

Uncovering stakeholders in public–private relations on social media: a case study of the 2015 Volkswagen scandal

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Abstract While researchers have focused on the nature of interpersonal communication on social media, few have investigated the patterns and structures of interactions among stakeholders engaged in an unexpected event. On September 18, 2015, the United States Environmental Protection Agency issued a notice of violation of the U.S. Clean Air Act to Volkswagen Group of America, Inc., citing Volkswagen’s inappropriate software that circumvented the United States’ emission standards. This research is systemically designed to examine the evolutionary structures of interpersonal issue networks on social media by focusing on the 2015 Volkswagen scandal on social media. The interpersonal network emerged and evolved to build a discourse on issues by stakeholders after the event. By using longitudinal data collected from the Volkswagen USA’s Facebook page between September 17 and 20, 2015, this research tests four hypothesized network structures, which are reciprocity, transitivity, popularity, and activity, which assess the evolution of interpersonal issue networks. The results of exponential random graph models, analyzing 4131 stakeholders, show that interpersonal issue networks on social media have evolved overtime into a set of reciprocal relations and stakeholders transmitting critical information to bystanders. The findings imply that stakeholders who have Volkswagen’s cars and stocks play a critical role in placating the scandal by mutually interacting with diverse bystanders on social media.

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1 Introduction

Interorganizational relations across sectors, including those between public and private organizations, range from simple, less restrictive arrangements (i.e., coordination and cooperation) to more complex, contractual relations (i.e., formal collaborations and contracts). Public–private relations have become a prominent topic in the field of public management and it is due in part to the introduction of New Public Management and the reinventing government movement—the idea that government should borrow market-driven approaches and apply them to the business of government and where possible, focus on creating policy as opposed to delivering goods and services. There has been a significant growth of scholarship in the public management field that helps us understand the organizational motivations for pursuing joint ventures (Gazley 2010; Guo and Acar 2005; Sowa 2009) and the impacts that these varied arrangements have on organizational performance. Despite these advances in the literature, we know little about the process of cross-sectoral, interorganizational relations such as how organizations, in the process of working with each other, communicate with key stakeholders—an area that scholars consistently cite as a key dimension of creating an effective collaboration process (Ansell and Gash 2007; Thomson and Perry 2006).

Social media tools have arrived as an alternative mode of communication that can help organizations connect with stakeholder groups in an inexpensive and relatively easy to use platform. Social media tools include popular platforms such as Facebook, Twitter, YouTube and Instagram, with each emphasizing different purposes and forms of communication. Organizations tend to use Twitter, for example, to primarily foster one-way communication (Waters and Jones 2011), whereas Facebook allows users to engage in two-way communication and is the most common tool adopted by private organizations to maintain stakeholders engaged (Maxwell and Carboni 2016). The current literature tends to focus on the adoption and use of social media by individual organizations, with less attention paid to how this web-based technology can foster effective stakeholder engagement within the context of interorganizational relations (Carboni and Maxwell 2015; Maxwell and Carboni 2016). Our research, therefore, makes a contribution to the developing literature on social media by uncovering stakeholders in a case of cross-sectoral interorganizational relations—the U.S. Environmental Protection Agency and Volkswagen scandal.

On September 18, 2015, the United States Environmental Protection Agency (EPA) issued a notice of violation of the U.S. Clean Air Act to Volkswagen Group of America, Inc. The notice declared that diesel cars produced by Volkswagen (VW) from 2009 to 2015 were comprised of inappropriate software that helped circumvent the United States' emission standards for air pollutants. This case presents an opportunity to explore the cooperation between a public and private organization, and how in the process of working with each other to resolve the dilemma regarding policy violations, key stakeholders are effectively engaged in the dialogue. We place specific focus on how Volkswagen as a private organization in this scandal engages stakeholders over social media. We accordingly pursue the following research questions: (1) how have interpersonal issue networks evolved overtime to react on social media? and (2) what are the patterns of stakeholders' interactions before and after the scandal on social media? To answer these questions, we

adopt a stakeholder analysis framework and use NodeXL to collect and analyze the networks of actors responding directly to VW via social media.

2 Theoretical consideration

2.1 Social media in public–private relations

We define social media as “applications built on Web 2.0 technologies that are internet-based and designated to promote the content generated by the users and to facilitate the sharing and diffusion of information through social linking and interactions” (Chun and Reyes 2012, p. 441). These applications include popular social media tools such as Facebook, Twitter, and Instagram, which allow users to connect with other users and share information in real time. The study of social media by public administration scholars is fairly new and largely focused on understanding adoption and extent of use by public and nonprofit organizations.

Some scholars have focused their attention on understanding the process of adoption and the factors that may explain why some organizations are more likely to adopt social media applications. Mergel and Bretschneider (2013), for example, propose a three-stage model by which government organizations adopts new information and communication technologies (ICTs) such as social media tools, and these stages include: (1) entrepreneurship and experimentation, (2) constructive chaos, and (3) institutionalization. In the first stage, a member of the organization begins use of a new technology and introduces such technology to the organization, which begins experimenting with the new tool through stage 2. In the final stage, the organization institutionalizes the use of the new technology by establishing “a set of standards, rules, and processes for managing the process and some resources associated with the enforcement of these protocols” (392).

