The Toyota Recall Crisis: Media Impact on Toyota's Corporate Brand Reputation

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ABSTRACT
The time trend of public opinion about carmaker Toyota dropped precipitously in early 2010 following a series of quality issues and recalls. The mathematical model of ideodynamics could predict the fall and subsequent rise in Toyota's reputation from coverage of Toyota in blogs, in Internet forums, in print news, and in news websites from 1 January, 2009 through 31 March, 2011. Internet forums represented crowd sourcing in social media. The model performance was high for all these types of media with R^2 values in the range of 0.7–0.8. Information favorable to Toyota was about twice as persuasive as information unfavorable to the company. Blogs had negative coverage of Toyota in the fall of 2009 before other media types but had limited effects on opinion. Impressions of Toyota only showed a notable drop after recall information hit the majority of the other media. The good predictions showed that all the media studied moved in reasonable synchrony, so all could represent the information shaping public opinion even though the messages did not include advertising or broadcast content.
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KEYWORDS: *news media; opinion; prediction; social media; time series; Toyota*

INTRODUCTION

Corporate reputation refers to opinions rather than facts about a company. These opinions can have little relationship to facts and everything to do with interpretations. This disconnect is seen in the halo effect where good financial performance by a corporation can lead to the impression that all the company's actions were wise without a careful analysis of the actual facts. The same actions tend to be interpreted as blunders if the financial performance changed to suboptimal (Rosenzweig, 2007).

This paper explores how opinions related to reputation are formed.

Opinion Agenda-setting

As Walker (2010) noted: 'A good reputation can lead to numerous strategic benefits such as lowering firm costs, enabling firms to charge premium prices, attracting applicants, investors and customers, increasing profitability, and creating competitive barriers.' Such a wide-ranging list means that individual benefits can be associated with stakeholder

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groups that can be quite distinct even though there may be overlaps. In fact, a corporation's reputation can differ by stakeholder groups. For example, Walker noted that Walmart had a good reputation for profitability and a poor one for employee treatment.

This paper focuses on just one stakeholder group, the general public. A key trait of this population is that most people will only have the time to think carefully in a limited number of domains. In consequence, most people do not have the basis for understanding technical facts for most issues, and thus are forced to rely on interpretations instead. For an issue for which opinions change rapidly, the mass media constitute the prime candidates for providing the most influential interpretations (Fan, 2012).

These considerations underlie the agenda-setting theory (McCombs, 2004; Scheufele and Tewksbury, 2007) that has been a prominent theoretical and research approach for studies of relationships between the media and public opinion. The original theory proposed that prominent news topics led the public to place these topics high on the public agenda.

The theory was subsequently extended to a second level where the media also can change public preferences by giving information that individuals use to understand, evaluate and respond to events and issues. In addition, the media can provide top-of-mind information that individuals use to access relevant information in memory to change opinions and behaviors.

Agenda-setting effects have been documented in hundreds of field studies around the world ranging from elections to issues at the national and local levels (Carroll and McCombs, 2003). In addition, Iyengar and Kinder (1987) demonstrated in controlled experiments that exposure to news stories can change the salience of issues.

A theoretical framework was proposed by Carroll and McCombs (2003) for extending agenda-setting to corporate reputations. Empirical work has indeed found that media content can change opinion about corporate reputations.

Quantitative studies on agenda-setting type have often used the argument underlying Granger causality as implemented in econometric models (Granger, 1969). The argument is that agenda-setting by the media requires that media content must precede opinion in time.

On the basis of this argument, agenda-setting studies have generally relied on regression analyses to explore the extent to which media content from an earlier time interval t_1 could predict opinion at a later time interval t_2. Significant contributions to the prediction have been used to indicate that the media have an agenda-setting role for opinion.

Inputs to such regression studies have included quantitative scores for media content likely to change opinion, as well as empirical measurements, for the opinion that is presumed to have changed in response. Regressions of this type have included the exploration by Carroll (2009) of relationships between *New York Times* content and companies' reputations measured six months later in a Harris Interactive poll; the use of Dutch newspaper and television coverage by Meijer and Kleinnijenhuis (2006) to predict corporate reputations in Holland one year later, based on a survey of a representative sample of the Dutch public; and the use of newspaper and magazine coverage by Einwiller *et al.* (2010) to predict 29 reputation related attributes derived from a convenience sample of 295 university students in Germany, 11 months later.

These studies using media data aggregated over 6–12-month time period have the potential limitation that corporate image sometimes moves quite quickly, as noted by Walker (2010), even while other aspects of reputation might move change slowly. Furthermore, the regressions were only made for single pairs of media and opinion data at different times rather than for time trends.

To complement earlier studies, this paper uses the media to predict reputations as time trends. Doing so illuminates both the media and the time actually needed to form opinions related to reputation. These considerations lead to this hypothesis:

H1: *Media time trends can give good predictions of corporate reputation time trends.*

Intermedia Agenda-setting

Before the advent of the Internet, journalists and mass media were restricted to organizations with the wherewithal to transmit large numbers of identical messages to a mass audience.

However, individuals can now use the Internet in both an interpersonal communication mode where a message sender expects a reply and in a mass media mode where the sender aims a message to a large number of potential readers with no expectation than any will respond. Persuasive messages sent by individuals in mass media format include blogs and Internet forums. Information from such Internet sources have sometimes been referenced as being crowd-sourced because the information comes from a large collection of individuals.

For the general public, mass media persuasive information can come from all channels that can carry messages to a wide audience and therefore encompass blogs and forums, as well as the mainstream media. For brevity, the term mass media will sometimes be shortened to media.

As the Internet has become more prominent, an accompanying issue is the role of Internet communications in agenda-setting. In terms of persuading the public, the end result will be the same if the content of blogs, forums and the mainstream press all have about the same content at approximately the same time.

Therefore, one question is the synchrony of these media types. This synchrony can be because of intermedia agenda-setting where information is transferred from one medium to a second, thereby setting the agenda of the second outlet.

Research into intermedia agenda-setting has also used the Granger argument. As with the setting of the public agenda, a prevalent strategy is to perform regression analyses where information from a first medium in an earlier time interval t_1 is used to predict the information in a second medium at a later time interval t_2. Statistically significant contribution to the prediction is interpreted as the first outlet helping to set the agenda for the second.

