lawsuits against VW for civic for CAA violation.
Period 2 (EPA public notice on 2-liter cars, DoJ lawsuits): 9/18/2015 ~ 12/31/2015	
9/18/2015	EPA issued a public notice of violation, alleging recall 482,000 2-liter diesel cars in the U.S.
9/23/2015	Class-action lawsuits were filed, and criminal investigations launched by DoJ.
10/2/2015	Investors from 14 countries filed a lawsuit in Germany over fraudulent reporting.
10/8/2015	VW's top U.S. executive testified before Congress. He apologizes for the scandal.
Period 3 (Litigations & EPA Settlements in U.S.): 1/1/2016 ~ 6/28/2016	
1/4/2016	DoJ sued VW for CAA violations over cheating devices in nearly 600,000 diesel cars.
2/8/2016	VW plans to make U.S. diesel owners a compensation offer.
2/24/2016	Civil class action was filed against VW for fraud in marketing its diesel cars in the U.S.
6/28/2016	VW settlements: \$10 billion field activities, \$2.7 billion environmental, and \$2 billion technology.
Period 4 (Other Settlements in the U.S.): 6/29/2016 ~ 12/31/2016	
8/26/2016	VW agreed to pay \$1.2 billion to its dealers for loss in franchise value.
9/1/2016	3.0-liter vehicles settlements - CA unfair competition, environmental mitigation, and injunctive relief.
10/25/2016	DoJ approved final fix of 2.0-liter diesel vehicles and settlements of \$14.7 billion with VW.
12/20/2016	VW agreed to pay 1.2 billion euros to the US owners of its 3.0-liter diesel vehicles.
Period 5 (Litigations and Settlements in other Countries): 1/1/2017 ~ 12/31/2021	
4/27/2017	Civil settlements of \$2.1 billion in Canada.
2/27/2018	Court ruling opens door for diesel bans in German cities.
6/13/2018	VW is fined 1.0 billion euros by German prosecutors over the diesel emissions cheating scandal.
9/10/2018	VW investors sue VW for 9.2 billion euro (or \$10.7 billion) over diesel scandal.
4/5/2019	EC officially accuses carmakers VW, BMW, and Daimler of illegal collusion.
5/27/2019	Auto parts supplier Bosch is ordered to pay a 90 million euro fine for negligence.
9/30/2019	Mass lawsuit opens in Germany with the first hearing over emission test cheating against VW.
2/28/2020	Civil settlements of \$912 million in Germany.
4/20/2020	VW agreed to pay out a total of 620 million euros to settle with all participants of in the class action.
5/25/2020	German Federal Court ruled that VW car owners are entitled to damages in the scandal.

The turning point of the litigations, however, was the 'guilty plea' where VW's engineers admitted to the installation of a cheat device to bypass the emission tests in September 2016 (Tabuchi & Ewing, 2016). In January 2017, VW also pleaded guilty to conspiracy and obstruction of justice. The VW's emission

scandal concluded with their modification plan to fix the affected vehicles still owned by the public or repurchased by the company in early January of 2017. In January, VW agreed to pay \$2.8 billion criminal fines in guilty plea and \$1.6 billion in the civil settlements (DoJ, 2017).

Settlements with the ‘guilty plea’ in the U.S. court triggered another round of legal battles in other countries around the world, including Germany and Canada to name a few (Jolly, 2019). Table 1 lists key dates of the litigations and settlements in the U.S. and other countries, including Germany, Canada, and EU. According to Taylor & Martin, 2020, the total costs from the settlements in the U.S. and other countries are approximated as \$34.7 billion by March 2020 and would continue to increase until 2021.

METHODOLOGY

Data

This study compiled various information related to the VW emission scandal from multiple sources, such as the companies’ annual reports and multiple news media outlets. This study also utilized several search engines such as Lexis Nexis and Business Source Complete. This study used DataStream to compile the daily prices of VW common and preferred stocks from April 22, 2014, a week before the diesel scandal started, to the end of 2016, by which most of the litigations in the U.S settled, including the one with the DoJ on June 28, 2016.

Measurements of the COQ

This emphasis of this study is to explore the measurement gap between different approaches: accounting- based and market-based. This study employed two estimation approaches in order to measure and compare the costs of quality failures.

Accounting-Based Approach

This study estimates the COQ by compiling the operating expenses reported as diesel-related special items by VW in its income statement. VW reported both operating expenses and provisions in its financial reports and disclosed contingent liabilities based on International Financial Reporting Standards (IFRS). According to the IFRS, VW recognizes the expenses when they are probable, and a reasonable estimate is available at the time of its financial reporting and liabilities (or provisions) based on three conditions: 1) the present obligation has arisen due to an event, 2) the payment is probable, and 3) the amount can be estimated. Under the IFRS, a provision records a present liability of an entity. The recording of the liability in the entity's balance sheet is matched to an appropriate expense on the entity's income statement. In comparison, under the Generally Accepted Accounting Principles (GAAP) in the U.S., a provision is an expense. Contingent liabilities represent possible obligations and present obligations that are not probable nor reliably measurable. Most of contingent liabilities are in conjunction with lawsuits filed by investors, and VW disclosed contingent liabilities in notes of its annual reports.