Other scholars have explored the adoption decision and the specific factors that may predict the adoption of social media tools. Li and Feeney (2014) find that among a random sample of local government managers, higher levels of external influence (i.e., media, advocacy groups, and business groups) and citizen demands explains the adoption of communication technologies. Their finding suggests that external stakeholders play a key role in a public organization’s adoption of new forms of communication technologies such as social media. This relationship makes sense when stakeholder groups such as citizens and other entities served by the local government have an interest in maintaining constant communication. Maxwell and Carboni (2014) explore factors that explain effective stakeholder engagement on social media by private nonprofit organizations, specifically Facebook. That is, if an organization adopts new communication technology, what helps keep stakeholders engaged? Their research found that type, length and total number of posts on Facebook matter. For example, posts that include a link share a negative relationship with user engagement whereas posts that include a photo share a positive relationship with user engagement. In addition, the results suggested that longer Facebook posts increased effective stakeholder engagement whereas the more overall posts were a negative predictor of effective stakeholder engagement. While this literature provides an early understanding of the role of social media in public and private organizations, we still know little about the role of stakeholders in public–private relations and the structure of the relationships that develop over social media.

2.2 Stakeholder analysis on social media

Freeman defines a stakeholder as “any group or individual who can affect or is affected by the achievement of the organization’s objectives” (quoted in Bryson 2004, p. 22). Bryson similarly defines a stakeholder as “any person group or organization that can place a claim on the organization’s attention, resources, or output, or is affected by that output” (Bryson 2011, p. 48). Some scholars differentiate between internal stakeholders—typically employees of a firm—and external stakeholders (de Chernatony and Harris 2001; Morsing 2006). In the case of the EPA-VW scandal, therefore, external stakeholders may include car owners, elected officials, and regulatory agencies. The list could also include globally active environmental groups and VW competitors who see the debacle as an opportunity to gain market share. At the local level where the private organization is embedded, external stakeholders may include organizations like the Chamber of Commerce, property entrepreneurs, civic organizations that benefit from VW’s corporate philanthropy, elected officials who pledged tax incentives, automotive suppliers and ideologically motivated pro-business or anti-business groups to name a few.

Recent research on social network analysis is varied. An analysis of 20 key media Twitter users in South Korea found that the geographic location of users can predict who controls the flow of information (Chien-leng Hsu et al. 2013). The researchers, though, focused on a high profile issue most germane to residents in Sejong City. An analysis of 15 American, European and Korean elected public officials Twitter interaction found that such platforms do not necessarily generate genuine interactive communication between elected officials and the public (Otterbacher et al. 2013). Other researchers have found relationships between pivotal events and online content. For example, after the start of the Arab Spring, networks in Muslim majority countries grew and the use of the words such as “jihad” and “sharia” increased (Danowski and Park 2014). Likewise, social networks can generate knowledge among users (Fadul 2014). Investments in big data suggest that organizations that are adept at mining information from the crowd might have a competitive advantage over organizations that cannot. That being said, there is a temporal aspect of modern data that affects the value of data. In a world of 24/7 news and reporting, the attention span of the public wanes quickly as the next “big event” drives the news cycle. Simon (1971) believed that a wealth of information creates a poverty of attention, and the velocity of information in modern society is unprecedented. In our analysis, the intensity of interaction decreases over time. In the case of VW, getting access to major actors would be nearly impossible. Under the stakeholder framework, to fill the gap, we utilize a webometric approach proposed by Jung et al. (2015) for analyzing the stakeholders embedded in the scandal. That is, because after VW admitted to duping federal regulators, the crowd weighed in via social media. A particular weakness of analyzing the crowd is that it is not a random sample. However, social network analysis allows us to see the formation of interest group by various themes. Despite the fact that crowds are amorphous, crowds can support an organization’s knowledge base (Oinas-Kukkonen 2008). The method is also a tool for better understanding social processes (Butts 2008).

Applying the stakeholder analysis perspective to the VW scandal, this research hypothesizes the patterns of interactions among actors directly engaged in the networks. The basic presumption is that the evolution of a network is explained by the change of network structures, which may contribute actors to enhance interactions among stakeholders. First, because of prior experiences in VW, stakeholders may have established mechanisms to reduce uncertainties embedded in interactions. Actors also have a strong

commitment to establish joint activities and share information with those that they had established relations overtime. Second, joint activities provide actors with critical information and communication adding value and legitimacy to the acquisition of stakeholders' outcomes. Previous experiences and cases can also be used to facilitate information exchange and the process of acquiring new ties with others. It reduces the risk of interactions among stakeholders, especially on social media (Jung et al. 2014). Based on this logic, we can empirically examine the change of four structural properties: reciprocity, transitivity, popularity, and activity (Jung et al. 2015; Yang and Jung 2016). The visual characteristics on the pattern of interpersonal issue network are presented in Fig. 3.