Using this strategy, a number of investigators have performed regressions cross-lagged in time. In the simplest case, there are two news outlets, A and B. Content from outlet A at t_1 is used to predict content in both outlets A and B at t_2. That could occur when newspaper A gets information before outlet B and passes that information on to a newswire like the Associated Press (AP), which then forwards the information on to other newspapers. Simultaneously, newspaper B reports a new finding that then appears in other newspapers for simultaneous two-way intermedia agenda-setting.

Obviously, this intermedia transfer can occur among all media types including the mainstream press and Internet channels like blogs and forums.

As with opinion agenda setting, the sizes of time intervals t_1 and t_2 are of crucial importance. The optimal time for seeing an effect is the time required for information to pass from one outlet to another. Researchers have recognized that the time between t_1 and t_2 could be in the range of one day to a few weeks as reviewed by Vliegenthart and Walgrave (2008). Other reports using similarly short time spans have included Meraz (2011); Sikanku (2011); Sweetser *et al.* (2008); and Lim (2011).

Perhaps the most comparable data were those of Meraz (2011) and Sweetser *et al.* (2008)

because both explored the intermedia effects among political blogs and the mainstream media in the United States. The Meraz study was for 2007 data with the optimal time interval *t* for intermedia effects being one day. Sweetser *et al.* used *t* intervals of one week for 2004 data. The Meraz and the Sweetser *et al.* studies combined showed complex intermedia agenda-setting with blogs setting the agenda of the traditional news, as well as the reverse.

In general, intermedia agenda-setting studies are consistent with the rapid synchronization of persuasive information among both the news and the social media. Further support for rapid media synchrony was found in other studies using short time intervals *t* in a wide variety of geographies with Sikanku (2011) examining non-newspaper website coverage and newspapers in Ghana; with Lim (2011) examining newspapers and newswires in Korea; and with Vliegenthart and Walgrave (2008) comparing newspapers with television in Belgium.

The result of rapid transfer of content among the media would be similar opinion predictions based on any media type alone and hence this hypothesis:

H2: *Different media types are sufficiently synchronous that predictions of corporate reputation time trends should be quite similar from any one media type or from any combination of media.*

TOYOTA CASE STUDY

The automaker Toyota provides a good case study for exploring **H1** and **H2** for two reasons. First, time trend data finely spaced in time were available for both media coverage and opinion about reputation. Second, opinion changed markedly and rapidly over time. Time dependent change is essential for time trend studies because opinion constancy can be explained in a large number of trivial ways.

Toyota built a world-class corporate brand reputation based on its commitment to quality, reliability, continuous improvement, customer focus and excellence in design and manufacturing (Liker, 2004; Quelch *et al.*, 2011; Spear, 2004; Stewart and Raman, 2007). Toyota's reputation brought many benefits including market share, customer loyalty and financial strength. According to Quelch *et al.* (2011) and Steinmetz (2010), Toyota's rapid growth put strains on design, engineering and manufacturing that led to a succession of quality issues and recalls beginning in 2003.

National attention in the United States began to focus on Toyota's quality problems with the release on 10 September, 2009 of a recording of a 911 call of a crash on 28 August, 2009 of a car driven by an off-duty California highway patrol office resulting in the deaths of the officer and his family. This incident led to the recall of 3.9 million vehicles in the United States on 29 September, 2009 because of uncontrollable acceleration ascribed to floor mat problems leading to sticking accelerator pedals.

The serious nature of Toyota's problems grabbed national attention in late January and early February, 2010: An additional 2.3 million vehicles were recalled for sticking accelerator pedals. Toyota suspended sales of eight models in North America, expanded recalls to Europe and China and shut manufacturing plants. Company President and CEO, Akio Toyoda, apologized for the recalls. A third recall involved a company bestseller, the Prius Hybrid, for braking problems. Recalls totaled about 8 million vehicles worldwide in 2009 and 2010, including 6 million in the United States.

Subsequently, the Department of Transportation and the National Highway Transportation Safety Board increased scrutiny of Toyota. Congressional hearings were held in March, 2010. Toyota's strong corporate brand reputation did buffer the company at the start of the crisis (Jones, 2010). However, Toyota's responses were seen as inadequate

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and began to strain the trust of the public, car buyers, regulators and government officials. Toyota vehicle sales in the United States fell 16 percent in January, 2010 and 8.7 percent in February compared with the same months in 2009. Toyota shares lost 11.6 percent through 23 February, 2010 at a time when the Dow Jones Industrial Average lost 0.23 percent (Quelch *et al.*, 2011).

METHODOLOGY

This paper used quantitative media content scores in the ideodynamic model (Fan, 1988; Fan and Cook, 2003) to predict the time trend of Toyota's reputation. 'The model has been used in successful predictions of more than 60 opinion time trends ranging from public concerns that drugs are the most important problems in the United States to polls of political preferences prior to elections in the United States, Germany and the Netherlands. Behavioral modeling has extended from use of cocaine by high school seniors to infection of gay men by the HIV virus' (Fan and Cook, 2003). An ideodynamic study in the corporate domain was a study about caffeine-free colas (Tims *et al.*, 1989).

Ideodynamic Model

The ideodynamic model uses the perspective of global positioning system (GPS) navigational devices found in automobiles where the computation begins at an initial position. Then the device proposes changes to give a complete trajectory from two types of input, the initial condition and instructions for change at every later time point.

In an equivalent way, the ideodynamic model uses differential equations to implement the same strategy to predict opinion through time. The initial conditions are opinion values at the onset of the time trend predictions and can come from empirical data values or from constants optimized to give the best fit to actual opinion time trends. The equations of the model then specify how opinion should change upon receipt of new persuasive information, one time unit after another.

This paper used the ideodynamic model to predict the time trends of public opinion about impressions of the Toyota corporate brand, as expressed in surveys. Polls divided opinion into the three categories of positive, neutral and negative for Toyota. The calculations for the model begin with estimated initial values for the three opinions.