VW used the term ‘field activities’ to refer such repair and recall-related costs typical in auto recalls. Because of the illegal and unethical nature of the diesel emission cheating in VW, the costs borne to VW are greater than the typical auto recalls that require only replacement of the defective parts. In the 2016 annual report, costs of field activities (i.e., emission modification or buyback from owners and early termination for leased vehicles) were \$10.0 billion, which counts only 40% of the total diesel-related costs of \$25.7 billion accumulated until 2016 and the remainder was litigation-related costs (approximately 60%). VW continued to recognize additional operating expenses each year over the period of 2017 to 2021, and such operating expenses are most related to the outcome of the settlements of the pending litigations in other countries.

Market-Based Approach

Market model has been used to identify and evaluate the value-relevancy of the information disclosed, given market efficiency, in various quality failure contexts, including environmental disasters (Burrowes, Karayan & McClain, 2011; Capelle-Blancard & Laguna, 2000; Lee & Garza-Gomez, 2017), product-harm

cases (Chen, Ganesan, & Liu, 2009; Freedman, Kearney & Lederman, 2012), and auto-related recalls (Govindraj, Jaggi, & Lin, 2004; Rhee & Haunschild, 2006). This study computes a market capitalization $MC_{i,t}$ as a measure of the gross value of a firm over the event period. As this study did not make any adjustment for market-wide movement, any changes in market cap should reflect the information content effects. The net change in market cap is calculated as:

$$\Delta MC_{i,t} = MC_{i,t} - MC_{i,0} \tag{1}$$

Unlike the traditional accounting-based approach that counts for only the direct costs and cash outlays incurred due to the scandal, the market model captures both visible and invisible costs, including the opportunity costs such as sales loss and reputational damages. Therefore, this study suggests that such difference in measures between the traditional accounting model and the market model is due to the difference in the treatments of the opportunity (or hidden) costs.

RESULTS AND FINDINGS

Accounting-Based Estimates

Table 2 summarized the diesel-related operating expenses (or costs) reported by VW in its annual reports over the periods of 2015 to 2021. VW recognized expenses related to the diesel scandal starting from 2015. VW recognized \$18.4 billion as a “special item” of operating expenses to cover the costs of the scandal in its 2015 annual report. In 2016, the cumulated operating expenses increased to \$25.7 billion with the additional operating expenses of \$7.3 billion recognized in 2016. The estimated COQ increases to \$31.5 billion if the provisions of \$5.8 billion recognized in 2016 are included and to \$35.1 billion if the contingent liabilities are also considered. These two figures are used for the purpose of the comparison with the market-based estimate, which continues to adjust until the end of 2016.

TABLE 2
COQ ESTIMATES (US DOLLARS, IN BILLION) BASED ON FINANCIAL REPORTING:
2015-2021

	2015	2016	2017	2018	2019	2020	2021
Operating Expenses (Special items)							
Annual (A)	18.42	7.28	3.64	3.64	2.62	1.02	0.91
Cumulative (AA)	18.42	25.70	29.34	32.97	35.59	36.61	37.52
Provisions Recognized Annual (B)	7.96	5.80	2.27	2.73	3.30	2.16	2.39
Contingent Liabilities Disclosed (C)	1.14	3.64	4.77	6.14	4.21	4.78	4.89
Total							
AA+B	26.38	31.50	31.61	35.70	38.89	38.77	39.91
AA+B+C	27.52	35.14	36.38	41.84	43.10	43.55	44.80

As VW settled multiple litigations in Germany, Canada, and other countries around the world from early 2017, the operating expenses reported in 2017 and thereafter are likely to reflect diesel-related legal risks associated with the litigations and settlements entered in other countries. For instance, in April 2017, VW reached \$2.1 billion settlement in Canada in diesel emissions manipulation case (Sagan, 2017). In June 2018, VW agreed to settlements with German prosecutors with fines of \$1.18 billion over emission cheating (Cremer & Schwartz, 2018). In February 2020, VW agreed to pay \$912 million to German customers in diesel emissions manipulation case (AP, 2020).