- a. *Reciprocity* A mutual relationship between two or more actors may be conducive to sharing information and exchange knowledge (Almeida and Kogut 1999). They are also assumed to likely to enhance interactions among stakeholders. An actor with a greater reciprocity tie will have more opportunities to learn about the scandal from others than those who are not. H_1 : *Actors engaged in the VW scandal are likely to mutually interact with other actors over time.*
- b. *Transitivity* Actors may learn easily about a new type of information from others. They are likely to conform to norms if the new channel of communication becomes common usage. H_2 : *Actors engaged in the VW scandal are likely to build a close-knit structure by closely interacting with other actors over time.*
- c. *Popularity* An actor that is popular, i.e., with extensive links in receiving requests from external actors, should be able to exchange information through multiple channels of communication. H_3 : *Actors engaged in the VW scandal are likely to receive support from other actors over time.*
- d. *Activity* An actor receiving supports externally may need multiple channel of a communication in order to communicate and coordinate policy preferences to diverse set of stakeholders. H_4 : *Actors engaged in the VW scandal are likely to actively seek other actors over time.*

3 Before and after the 2015 VW scandal

On Friday September 18, 2015, VW's corporate reputation and global brand was forever changed when the U.S. Environmental Protection Agency (EPA) publically announced VW's violation of federal Clean Air Act legislation. According to the EPA, "VW manufactured and installed defeat devices in certain model year 2009 through 2015 diesel light-duty vehicles equipped with 2.0 L engines. These defeat devices bypass, defeat, or render inoperative elements of the vehicles' emission control system that exist to comply with CAA emission standards" (EPA). The charge is highly damning: intentionally engineering systems that violate the US Clean Air Act.

Critics responded with a wave of media coverage shaming VW. The VW scandal was claimed by some to be worse than the BP oil spill, Enron, GM's faulty ignition switches and Toyota's runaway cars (Adamson 2015; Phelan 2015; Bach 2015). A New Jersey VW dealer said the VW scandal was worse than Bernie Madoff's Ponzi scheme (Flessner 2015). Bach used the terms "deliberate fraud" and "criminal intent" to differentiate VW's sins from those of other companies that typically get in trouble for negligence. VW's American leaders downplayed the significance of the EPA investigation, but the company faces up to \$18 billion in future fines from the EPA (Harrison 2015).

The initial corporate response was a formal video apology, followed shortly thereafter by the resignation of CEO Martin Winterkorn on September 23. The stock market reaction was more pronounced and immediate. As Fig. 1 shows, VW stock dropped precipitously after trading resumed on Monday September 21. Following that, VW offered diesel consumers a goodwill package consisting of \$500 cash, \$500 VW dealer credit and free 24-h roadside assistance for three years (Hirsh and Masunaga 2015).

The financial losses suffered by stockholders were followed by an array of class action lawsuits filed by VW owners. Within two weeks of the scandal, at least 34 federal lawsuits had been filed (Lam 2015). Many European, North American and Asian countries initiated investigations that could result in heavy fines and other severe penalties in the future. German investigators raided VW headquarters on October 8th, 2015 searching for evidence of fraud and deception (Kostov and Chow 2015). Pundits pointed out that VW's stellar global brand was badly damaged by the fiasco (DiPietro 2015). According to Jennifer Vickery, "To really fix things, the company is going to have to communicate in a new way. It should break things down, step-by-step, in terms of where they are in the investigation and correction of all internal corruption. It must be as public as possible, even using social media and media airtime purchases, to reach the public" (quoted in DiPietro 2015, p. 1).

Despite the scandal, the Volkswagen Group's (VWG) overall sales volume in 2015 was down only 2 percent compared to 2014 (VW Group 2016). Of course, the scandal broke late in the year and, VWG includes Porsche, Audi and other brands. The volume of VW passenger vehicles sold in December 2015 compared to 2014 dropped 7.9 percent. These numbers suggest that "dieselgate," as the incident is sometimes referred to in the United States, will have an impact on future VW passenger sales.

4 Background of VW USA in Chattanooga, Tennessee

The first VW investment in Chattanooga was in 2008. The plant produces the American built Passat. In 2014, VW announced plans to expand the Chattanooga plant to produce a midsize SUV. VW will invest an additional \$650 million to expand the plant and create an additional 2000 factory jobs (Niquette 2015). Fox and Kessler (2015) estimated VW's

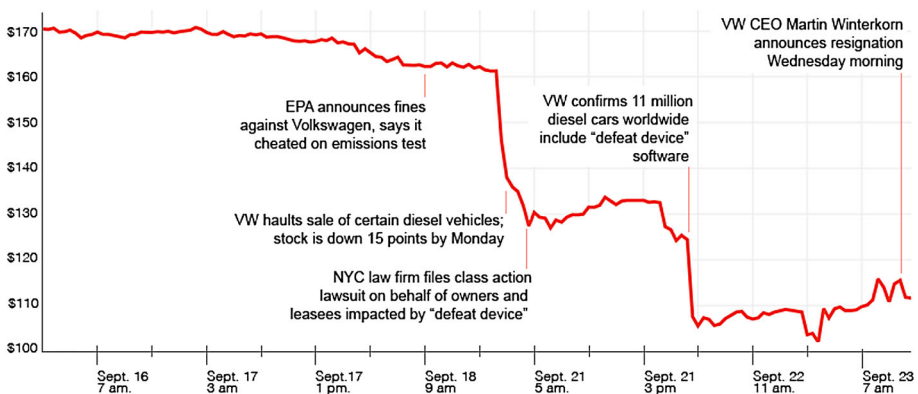


Fig. 1 Investors' reaction to the VW scandal. Source Snyder and Jones (2015): <http://fortune.com/2015/09/23/volkswagen-stock-drop/>

Table 1 Estimated impact of VW on Tennessee economy. *Source* Fox, William and Lawrence Kessler. Economic Impacts of Volkswagen's Chattanooga Expansion Plan. The University of Tennessee Center for Business and Economic Research. May 27, 2015

	Operations phase: FTE jobs	New income (million)	State and local tax revenue (million)
Current facility	12,400	\$643.1	\$53.5
New facility & RD center	9799	\$372.6	\$20.5
Total	22,199	\$1015.7	\$74.0

economic impact on Tennessee's overall economy. As shown in Table 1, they estimate both facilities will create over 22,000 direct and indirect jobs, \$1.016 billion in new income, and \$74 million in state tax revenues. After the recent scandal, VW has vowed to move forward with the expansion.