Subsequent time trends then obeyed the model's equations implementing the condition that persuasive information should move people from one opinion to another. At any given time, that information was quantified as the number of media documents scored as favorable (pro-) and unfavorable (con-) to Toyota. Documents neutral toward Toyota did not enter the model because they should not change favorability toward the brand.

Content scores from every type of document were multiplied by a persuasibility constant K to give a persuasive force. Then each type of force was modeled to act on a target population to persuade a fraction of its members to move to a destination population.

In one transition (Figure 1), the persuasive force was favorable to Toyota. That force was assumed to cause some people in a target public with a negative opinion to change their minds and join the destination population holding a neutral opinion. The persuasive force was computed by multiplying the number of favorable documents by persuasibility constant K_3. Higher K values corresponded to associated documents being more persuasive.

The other transitions in Figure 1 were for movement from neutral to positive opinion due to positive messages with persuasibility constant K_4, from positive to neutral opinion due to negative messages with persuasibility constant K_1 and from neutral to negative opinion due to negative messages with persuasibility constant K_2. All four constants were allowed to have different values, thereby giving four constants to estimate. Conversions

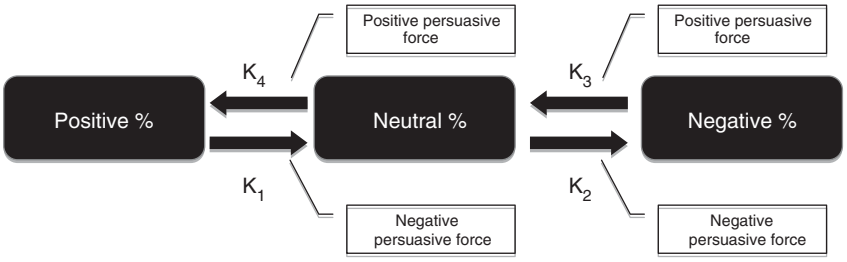

***Figure 1**: Ideodynamic model for predicting changes over time in the percentage of the population with negative, neutral and positive opinions. Persuasibility constants K_1–K_4 give the weights for pro- and con- messages used for computing the persuasive forces moving individuals from one subpopulation to another as discussed in the text*

to and from all populations could occur simultaneously. The equations describing the conversions of Figure 1 are described in Fan (1988) and Fan and Cook (2003).

The initial conditions were the percentages of the population in each of the pro-, con- and neutral subpopulations at the beginning of the modeling on 1 January, 2009, nine months before the significant events of the Toyota recall crisis. These percentages were unknowns to be estimated along with the other constants of the model. That added two constants corresponding to pro-opinion and con-opinion for brand impression. The third opinion of neutral impression was computed by subtracting the pro- and con-opinions from 100 percent. These two opinion constants together with the four persuasibility constants led to the estimation of six constants.

The computation began with the initial conditions and then proceeded with calculations of predicted pro-, con- and neutral opinion every 24 hours assuming that a persuasive message had a decay half-life of zero days consistent with studies, such as Fan and Cook (2003) showing that persuasive information is very quickly forgotten. This condition corresponds to the population acting mainly on new information. A rapid response means that old information must be quickly forgotten.

In the model in Figure 1, individuals could not shift directly from positive to negative opinion in one step; rather, they had to transit through the neutral position. Similarly, information unfavorable to Toyota was modeled to shift individuals away from positive through neutral to the negative stance in two steps. A person could move rapidly through the neutral opinion from one extreme to the other upon receipt of two pieces of information. The model assumed no reinforcement mechanisms.

Obviously, variations in these models could be conceived including the shortcut of moving directly from negative to positive opinion and *vice versa*. However, the good success with the Figure 1 model indicates that the predicted time trend would not be improved much by alternate models.

The ideodynamic method can continue to predict opinion time trends so long as persuasive information data are available.

In linear autoregressive models used for time trend analyses including those of the Granger (1969) type, inaccuracies in the predictions increase as time proceeds if there are errors in media measurements and if predicted opinions are used for predictions at later times. To prevent the error growth, linear time trend models typically use empirically measured opinions in one time interval to predict those in the next.

It might be expected that the ideodynamic predictions would also become progressively less certain over time if the only input is

persuasive information measured with error. Fortunately, the statistics of the model shows that the certainty in the prediction does not grow without limit (Fan and Cook, 2003). Instead, the variance converges to a stable value. Therefore, accurate trajectories of all opinion time trends could be and were computed daily from media data alone because the media were available at those time spacings.

The predicted time trends could be compared with measured opinion whenever they were available, namely, weekly in this study. The restriction of the predictors to persuasive information alone further makes the prediction exquisitely sensitive to input persuasive information because the computation omits prior opinion values that typically have a large effect on current opinion.

Toyota Brand Reputation Data

The corporate brand reputation data used in this research were kindly provided by YouGov.com from its ongoing BrandIndex surveys. The data were for the time period from 1 January, 2009 through 3 March, 2011 for the United States. The BrandIndex survey was conducted over the Internet using an opt-in panel of the general public.

The daily BrandIndex sample was weighted using propensity scores on gender, age, education, race and income. The sampling frame used for weighting was derived from public use microdata files of the 2005–2007 US Census Bureau's American Community Survey. For the propensity score weighting, let X_i denote a vector of measurements on the ith respondent and R_i, a response indicator for this respondent. We defined the propensity score for the ith respondent by $e(X_i) = P\{R_i = 1 \mid X_i\}$,which is often assumed to be in the form of a logistic regression. In such cases, case-control methods allowed for estimation of the parameters of the propensity score by combining the self-selected sample with a random sample from the same population.

The key result on propensity scores is because of Rosenbaum and Rubin (1983) who showed that R_i and X_i are conditionally independent, given the propensity score $e(X_i)$. The import of this result is that, in the case of ignorable selection, it suffices to balance a sample on the propensity score. Instead of weighting on a large number of variables, calculations are made for a propensity score and sample weights that approximately balance the sample on the propensity score. This converts a difficult high-dimensional weighting problem into a much simpler and more tractable one-dimensional weighting problem.