If the costs from all the settlements VW in countries other than U.S. are included, the estimated COQ (operating expenses accumulated plus provisions) would increase accordingly. If the newly added operating

expenses of \$11.8 billion during 2017-2021 are included, the total cumulative operating expenses (or COQ) would be \$37.5 billion by the end of 2021. If provisions of \$2.4 billion reported in 2021 are also added, the total costs of COQ go up to \$39.9 billion by the end of 2021 and if contingent liabilities are considered, the total estimate is \$44.8 billion at the end of 2021.

Market-Based Estimates

By observing market responses surrounding the event, this study measures the changes in market value due to the new event, VW's diesel emission cheating scandal in the current study. Table 3 shows the effects of the scandal on the market capitalization over the scandal period.

TABLE 3
COQ ESTIMATES BASED ON MARKET CAPITALIZATION CHANGES (IN \$ BILLION)

Dates	Mkt Cap.	Relative Changes to Base	
		Δ in Dollars	Δ in %
Pre-Scandal: 4/22/2012 ~ 4/29/2014			
4/22/2014	\$125.80	\$0.00 (Base)	0.00% (Base)
4/29/2014	\$122.49	-\$3.31	-2.63%
Period 1 (ICCT report, VW's internal prove, DoJ lawsuits): 4/30/2014 ~ 9/17/2015			
5/30/2014	\$123.20	-\$2.60	-2.07%
10/13/2014	\$92.64	-\$33.16	-26.36%
12/1/2014	\$108.67	-\$17.13	-13.62%
1/12/2015	\$100.61	-\$25.19	-20.02%
Period 2 (EPA public notice on 2-liter cars, DoJ lawsuits, U.S. Congress Hearings): 9/18/2015 ~ 10/8/2016			
9/18/2015	\$87.52	-\$38.28	-30.43%
9/23/2015	\$63.44	-\$62.36	-49.57%
10/2/2015	\$52.96	-\$72.84	-57.90%
10/8/2015	\$60.30	-\$65.50	-52.07%
Period 3 (Litigations and EPA Settlements in the U.S.): 10/9/2015 ~ 6/28/2016			
1/4/2016	\$71.81	-\$53.99	-42.92%
2/8/2016	\$58.65	-\$67.15	-53.38%
2/24/2016	\$60.91	-\$64.89	-51.58%
6/28/2016	\$65.79	-\$60.01	-47.70%
Period 4 (Other Settlements in U.S.): 6/29/2016 ~ 12/31/2016			
8/26/2016	\$71.49	-\$54.31	-43.17%
9/1/2016	\$71.67	-\$54.13	-43.03%
10/25/2016	\$71.45	-\$54.16	-43.05%
12/20/2016	\$72.05	-\$53.76	-42.72%

Note: Base date used for computing the changes in VW's market cap was 4/22/2014, which is a week before the release of the ICCT 2014 Report on 4/30/2014.

The market cap of the VW continued to drop with the development of the new information about emission issue over time. In the week before the scandal, the market capitalization was \$125.8 billion, which is reference value used for comparison. Period 1 covers the period from the ICCT 2014 report to the DoJ's lawsuits to the EPA's public notice. During this period, VW lost about \$25.2 billion relative to the base date.

Period 2 represents the litigations that arose from the EPA's public notice on 2-liter cars to another EPA notice on 3-liters cars. During this period, VW's market value tumbled down further than the level in

Period 1. VW reached its lowest point of loss at \$72.8 billion on October 2, 2015, one week before the hearing in the US Congress. VW lost \$65.5 billion in market value on the date of hearing.

Period 3 represents the litigations, from the DoJ lawsuits to the final settlements on June 28, 2016. During this period, VW lost \$60.0 billion in market value relative to the pre-scandal period. Accordingly, this study uses \$60.0 billion as the market-based estimate of COQ as most of the litigations entered in the U.S. were resolved by the end of 2016.

Period 4 covers the six-month period from the settlements with the DoJ and EPA. VW's market cap was recovered by about \$10 billion primarily because of the stabilization in market after the settlement with the EPA. Therefore, the estimated COQ was adjusted to \$53.8 billion.

SUMMARY AND CONCLUSIONS

This study compares the estimates of the COQ obtained from two approaches: accounting-based and market-based. The accounting-based model relies on the expenses (or costs) recognized by VW in each reporting period. It includes the direct operating expenses reported as special items and provisions for probable liabilities reported and the disclosure on the contingent liabilities associated with the diesel-related litigations. This study has come up with a cumulative sum of \$35.1 billion in 2016 and \$44.8 billion in 2021 as the accounting-based COQ estimates. In contrast, the market-based estimates of the COQ ranges from \$60.1 billion (at the time VW settled with the EPA) to \$53.8 billion (at the end of 2016). This study confirmed that the gap between the market model and accounting-based model is significant; it ranges from \$18.7 billion with information up to 2016 going down to \$9 billion when information up to 2021 is considered

What causes such gaps in measurements of COQ? One plausible reason is the omission in financial reports of the hidden costs arising from the scandal. The hidden costs such as the loss in sales due to the sales ban and the reputational damages were not explicitly specified in VW's income statement. This study acknowledges two types of hidden costs associated with the scandal, i.e., the loss of sales and the reputational damages to its brand and corporate image. There are reports that the sales ban imposed by several countries including the U.S. from immediately after the EPA's public notice contributed to the loss in VW's new car sales (Kasperkevic, 2015).