4.1 Political impacts

In early October 2015, the head of VW America, Michael Horn, testified in front of a congressional panel. Congressmen vented their anger at VW by accusing it of cheating and deception. Representative Chris Collins from New York had a harsh assessment of VW management. He stated, "Either your entire organization is incompetent when it comes to trying to come up with intellectual property, and I don't believe that for a second, or they are complicit at the highest levels in a massive cover-up that continues today" (Fung 2015).

Tennessee and Chattanooga political leaders used large incentive packages to attract VW to Chattanooga. Now, post-scandal, some state legislators are threatening to retract some of those promised incentives. Chattanooga, through a combination of federal, state and local sources, pledged roughly \$577 million in incentives for the first VW plant and another \$300 million in 2015 for the expansion (Flessner 2014).¹ Huntsville, Alabama, the runner-up in the contest to attract the VW industrial plant offered \$350 million in incentives to VW back in 2008. Political leaders in Tennessee have invested both physical and political capital on VW's success. VW is part of a larger automotive manufacturing strategy that has propelled Tennessee to the state with the sixth most automobile manufacturing jobs in the country (Michigan Live 2015). Tennessee is also home to Nissan USA's headquarters in a small town near Nashville, TN, USA.

Political stakeholders have vested hundreds of millions to attract and retain VW. As such, they are keenly aware of the risks involved in the VW scandal. The Tennessee Senate Finance, Ways, and Means committee met on October 29, 2015 to discuss the future health of VW and its commitment to TN. Some lawmakers have publicly expressed concerns about VW's ability to meet its job commitment—failure to do so could lead to a retraction of pledged incentives (The Commercial Appeal 2015). In fact, Tennessee negotiators included "clawbacks" in the VW incentive deal that would force VW to repay incentives in the case it fails to meet promised job creation benefits.

Another political consideration in Tennessee is unionization. Like most southern states, Tennessee is a right-to-work state and unionization is generally discouraged. The United

¹ <http://www.timesfreepress.com/news/business/aroundregion/story/2014/jul/15/state-local-governments-boost-incentives-to-lure/252206/>.

Auto Workers (UAW) has worked hard in Chattanooga to unionize VW. These efforts have prompted disdain from Tennessee's elected officials. The governor, both senators and a large contingency of state legislators have voiced public disapproval of the UAW's efforts. The Chattanooga plant voted 712-626 against unionizing in February 2014; however, after the scandal a smaller group of skilled tradesmen voted 108-44 to join the UAW. VW has appealed the vote to the National Labor Relations Board because it was not representative of the entire work force, only a subset (Pare 2015).

4.2 Chattanooga's renaissance

In the late 1960s Chattanooga was known as one of the most polluted cities in the United States. It was a small city with a bad reputation. Its economy was dominated by dirty manufacturing and its foundries provided jobs for those with limited human capital. The foundries started to close in the 1980s and local leaders undertook a 30-year process to radically revitalize downtown Chattanooga and the city's external image. In the 1990s the riverfront was reclaimed and new projects such as the Chattanooga aquarium, walking bridge, public squares and a children's museum combined to create a strong tourism magnet. Since then, local foundations have invested heavily in downtown amenities that have fueled residential development and gentrification. Chattanooga's downtown and inner-urban neighborhoods are thriving with boutiques, coffee houses, restaurants and bars. In addition, city leaders have promoted the Chattanooga brand that consists of rock climbing, hiking, mountain biking, paddle boarding and general outdoor adventures. All of these efforts were rewarded in 2015 when Chattanooga was named *Outside Magazine's* "best town" award for the second time (Outside 2015).

Chattanooga has also been lauded by Bruce Katz for its innovation economy (Katz 2015). Chattanooga has one of the fastest internet connection times in the nation due to its fiber optics network initiated many years ago by the Electric Power Board (EPB). Chattanooga's relentless place-making initiatives have made it an attractive venue for young entrepreneurs and investors in the innovation economy. VW contributes to Chattanooga's identity in critical ways. First, it is a good corporate citizen that invests in local events like bike races, triathlons music festivals and other downtown street events. Second and perhaps more importantly, it provides employment opportunities for those residents who lack the human capital skills to fully participate in the innovation economy.

VW has partnered with Chattanooga State Community College to create the VW Academy (Chattanooga State). The partnership is designed to meet VW's local labor needs. The program attracts individuals interested in working at VW. The program consists of formal academic training and paid on-the-job training. It is similar to the German apprenticeship model used in Europe to train future workers. At present, the program only accepts 24 students per cohort. The program shows how deeply embedded VW is in the local community.