The BrandIndex survey tracked public perceptions of corporate brand reputation using questions in the following areas (YouGov.com): (i) quality, (ii) value, (iii) customer satisfaction, (iv) corporate reputation, (v) general impression, (vi) recommendation, (vii) buzz (whether people have heard anything positive or negative about the brand in the media or through word of mouth) and (viii) attention (the percentage of the general public that has heard anything, positive or negative, about the brand in the media through word of mouth).

The respondents for this Toyota project answered questions about companies in the automotive sector. The online survey instrument provided a list of automotive brands to respondents and then presented two questions: (i) 'Overall, of which of the following brands do you have a *positive* impression?' and (ii) 'Now which of the following brands do you have an overall *negative* impression?' Respondents including Toyota in their responses to the first question were assigned to have a *positive* or 'pro' impression of Toyota. Similarly, respondents including Toyota in their responses to the second question respondents were categorized as having a *negative* or 'con' impression of Toyota. Respondents were considered to be *neutral* if they did not list Toyota for either of these two questions.

The total survey required about 8–10 min to complete. The survey also included questions

regarding current affairs, respondents' lives and personal views on a range of topics, as well as demographic questions about the respondent.

Approximately the same number of responses was obtained for Toyota each day from Monday through Friday including holidays. For the time trend analysis, all responses were aggregated for each Monday–Friday time interval and were assigned to the Wednesday in the middle of the week. The average number of responses per week was 647, with a standard deviation of 76.

BrandIndex used the reciprocal of the square root of the sample size to calculate the confidence interval. The average of 647 respondents per week gives 4 percent as the approximate 95 percent confidence interval.

Media Data

This study was based on documents (or texts, these terms being used interchangeably) from five categories of media: (i) print newspapers, (ii) online editions of print newspapers, (iii) the AP newswire, (iv) blogs and (v) Internet forums. All documents were collected and scored using evolve24's system. Other potentially useful data not included were broadcast television news, Twitter feeds and advertising. A complete list of media outlets in this research is available from the authors.

Newspapers

Twenty-five print newspapers were included because the stories were written by professional journalists, typically including a degree of journalistic balance, passed through a copy editing process and may have benefitted from the credibility of the publication. For this study, 24 leading daily newspapers were included and were considered to be representative of the daily newspapers to which the American public was exposed. Stories were obtained from the leading electronic database ProQuest Dialog™.

Unfortunately, no news aggregator database such as Dialog™, Factiva™ Lexis-Nexis™ or the online editions of newspapers (to be discussed below) can be considered to be a complete archive of stories appearing in the print editions because 'content originating with wire services is typically stripped out of newspapers before stories are archived' (Weaver and Bimber, 2008). This was not a trivial loss because a good deal of news, especially national news distributed at the local level, comprised wire stories (Weaver and Bimber, 2008). The removal of news content extends beyond wire stories to all documents to which a newspaper does not have clean copyright including the works of freelance journalists who did not give explicit permission.

This inability of electronic databases to represent the news that readers see originated with the US Supreme Court ruling in *New York Times Co.* v. Tasini, 533 US 483 in favor of freelancers (Freeman, 2001). The unrepresentativeness of news aggregator databases has not been widely recognized by researchers.

Online news

This study also included the online editions of all print newspapers included in this research (eg, *Los Angeles Times* and latimes.com). Online and print versions of newspapers are similar but not identical (Paterson and Domingo, 2008).

According to a December 2010 Pew Center survey, 41 percent of Americans said they got most of their national and international news from the Internet compared with 66 percent from television and 31 percent from newspapers, with both television and newspapers on downward trends (Pew Center for People and the Press, 2011). Furthermore, the print and online could reach and appeal to different audiences.

The online newspaper stories were obtained through Boardreader (www.boardreader.com), a leading Web search engine and document aggregator. Boardreader scaned millions of distinct URLs daily and maintained a complete archive of documents going back

four years or more. However, like Dialog and other aggregators, online news from Boardreader was also stripped of syndicated content such as that from the AP and other newspapers.

Newswires

The AP newswire from Dialog was included because AP stories were a primary source of news articles in newspapers around the United States. As noted above, databases like Dialog contained original stories written by the AP wire, but few of the other AP stories that readers see are in print and online news stories.

Blogs

The media data included the 11 blogs with the highest number of posts or articles about Toyota. These were all automotive blogs. The blog content was obtained through the Boardreader search engine as described above.

Internet forums

Finally, the media data set from Boardreader included texts from 12 Internet forums with the highest numbers of posts related to Toyota. These texts tended to be short, to be written in an informal style and to carry strong opinions.

Text Analysis

The media documents were analyzed by evolve24 for document sentiment specific to the reputation of the Toyota. First, evolve 24 determined whether a sentiment is fact or opinion. Factual sentences were considered neutral for purposes of this study. Second, evolve24 used a statistical model to identify and match subjective patterns within a document and assigned a tone (positive, negative or neutral) to each sentence. The sentence-level sentiment scores were then aggregated to give a document-level sentiment score for Toyota. Each document was assigned to be positive, negative or neutral and all documents were given the same weight, regardless of length. Persuasive forces were computed from numbers of positive and negative documents.

RESULTS

H1 and **H2** were both addressed by exploring the extent to which the ideodynamic model of Figure 1 could predict time trends of public opinion from five types of information: blogs, Internet forums, print editions of newspapers, online editions of news outlets and the AP newswire.

The numbers of documents scored as pro- and con- for Toyota for the entire time period of the study (Table 1) ranged from 4,557 for blogs to 50,979 for forums. The ratios of pro- to con- information were all in the range of 0.6–0.7 with the outlier being the AP newswire with the value of 0.3.

The pro- and con-Toyota scores from each type of media were used separately to predict simultaneously the time trends of positive, negative and neutral impressions of Toyota with computations made every 24 hours. With three time trends over the 113 weeks of the study, there were a total of 339 data points for the estimation of constants in the model. However, only two-thirds of the data points (226) were independent because the three opinion percentages for pro-, con- and neutral added to 100 percent thereby giving 220 degrees of freedom for the six constants estimated, namely, the two initial conditions and the four persuasibility constants.