Table 4 compiles the data for VW' new car sales in the U.S. over 2012 to 2021. VW's car sales have continued to decline since 2013. The sales in 2016 alone decreased by 30.9% (144,460) compared to 2012. VW's loss in sales in the U.S. market started from early 2013. Relative to 2012 level, VW' loss of sales was 12.8% in 2013, 21.5% in 2014, 25.3% in 2015, and 30.9% in 2016.

One significant finding from this study is that the COQ reported in accounting-based model is much smaller than those approximated by the market-based model. This study interprets such gap in estimates is due to the hidden costs, such as the sales loss and reputational damages arising from the scandal. While the accounting-based model omitted the opportunity costs, the market-based model incorporates them in the COQ estimation process. The VW's sales data confirms the existence of opportunity costs, loss in sales due to sales ban and reputational damages given the fact that the ICCT 2012 report served as a triggering point of the VW's diesel scandal. This study does not consider the changes in market cap in the year 2017 and thereafter as relevant to the diesel scandal. The lift on ban of VW's diesel engines and the shift in focus to electric vehicles started from early 2017, and it brought an increase in sales of new cars. Such recovery stopped with the Covid-19 pandemic that affected the market in 2020 and thereafter.

TABLE 4
CHANGES IN VW'S NEW CAR SALES IN THE US (IN UNITS): 2012~2021

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Annual	467,408	407,703	366,970	349,440	322,948	339,676	354,053	363,322	355,684	366,462
Δ to prior year		-59,705 -14.6%	-40,733 -10.0%	-17,530 -4.3%	-26,492 -6.5%	16,728 4.1%	14,377 3.5%	9,269 2.3%	-7,638 -1.9%	10,778 2.6%
Δ to 2012		-59,705 -12.8%	-100,438 -21.5%	-117,968 -25.2%	-144,460 -30.9%	-127,732 -27.3%	-113,355 -24.3%	-104,086 -22.3%	-111,724 -23.9%	-100,946 -21.6%
Cumulative Δ		-59,705 -12.8%	-160,143 -34.3%	-278,111 -59.5%	-422,571 -90.4%	-550,303 -117.7%	-663,658 -142.0%	-767,744 -164.3%	-879,468 -188.2%	-980,414 -209.8%
Δ to prior year				-17,530 -4.8%	-26,492 -7.6%	16,728 5.2%	14,377 4.2%	9,269 2.6%	-7,638 -2.1%	10,778 3.0%
Δ to 2014				-17,530 -4.8%	-44,022 -12.4%	-27,294 -7.2%	-12,917 -3.0%	-3,648 -0.3%	-11,286 -2.4%	-508 0.6%
Cumulative Δ				-17,530 -4.8%	-61,552 -16.8%	-88,846 -24.2%	-101,763 -27.7%	-105,411 -28.7%	-116,697 -31.8%	-117,205 -31.9%

Source: Cain (2021) Volkswagen US Car Sales Data.

One primary contribution of the current study to the extant literature, therefore, rests on the fact that this study demonstrated utilization of a market-based model as an alternative way to measure the COQ because this model incorporates all the relevant costs including the opportunity costs of quality, which are likely to be omitted in the financial reporting. Therefore, the market-based model addresses one important measurement problem inherent to the accounting-based method. For instance, the loss due to the ban on sales and reputational damages are reflected as the decline in sales but not treated as diesel-related expenses. Therefore, it is likely that accounting-based measures underestimate the COQ because of the opportunity costs omitted from the estimation. The market approach also addresses another drawback of the accounting-based model that the estimation is not feasible until all the relevant cost information is counted internally and made available to users via financial reporting. Therefore, it is almost impossible, particularly for outsiders, to update the COQ estimates until next financial report is published. Unlike the accounting-based method, the market-based aggregation model not only provides an early approximation of the COQ immediately after the incident, but also allows users to correct or adjust the estimates when new information relevant to the value of the company arrives.

This study limited its scope of investigation on the economic effects of the scandal to VW. The current study did not examine the public health effects or spillover effects to other automobile companies or to other related industries such as travel or auto parts manufactures. Findings on the spillover effects would be complementary to the current study as it helps to better understand the multi-faceted nature of the scandal. If such spillover effects to other diesel car manufacturers and other related industry are included, the COQ arising from the diesel emission scandal would be much larger.

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