The economic impact of VW is the most important aspect of the development. The Chattanooga region does not have a highly educated labor force and the jobs at VW provide access to a middle class lifestyle. As Fig. 2 below shows, prior to 1990 the region had over 45,000 manufacturing jobs. Since then, the number has steadily dropped—reaching less than 30,000 during the 2009 recession. Today, the number has stabilized largely due to VW and the suppliers it has attracted to the region.

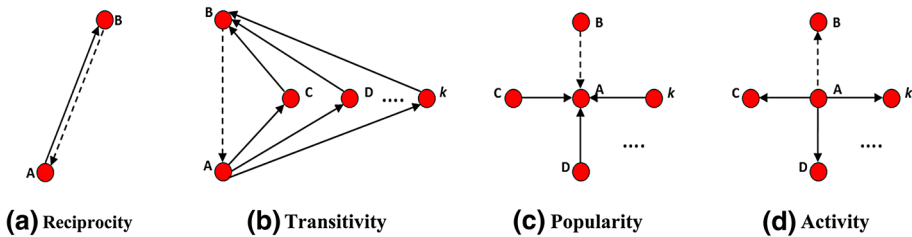


Fig. 2 Hypothesized networks: reciprocity, transitivity, popularity, and activity. Adopted from Jung et al. (2015)

5 Research design, data, and methods

This research is intentionally designed to investigate the evolutionary structure of stakeholders by exploring the case of the 2015 VW scandal. The Volkswagen Group of America (i.e., VW USA) is headquartered in Herndon, Virginia, but its largest manufacturing facility is in Chattanooga, Tennessee. According to VW USA’s website, they employ over 3200 local residents and an additional 9500 work in the automotive supplier industry. Ironically, the VW plant is the first and only Leadership in Energy and Environmental Design (LEED) Platinum automotive plant in the world. LEED is a status granted by the U.S. Green Building Council for environmental stewardship; LEED Platinum is the highest level of certification granted for environmentally sustainable development. The grounds of the facility include 33,000 solar panels, waste water is reused, and the building is covered by a white roof that limits the heat island effect (Volkswagen Group 2015).

This research utilizes longitudinal data gathered from September 17 to 20, 2015. It was collected from the VW USA’s Facebook page, which was established with the intention to facilitate stakeholders’ engagement in the promotion of VW USA. The VW USA’s Facebook page presents a clue to the evolutionary structure of interpersonal issue networks because its use of social media fosters dialogue and maintains constant interaction among diverse actors in order to develop and maintain the VW promotion process. From a webometric perspective (Jung et al. 2015), investigating the VW scandal network on social media is an innovative way to understand how interpersonal issue networks have evolved to enhance interactions among stakeholders overtime.

5.1 Data

This research collected ephemeral data that otherwise could not be recorded on the interactions of key stakeholders involved in the 2015 VW scandal. The data come from VW USA’s Facebook page. We use specialized analysis software—NodeXL— which is used by social network researchers to collect and analyze data on social media applications such as Facebook, Twitter, and YouTube. NodeXL presents a critical opportunity to test the hypothesized network structure of interactions among stakeholders in the context of social media (Jung et al. 2014). Based on the data collected from the VW USA’s Facebook page from September 17–20 (i.e., 4 days), this research examines the evolutionary structures of interpersonal issue network by testing the following network parameters: (1) relationships among stakeholders who had consecutively communicated with others on the Facebook page before and after the scandal, and (2) keywords of the stakeholders who had shared and responded to others engaged in the Facebook page. In order to reduce data

collection bias, overlapping user accounts were excluded. We collected data on 4 time points covering each 24 h per day. Doing so was important because cross-sectional data (i.e., data collected at only one time point) may not adequately capture a network's evolutionary structure or certain patterns of communication on social media (Jung and Park 2014). As a result of our data collection, a total of 4131 stakeholders with more than two consecutive comments and 6169 interactions among actors were captured as the final data set for our analysis (see Table 2).

5.2 Methods

In this study, we adopt a webometric approach to uncover the stakeholders of our case study. Webometrics is defined as “the study of web-based content with primarily quantitative methods for social science research” (Marchionini 2009, p. 6). Moreover, webometrics places a focus on measuring phenomena that arises out of the Internet such as website use, social networks, and other web-based platforms (i.e., blogs). Here, for example, our research studies the intercommunication between actors on social media. We specifically use social network analysis methods to explore the VW scandal network structure and patterns of stakeholders' interactions on social media. The generated social network data consisted of actors' relationships, which was measured by actors' communication and activities on social media. For instance, this research measured a tie between two stakeholders in three different forms: (1) an actor only responds to a post or reply more than two times (i.e., a unilateral tie); (2) both actors respond to a post more than two times (i.e., a reciprocal tie); and (3) neither actors respond to a post or reply (i.e., no tie). In the data collected from the VW USA Facebook page, the identified types of relationships are coded by the number of a stakeholder's consecutive comments. Here two possible ties are: (1) a mutual tie and (2) a unilateral tie. A mutual tie indicates the case when two actors communicate with each other (e.g., coded as both 1 and 1), while a unilateral tie indicates a unidirectional communication where one actor transmits information to the other and the other does not respond (e.g., coded as each 1 and 0 or 1 and 0). False relationships between two actors are coded as both 0 and 0.