All estimated persuasibility constants in Table 2 for predictions from the five media types are provided in Lines 1–5 (Table 2). All constants were significant at $p < 0.005$. The performances of the predictions are given both in terms of the root mean squared deviation (RMSD) and the R^2 value.

The R^2 values in Lines 1–4 (Table 3) ranged from 0.754 to 0.821 for predictions based on pro- and con-Toyota scores from blogs, forums, print news and online news. The similarities in performance were consistent with the closeness of the ratios of pro- to

Table 1: Data Used in the Toyota Analysis in Various Time Periods

Line		*Pros*	*Cons*	*Pros + Cons*	*Pros/Cons ratio*
Full time period: 1 January, 2009–31 March, 2011					
	Media count				
1	Blog	1,927	2,630	4,557	0.733
2	Forum	20,864	30,115	50,979	0.693
3	Newspaper	2,321	3,750	6,071	0.619
4	Online news	5,227	7,856	13,083	0.665
5	Wire	1,606	5,260	6,866	0.305
6	Total	31,945	49,611	81,556	0.644
7	Opinion average	48.69%	17.88%		2.724
Pre-crisis: 1 January, 2009–30 June, 2009					
	Media count				
8	Blog	63	38	101	1.658
9	Forum	4,374	5,374	9,748	0.814
10	Newspaper	516	484	1,000	1.066
11	Online news	1,332	1,397	2,729	0.953
12	Wire	117	161	278	0.727
13	Total	6,402	7,454	13,856	0.859
14	Opinion average	58.61%	7.83%		7.482
Post-crisis: 1 July, 2009–31 December, 2010					
	Media count				
15	Blog	669	763	1,432	0.877
16	Forum	4,135	5,529	9,664	0.748
17	Newspaper	437	671	1,108	0.651
18	Online news	864	1,238	2,102	0.698
19	Wire	122	590	712	0.207
20	Total	6,227	8,791	15,018	0.708
21	Opinion average	42.92%	23.14%		1.855

Each set of rows gives counts of documents, as well as average reputation, as an opinion percentage.

con- scores for the same four data series. The AP wire content with more negative stories predicted less well with an R^2 value of 0.657 (Table 2, Line 5).

The similarity between the RMSD and R^2 values for the individual media types of Lines 1–4 suggests that blogs, forums, print news and online news have much the same content thereby supporting **H2**. The low RMSD and high R^2 values further indicate that these media types each are quite representative of the total information used by the public for forming opinions about Toyota's reputation, thus also supporting **H1**.

In addition to predictions using scores from individual types of media, a prediction was also made from all types of scores combined. In one study (Table 2, Line 6), each of the four persuasive forces in Figure 1 was simply the sums of all the comparable media scores used for Lines 1–5 multiplied by a common persuasibility constant. With the media dominated by forum documents, that meant that forum scores made the greatest contributions to the prediction. The set of media scores constructed by simply adding the scores from the different media did improve the R^2 value to 0.840 (Table 2, Line 6), a value marginally higher than that for forum scores alone (0.821).

In an alternate method, each type of media scores was allowed to have its own weight in the form of a different persuasibility

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Table 2: Models for Predicting Positive, Neutral, and Negative Impressions of Toyota

Line	*Media scores*	*Initial Opinion (in percentage)*		*Persuasibility Constant*				R^2	*RMSD (in percentage)*
		Pro	*Con*	K_1	K_2	K_3	K_4		
1	Forum	63.63	3.86	1.00	0.56	1.24	1.91	0.821	4.8
2	Blog	54.72	8.20	1.00	2.55	4.66	1.66	0.754	4.1
3	News	54.22	7.46	1.00	0.99	2.59	2.00	0.790	4.5
4	Web	56.00	4.24	1.00	2.00	4.81	1.86	0.766	4.6
5	Wire	56.04	8.23	1.00	3.72	15.39	1.90	0.657	5.0
6	All (combined)	56.78	3.35	1.00	0.73	1.78	2.05	0.840	4.5
7	All (individually)	59.75	7.38					0.856	3.2
8	Forum			1.00	?	0.450	0.89		
9	Blog			?	3.090	3.760	?		
10	News			?	3.460	12.610	10.40		
11	Web			?	?	?	?		
12	Wire			?	1.690	?	?		
13	All (individually)	60.29	7.05					0.853	3.2
14	Forum			1.00	?	?	0.88		
15	Blog			1.64	4.11	5.69	?		
16	News			?	?	5.93	9.87		
17	Web			?	1.00	3.90	?		
18	Wire			?	1.52	?	?		

All persuasibility constants are significant at 95 percent confidence and are relative to K_1 arbitrarily set to 1.0 for ease of comparison. Question mark values for persuasibility constants indicate that the values are not significant at $p < 0.5$. All other estimated values are significant at this level.

constant. As was a set of four persuasibility constants in Figure 1, the more detailed model had five sets of constants, one for each of the five media types. The result was 20 persuasibility constants and the usual two initial opinion values for a total of 22 constants to be estimated simultaneously.

The parameter estimations were performed using the Nelder and Mead (1965) simplex algorithm seeded in 30 runs with different random numbers. The best estimates for the 22 parameters are shown in Table 2 (Lines 7–12). Line 7 gives the two opinion estimates along with the RMSD and the R^2 values. Lines 8–12 give the 20 persuasibility constants for each of the five types of media with all values not significant at $p > 0.05$ indicated by the ? symbol. The same type of presentation is used for Lines 13–18 (Table 2) for the next best set of estimated constants.

Table 3: Ratio of Average Positive to Negative Persuasibility Constants from Table 2

Media channel	*Positive/Negative*
Blog	1.8
Forum	2.0
Newspaper	2.3
Online newspaper	2.2
Wire	3.7
All (combined)	2.2

The persuasibility constants for the best (Lines 8–12) and next best (Lines 14–18) sets of persuasibility constants were quite different. Nevertheless, the RMSD and R^2 values were the same for both out to two decimal places. Therefore, essentially the same R^2 could be obtained from quite varied sets of parameters.