Following Jung et al. (2015), this research was applied to exponential random graph models (ERGM) by using SIENA P^* (Snijders et al. 2006). The basic idea behind the P^* analysis is as follows: when the researcher considers an observed network shown as a

Table 2 Descriptive statistics of VW scandal networks from Sep. 17–20, 2015

	17	18	19	20
Vertices	686	1144	2007	294
Unique edges	976	1421	2768	370
Edges with duplicates	140	186	405	25
Total edges	1116	1607	3173	395
Connected components	6	19	31	10
Single-vertex connected components	1	5	9	2
Maximum vertices in a connected component	596	848	1521	240
Maximum edges in a connected component	980	1192	2487	342
Average geodesic distance	6.532	15.677	18.949	10.991
Graph density	.002	.001	.0001	.004

dependent variable, the P^* model can estimate the potential arrangement of network patterns that may occur from the observed network (Snijders et al. 2010). In this research, four hypothesized network structures about whether the observed pattern of VW scandal networks can occur more frequently than can be explained by random graphs with the same numbers of nodes and ties were tested. More specifically, the P^* model was used with the VW USA Facebook page data collected from September 17 to 20 in order to assess the evolution of VW scandal networks.

The analysis results based on the ERGM are interpreted for explaining network evolution before and after the scandal by comparing the estimated parameter values (E) and standard errors over time. It indicates that the statistical significance of the effects is based on the ratio of the parameter value to the corresponding standard error (i.e., t-statistics). In the ERGM, a positive parameter suggests that, with other effects held constant, network effects are more likely to appear in the observed network structure than in the network predicted by a random graph with the same numbers of nodes and dyads (Robins et al. 2007; Snijders et al. 2010). As indicated earlier, the results with the change of significant effects provide relatively clear evidence for the evolution of stakeholders' interactions over time.

5.3 Hypothesized network structures: reciprocity, transitivity, popularity, and activity

Four network effects were considered (reciprocity, transitivity, popularity, and activity) to determine the nature of e-participation in Government 2.0. The left-hand side of Fig. 1 graphically illustrates the reciprocity effect. For example, when actor i seeks information from actor j , the tie between the two actors can be operationalized as x_{ij} to indicate the existence of a tie from actor i to actor j . The reciprocity effect is formally defined as $\sum_{i < j} x_{ij} x_{ji}$ to account for the total number of mutual relationships between actor i and actor j (Snijders 2005; Snijders et al. 2007).

The transitivity effect was measured by the “alternating k -triangle, parameter two,” which suggests that the tendency to form a highly transmittable network structure is very likely. The left-hand side of Fig. 1 shows the bonding effect, which can be formally written as $k \sum_{i,j} x_{ij} \left\{ 1 - \left(1 - \frac{1}{k} \right)^{L_{2ij}} \right\}$, where $L_{2ij} = \sum_h x_{ih} x_{hj}$ is the number of two paths connecting actors i and j . A positive parameter suggests the tendency of actors in the network to forge a tie toward a comparatively large number of transmittable structures as a set of triangles.

The popularity effect was captured by “alternating k -in-stars,” which indicates a localized structure of an actor who is taking ties from k numbers of actors supporting this ego network (Buchanan 2002; Robins et al. 2007; Snijders et al. 2010). The popularity effect can be formally defined as $c^2 \sum_{i=1}^n \left\{ \left(1 - \frac{1}{c} \right)^{x+i} + \frac{x+i}{c} - 1 \right\}$ for some value c to explain the probability of incoming ties from exactly k actors in the network. A positive parameter implies the propensity of the ego networks in a given network to have incoming ties from those actors who formulate a localized structure in transmitting information, whereas a negative one proposes that actors are less likely to have ties from them in the expected network based on random graphs.

The activity effect was measured by “alternating k -out-stars,” which captures the likelihood of establishing an ego network by actively supporting k actors (Robins et al. 2007; Snijders et al. 2010). The activity effect can be formally defined as

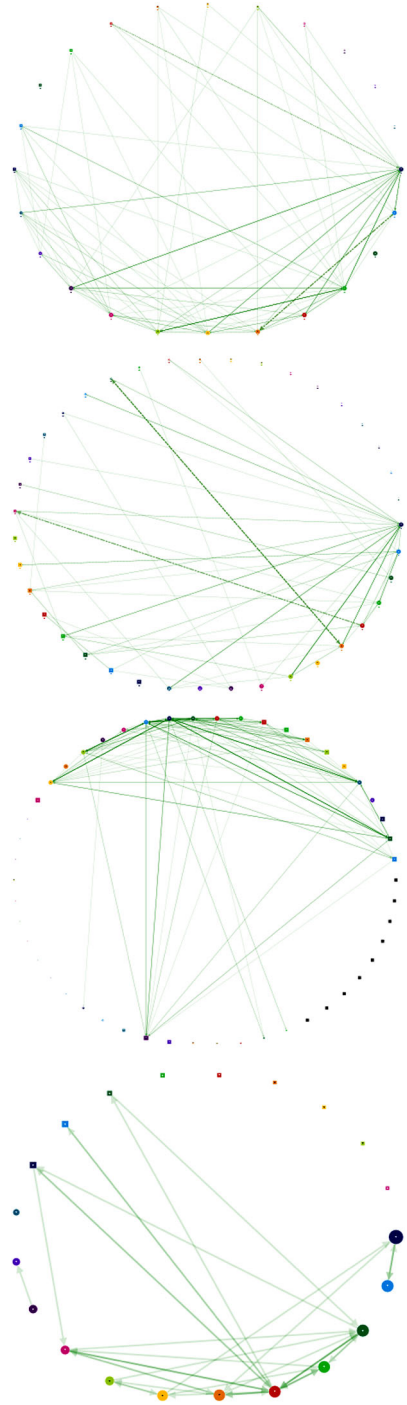
$c^2 \sum_{i=1}^n \left\{ \left(1 - \frac{1}{c}\right)^{x_i^+} + \frac{x_i^+}{c} - 1 \right\}$ to explain the total number of outgoing ties with exactly k actors. A positive estimate, such as boundary-spanning (Van Geenhuizen 2016), suggests the propensity for actors with high out-degree centrality in the given network to form an active ego network, whereas a negative one proposes that an active ego network tends to seldom appear in the expected network based on random graphs.