The explanation is that all media types were similar in their abilities to predict opinion from Lines 1–4. As a result, the media types were close to being interchangeable, so any one media type could take a dominant or a subservient role for opinion predictions depending on the random numbers used for seeding the parameter estimation. A natural consequence was the disparate persuasibility constants in estimations, as shown in Lines 7–12 and Lines 13–18. Therefore, these inconsistent constants are also consistent with **H2**.

However, the marginal improvement due to the inclusion of more media types did indicate that any one medium was not entirely complete, even if it was close to being representative of all the relevant persuasive information used by the population.

For ease of comparison, all persuasibility constants were relative values normalized to K_1 with the constant given the arbitrary value of 1.0. One striking feature was that the pro-Toyota scores were consistently more persuasive than con-Toyota scores for all predictions in Table 2. The effect can be quantified by averaging the two pro-Toyota persuasive constants, K_1 and K_2, and dividing by the average of the two con-Toyota constants, K_3 and K_4. This division yielded the values in Table 3. If the outlier of 3.7 corresponding to the AP wire is omitted, then the average is 2.1 times with a standard deviation of 0.2. In other words, pro-Toyota information was generally about twice as persuasive as con-Toyota messages.

Figures 2–7 give both the media scores used in the prediction and the opinion time trends predicted using the estimated constants of Table 2. Visual inspection of the figures for all media types shows that pro- and

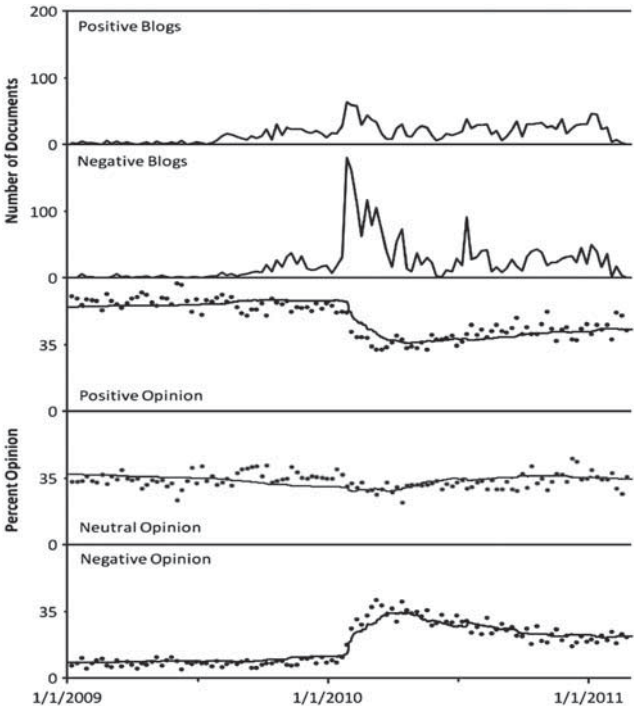

***Figure 2**: Predictions of impressions of Toyota's reputation from blogs. Parameters and statistics for the predictions are in Table 2, Line 2. The top two frames give the counts of pros-Toyota and con-Toyota documents summed by the week. In the lower three frames, the dots give empirically measured opinion, whereas the lines give the daily predicted opinion values*

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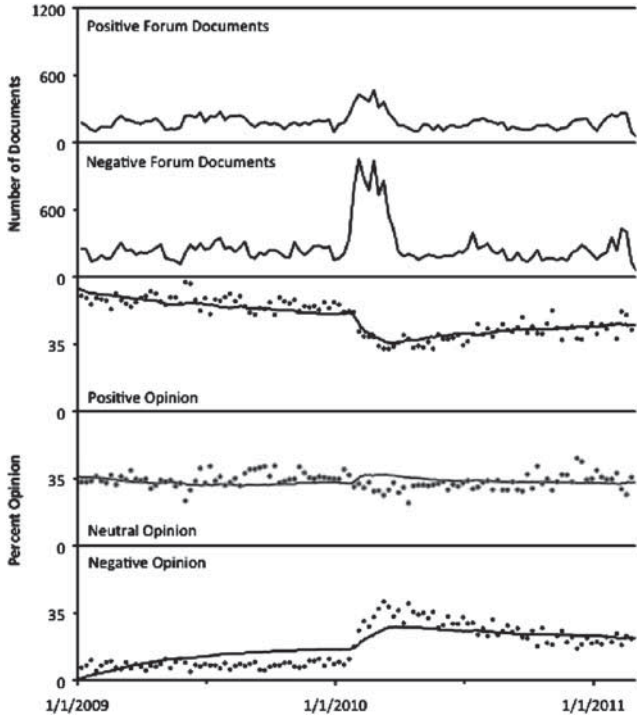

***Figure 3**: Predictions of impressions of Toyota's reputation from forum documents. Parameters and statistics for the predictions are in Table 2, Line 1. The layout of this figure is the same as in Figure 2*

con-Toyota news changed little throughout 2009. A noteworthy difference was the rarity of both pro- and con- coverage in blogs and the AP wire in this time period relative to the other types of documents. However, the volume of both pro- and con- content in the blogs did climb a small amount toward the end of 2009, following a succession of Toyota announcements: the 29 September, 2009 recall of 3.8 million vehicles, the 2 November recall of floor mats and the 25 November announcement of measures to prevent floor mat interference with accelerator pedals.

During 2009, the predictions of pro-, con-, and neutral opinion moved slowly with all trajectories being reasonably similar for all types of media. Some lines rose or fell slightly, whereas other lines were closer to flat. The negative information in the automotive blogs toward the end of 2009 was not echoed by the other media and hence did not have a major impact on opinion. The non-blog media seemed to have ignored the recalls in the fall of 2009 because recalls in the auto industry are a regular occurrence.

Figures 2–7 showed pronounced spikes of negative news beginning in early 2010. Toyota recalled another 2.3 million vehicles on 21 January, 2010, suspended sales in North America of eight models on 26 January, expanded the recall to 1.1 million vehicles on 27 January to include Europe and China, and announced a mechanical fix to accelerator pedals on 1 February with the Toyota CEO personally apologizing for the quality problems and recalls on 5 February. In some, but not all, of the figures, there was also a noticeable rise in pro-Toyota information at the same time.

During the surge in negative news, the predictions were for marked drops in favorable opinion and an accompanying increase in

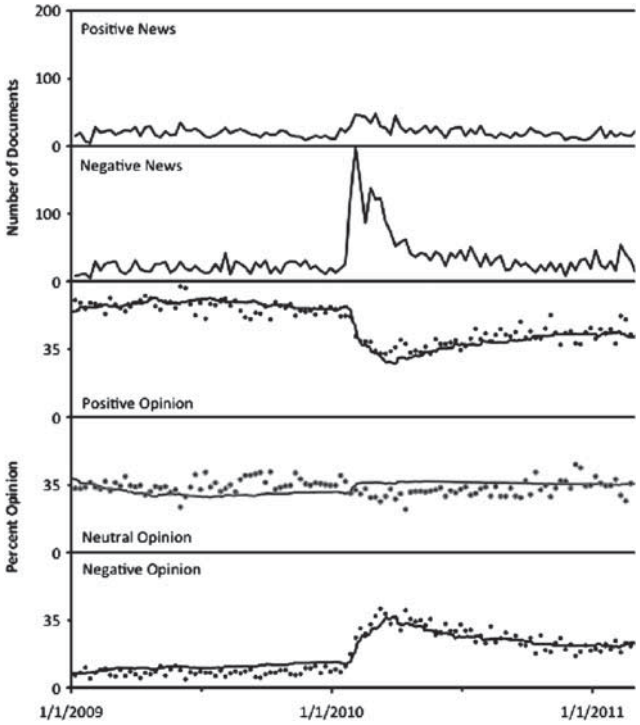

***Figure 4**: Predictions of impressions of Toyota's reputation from print newspapers. Parameters and statistics for the predictions are in Table 2, Line 3. The layout of this figure is the same as in Figure 2*

unfavorable impressions (bottom three frames of Figures 2–7). The model predicted approximate constancy for neutral opinions.

After the first quarter of 2010, information about Toyota both decreased in volume and approached a steady state again. Visual inspection of Figures 2–7 showed that the patterns were not quite the same across all information types. Blog posts had consistently higher volumes of both pro- and con- after the spike relative to before. There were also more AP stories than before the shock, but there continued to be a larger proportion of negative than positive stories. Text from forums, print newspapers and online news returned to their approximate volumes of early 2009.

Predicted opinion time trends for all media except the AP showed a gradual rise in favorable impressions accompanied by a drop in negative opinion. However, the AP had so much negative news from the second quarter of 2010 onwards (Table 1 and Figure 6) that the positive news was unable to increase favorable opinion. A consequence was the lower R^2 value for predictions from AP news alone.

These qualitative interpretations from Figures 2–7 were supported by the ratios of positive to negative values for both media document counts and opinion about Toyota (Table 1).

Among the media studied, forums are perhaps the most interesting because they include authors who are the best candidates for being contributors to crowd sourcing. After all, forums have the lowest barrier to entry for media generation. All the other media scored have higher barriers with blogs, for example, requiring a setup process that forums do not.

As seen visually in Figure 6, Line 9 (Table 1) gives a pro/con ratio (0.814) for forums before the crisis that is very similar to the Line 16 value (0.748) after the crisis.

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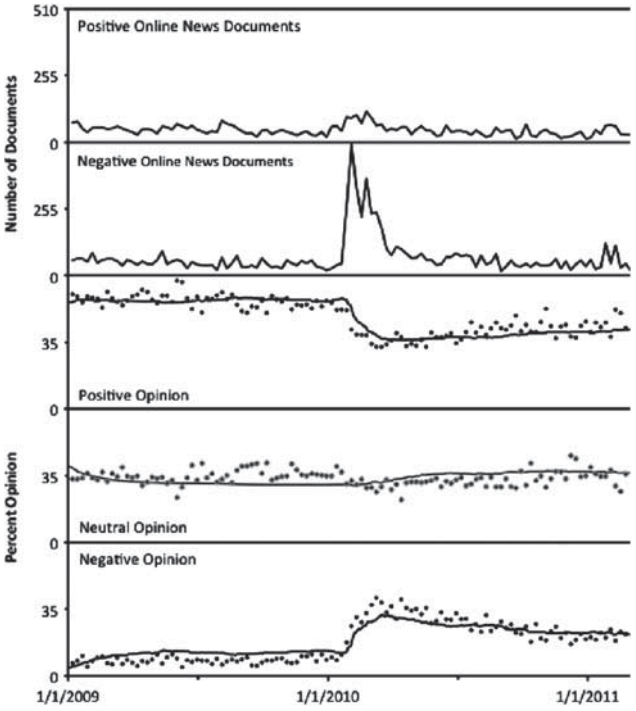

***Figure 5**: Predictions of impressions of Toyota's reputation from online news (web editions of newspapers). Parameters and statistics for the predictions are in Table 2, Line 4. The layout of this figure is the same as in Figure 2*

In contrast, the pro/con ratios for opinion were quite different being 7.482 before the crisis and 1.855 afterward, a difference that is much more pronounced than for forum content.

The explanation is that opinion had not yet equilibrated with the media structure in the latter time period, as seen in the continued rise of pro-opinion in the center frame of Figure 7, despite approximately constant media time trends in the top two frames.

These data show that it is dangerous to use crowd sourcing form forums and other social media as a replacement for public opinion. Instead, forums are like any other medium in providing information to a generally inattentive public whose response can be predicted using the ideodynamic model.

DISCUSSION

H1 was that the ideodynamic model should give good predictions for public opinion over time for the Toyota commercial brand. This paper shows that the predictions were quite good with R^2 values in the range of 0.8 when media coverage alone was used for the predictors. These R^2 values actually do represent the ability of information to move the public because none of the predictors were empirically measured opinion in contrast to linear autoregressive models.

H2 was that different media types would move quite synchronously in time because prior intermedia agenda setting studies had already indicated that information can flow from one medium to another within one to a few days. Therefore, it was conceivable that the diffusion of information from one medium to another was sufficiently rapid, that all major media were sufficiently synchronous and were able to represent the relevant information influencing public opinion.