6 Results and discussion

Figure 3 shows dramatic changes in the VW scandal networks from September 17 to 20, which is consistent with the media and public reactions after the EPA announcement. Two major differences among figures are the structure and the content of the public–private relations embedded in four networks. In terms of the structure that we are focusing on, reciprocal ties capturing mutual relations decreased from 140 on 17th to 86 on 18th, September while it dramatically increased from 86 on 18th to 405 on 19th, September. The findings imply that public–private relations were mainly formed by information diffusion just after the EPA announcement. Despite that, the VW scandal network on 19th, September shows that various clustered groups were mutually communicating within and beyond each group. Lastly, the VW scandal network on September 19 shows that interactions within the network were few, with the majority of ties falling into only groups 1 and 2. On top of that, The network structure intensely developed after the scandal where the number of ties among stakeholders grew exponentially and evenly spread across groups. This change in network structures has some interesting parallels with other changes of the VW scandal network, including the substantial drop in VW’s stock value and the announcement of multiple lawsuits. While no causal relationship can be established from these findings, one can infer that there is some degree of intercorrelations between the stakeholders’ response and other indicators of growth (i.e., stakeholders in a connected component) and effectiveness (i.e., increasing duplicated edges). As Jung and Park (2014) used, the keywords extracted from the content analysis based on all comments present a clue to understand the change of issue networks overtime. The keywords stakeholders consecutively used in their comments from September 17 to 20, generally correspond with the contents of the EPA’s announcement such as ‘fuel-economy’, ‘diesel-cars-engines’, ‘18-billion’, and ‘epa-needs’. More interestingly, stakeholders also used the emotional words ‘shame-vw’ and ‘never-buy’ after the scandal was exacerbated.

Table 2 presents the results on the descriptive statistics of VW scandal networks derived from our application of the webometric approach. Overall, all parameters increased by September 19, indicating a growth in the number of stakeholders and of the interaction among stakeholders on the VW USA’s Facebook page. Stakeholders as a vertex, for example, are Facebook users that may represent individuals and organizations. This parameter grew from 686 on September 17 to 2007 on September 19, but sharply decreased to 294 on September 20. This indicates that more stakeholders including individuals and organizations are becoming aware and interested in sharing critical information on the VW USA’s response over time with others. The edges with duplicates statistic, on the other hand, measures the number of network ties that are reciprocal—or the instances where there is mutual communication. On September 17, there were a total of 140 edges with duplicates, a number that grew to over 400 on September 19, 2015—indicating a significant growth in mutual interactions between the stakeholders on social media. Lastly, the

Fig. 3 VW scandal networks from September 17–20, 2015



total edges statistic measures the total number of interactions among users, which also grew from 1116 on September 17 to 3173 on September 19, 2015. The findings imply that a significant number of actors are engaging VW USA's Facebook page by either actively posting a comment or replying to others' comment.

The analysis results of ERGMs in Table 3 provide evidence of the evolution of the VW scandal networks from September 17 to 20, highlighting that all of four hypothesized network structures are statistically significant after the EPA announcement (also see Fig. 1). That is, interactions between stakeholders in the network tend to be mutually linked to each other in the models overall (e.g., $E = 4.177$ in the model for September 19; $p < .01$). In addition, the results showing positive estimates for the transitivity effect (e.g., $E = .767$ in the model for September 20; $p < .01$) also provide straightforward evidence that the relationships among any three stakeholders on the VW scandal network are likely to formulate a close-knit structure after the scandal (e.g., clustering within a global network). The popularity effect is only significant for the model for September 18 and 19, suggesting that an ego network with incoming ties from other stakeholders is more likely to be formed after than networks expected by random graphs ($E = 2.144$ and 2.541 in each model; $p < .01$). As Bryson (2004) and Reed et al. (2009) highlighted, the findings imply that the VW scandal networks induced by the EPA announcement have promoted mutual communication among diverse stakeholders, sharing critical information beyond a dyadic relationship between a single individual and a leading organization.