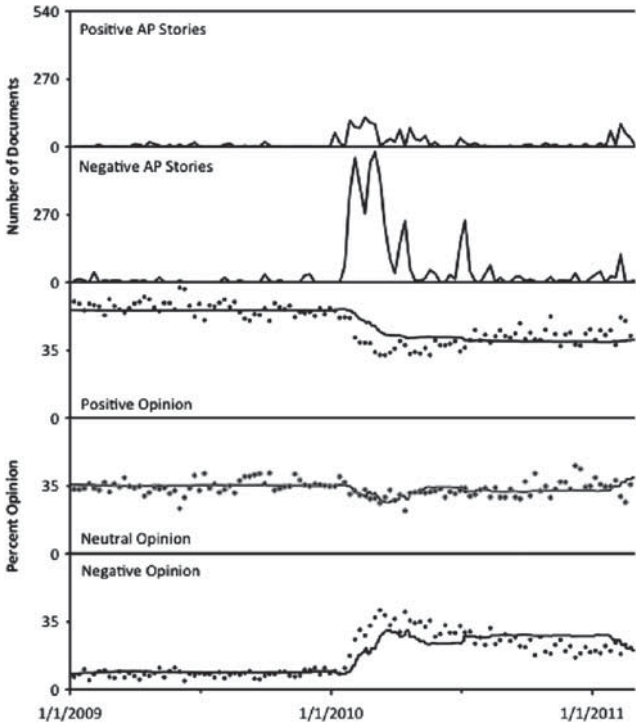

***Figure 6**: Predictions of impressions of Toyota's reputation from AP news wire stories. Parameters and statistics for the predictions are in Table 2, Line 5. The layout of this figure is the same as in Figure 2*

This media consonance was indeed observed because good predictions of Toyota's reputation from surveys could be made from a variety of media including newspapers, online news, blogs and forums. The R^2 values improved marginally from the range of 0.754 to 0.821 (Table 2, Lines 1–5) for individual media channels to the range of 0.840 to 0.856 for the all media combined (Lines 6, 7 and 13). As discussed above, this media similarity was further supported by the highly variability in persuasibility constants for various media types when each type was allowed to have its own set of constants.

A useful assessment of the quality of the media used for the analysis was the ability to predict opinion time trends. Media samples that were biased or were too small would have given poor predictions. Aside from the AP, the high R^2 values for the predictions suggested that the media samples were both of adequate size and were reasonably representative of the information moving the public.

An implication is that the media analyzed already included the major effects of other media including broadcasting and advertising. One possibility is that these omitted communications could have had their main impacts by being retransmitted in the news, blogs and forums.

The analyses in this paper further argue that crowd sourcing of media generation should not be confused with public opinion because the media, including crowd sourced media, are generated by people motivated by the topic studied, whereas opinion in the general population is because of members who were intently involved in their own issues but only peripherally concerned about other topics. In other words, crowd sourcers and general public members are two quite distinct stake holders who can hold quite different viewpoints.

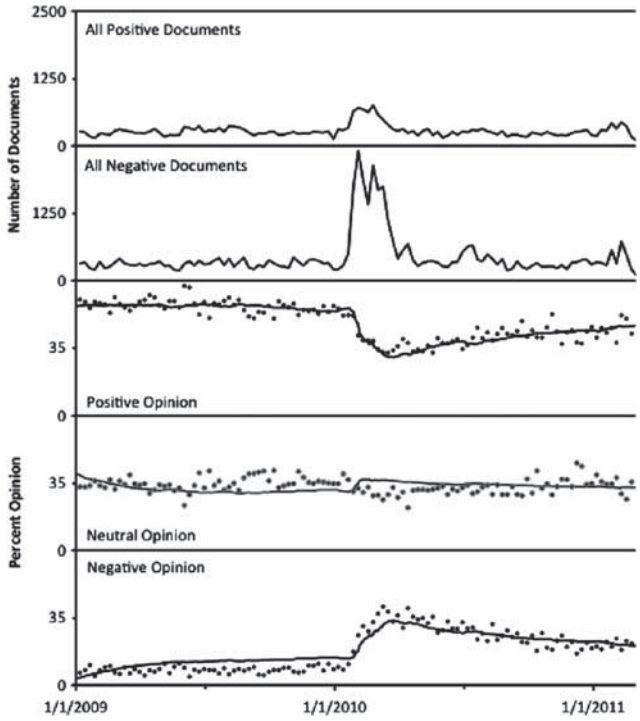

***Figure 7**: Prediction of impressions of Toyota from all documents combined without weighting. Parameters and statistics for the predictions are in Table 2, Line 6. The layout of this figure is the same as in Figure 2*

The persuasibility constants giving the high quality predictions in Table 2 corresponded to positive information being generally twice as effective as negative information (Table 3), a finding that does not support an intuitive worry about the higher impact of unfavorable information.

The good opinion predictions also have implications for the sizes of the samples used for the analyses. The total samples for individual types of media scores giving the highest R^2 (Table 2, Lines 1 and 3) were the news media with 6,071 documents and forums with 50,979 documents (Table 1). Therefore, the 8.4-fold difference in sample size only yielded a marginal increase in predictive accuracy. Consequently, the very much larger forum sample sizes did not greatly improve the opinion predictions. The caveat, of course, is that there could have been some differences in content between these two media.

The greater importance of representativeness over sample size was seen in the AP sample giving a distinctly lower R^2 of 0.657, despite a sample size of 6,866 that was somewhat larger than the 6,071 for the news media sample. The difference in representativeness was due to the news media sample including information from a wider variety of publications and writers, as discussed in the Methodology section above.

Another striking example of the greater importance of representativeness was the failure of the Literary Digest opinion poll of 1936, which mispredicted the presidential election by 20 percent, despite a sample size of 2.3 million (Squire, 1988).

This paper has demonstrated the similarity of information flowing through different media and the completeness of these channels for carrying information representative of persuasive information used by the public.

A next step will be to explore the reasons given in the media for favorable and unfavorable views. The content analytic tools used so far have been general in nature and have only scored texts for connotations of positivity and negativity without concern for the underlying reasons. Other analytic tools will need to be deployed to extract the rationales. These reasons will then be useful for determining communication strategies that succeeded or failed in improving a corporation's public reputation.

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