The results suggest that stakeholders on the VW USA's Facebook page are more likely to emerge through a popular ego network that seeks to forge outgoing ties with other actors than an active ego network with social status and prestige by establishing outgoing ties with other stakeholders. In this regard, the results verifying the hypothesized network effects of transitivity and popularity suggest that, in terms of directly connected stakeholders on social media, customers who purchased VW cars can obtain not only critical information on the inappropriate software from others but also insights into how wicked problems can be addressed by sustaining credible commitment on social media (Maxwell and Carboni 2014; Xu and Feng 2015). Despite these significant benefits of social media, without VW's sufficient efforts to immediately respond to citizens' requests, complaints, and suggestions, stakeholders embedded in the VW scandal network may not be fully satisfied due to overwhelming sources of communication and information. This notion also implies that enhancing social capital on social media relies on the maturity of private firms, which consists of managerial conditions, transparent procedures, spontaneous engagement, and expeditious collaboration.

In this point of view, the findings imply that there is a rapid growth after the scandal in the interaction among stakeholders on the VW USA's Facebook page. More importantly,

Table 3 Estimates of ERGMs for hypothesized network structures

	Sept. 17		Sept. 18		Sept. 19		Sept. 20	
	E	SE	E	SE	E	SE	E	SE
Reciprocity	2.781**	.518	3.258**	.479	4.177**	.484	1.249**	.529
Transitivity	.147	.054	2.144**	.456	2.541**	.364	.767**	.324
Popularity	.124	.107	1.048**	.354	1.179**	.321	.144	.117
Activity	.984**	.371	1.547**	.342	1.245**	.214	.571*	.385

All statistics converged with a t-statistic $< .10$ with a minimum of 1000 iterations

** $p < .01$; * $p < .05$

the growth is evident in reciprocal ties, where there is mutual interaction between the stakeholders (e.g., individuals and organizations) who were affected by the scandal. This is an important finding because it appears that more users are finding it useful to communicate via the VW scandal network on social media. In addition, their motivation to engage in interaction on social media could be multidimensional as suggested by the literature (DiMaggio and Powell 1983; Johar et al. 2010). This finding is also an indication of the network's commitment to be active on social media and engage in reciprocal relationships with stakeholders. This may be due to external pressure by stakeholders who demand greater levels of transparency and communication for the VW USA (Weber and Khademian 2008). Moreover, the growth in interaction on social media over time can also be a sign of the stakeholders' effort to expect the VW USA's legitimacy and commitment.

7 Conclusion

This research sought to better understand the nature of stakeholders engaged in the VW scandal network on social media by testing hypothesized network effects before and after the event. Following the stakeholder analysis and webometric approach to the scandal, the analysis results of the ERGMs show that the patterns of stakeholders' interactions dramatically changed to a close-knit and concentrated structure on influential actors with detailed scandal information. The findings confirm significant growth in stakeholders composing the VW scandal networks, and that multiple and diverse stakeholders are influential in leading interactions on the VW USA's Facebook page.

From a theoretical standpoint, this research fills the gap of the current literature on social media research by exploring the behavior of stakeholders involved in an unexpected event involving public–private interorganizational relations as opposed to a single organization. More specifically, this study makes a contribution to the limited literature on how social media is used by stakeholders who consecutively communicate with others. In addition, we employed the webometric approach that has been largely underused to better understand the structure and patterns of communication within a network of multifaceted stakeholders and more specifically, interactions that arise on social media tools such as Facebook and Twitter.

From a practical standpoint, the webometric approach can help strengthen public relations, such as the scandal networks derived from the VW USA's Facebook page, in several ways. First, overtime there were a total of 4131 stakeholders engaged in the VW USA's Facebook page, with this number intensely increasing from 686 in September 17 to 2007 on September 19, but dramatically decreasing to 294 in September 20. This type of comparative data over time provides organizations with an opportunity to assess whether reasonable progress has been made in developing relationships with stakeholders via social media. Second, results of our social network analysis helped identify the most influential stakeholders and keywords over time. Thus, private organizations can assess whether those central stakeholders are current key stakeholders targeted by the organization and whether the key words are in harmony with the message that the organization is trying to communicate to stakeholders. The application of a webometric approach helps extract key words that are dominant within stakeholders' communication, which helps an organization assess whether it is achieving its marketing and communication strategies.

Much of the stakeholder analysis and strategic planning literature predates the explosion of social media. Leaders have been taught to focus primarily on the strongest network ties,

but the growth of viral online events shows how important less focal players can have on an organization's brand. Future study should perhaps focus on a content analysis of immediate responses to crises. For example, Cho et al. (2012) used content analysis to better understand the differences between civic groups and government actors on the issue of importing U.S. beef to Korea. The combination of both content analysis and network analysis would yield more rigorous findings than either method if used alone.

This research, however, has the following limitations. The findings in this research cannot be universally generalized beyond the sociopolitical context in which issue networks exist. In this case, the findings may have been driven by the unique sociopolitical context embedded in the VW scandal. While the number of relationships and actors is sufficient to analyze, we cannot exclude any possibility that Facebook may report a limited number of actors and their ties. As indicated by Hansen et al. (2011), unreported ties due to any technical reason may present barriers to capturing the evolution of longitudinal networks. Future studies, therefore, should consider a broader set of data from both Twitter and Facebook for comparative analysis of similar issue networks in other countries. Since we only consider a network within a specific issue (i.e., VW scandal in the United States), future research is recommended to incorporate critical literature on social movement and studies that specifically address stakeholders' behavior.

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