

MULTIVARIATE TIME SERIES USE FOR THE MEASUREMENT OF SOCIAL MEDIA EFFECTS

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By providing a shift from the traditional one-way communication to an expanded dialogue between an organization and its publics, social media platforms are changing the way they connect with each other. This manuscript presents a methodology that will help measure the social media effort as part of an organization or company's marketing efforts. Specifically, this exploratory approach uses time series analysis to measure the impact of various social media activities for a non-profit organization. The results of the analyses are encouraging and suggest the model as conceptualized is able to establish which social media activities exhibited a significant relationship to the web metrics of the organization.

INTRODUCTION

Over the last several years, social media has arrived as an important part of many organizations' and companies' communication strategies. Just two years ago, over \$2 billion was spent on social media advertising and predictions indicate that spending may reach \$8.3 billion by 2015 (MarketingProfs 2011). Facebook, Twitter and YouTube, for example, have rapidly grown in size and importance. With now over 800 million active users on Facebook and upwards of 175 million registered users of Twitter, social media has not only been integrated into the makeup of consumers' daily lives but is changing the way companies and organizations connect with their consumers (Protalinski 2011; Kirkpatrick 2011).

Seventy-nine of the top 100 companies in the Fortune Global 500 index are using at least one social media platform to interact with their consumers. Of the Fortune Global 100 companies, 65% have active Twitter accounts, 54% have Facebook fan pages, 50% have YouTube video channels and 33% have corporate blogs (Burson-Marsteller 2010). Non-profit organizations as well have embraced use

of social media with 92% of their websites including at least one social media link (Mashable Social Media 2011). As many companies presently use these various social media platforms to build stronger consumer-brand relationships non-profits are finding that social media provides a great opportunity to foster conversations and interactions.

Social media is defined as "a group of Internet-based applications that build on the ideological and technological foundations of Web 2.0, and that allow the creation and exchange of User Generated Content" (Kaplan and Halenlein 2010). The various formats of social media include: blogs, video sharing, photo sharing, social networks, wikis, virtual worlds, micro-blogging and social bookmarking sites, among others. By providing a shift from the traditional one-way communication to an expanded dialogue between an organization and its consumers, social media platforms are changing the way brands connect to their consumers (Qualman 2009).

These social tools have offered brands and organizations a communication channel that delivers a massive audience and it also allows them to communicate in a way not possible before. Social media provides the ability to listen or directly track what kind of response their communication produces. For a business, it eventually all comes down to generating

revenue, so every marketing activity is tracked back to how much it costs and intuitively how much it returns: How much should a brand spend on building a social presence? Does that investment turn into producing a more engaged customer and, by extension, more revenue? A company creates a Facebook page or a Twitter presence because they believe it is going to positively impact the bottom line and increase revenue more than before they had it. In other words, a company must make decisions about the effectiveness of their social media as a communication medium or of their marketing campaign based on their social media.

Unlike most social media studies that are focused on online users' attitudes and behaviors to examine a brand's perception or an organization's communication effort, this manuscript presents an exploratory study that will examine the impact of social media on an organization's website metrics. While users' behavioral studies use either cross-sectional data (i.e. survey methodology) or controlled experiments to identify the possible factors influencing users' perception in social media, this study uses aggregated time series data rather than individual user data. A time-series analysis has an advantage to determine which if any social media variables are related to an organization's website exposure or popularity over time. From a marketers' perspective, social media activities represent opportunities to communicate its marketing message. Therefore, organizations' web site pageviews through social media activities are a good indicator of its web page's exposure in order to measurably increase potential revenue and ultimately, profits for an organization. By the use of this multi-disciplinary approach – time series analysis – various social media variables are included in a regression analysis to determine which if any are related to an organization's website pageviews and website visitors over the time.

LITERATURE REVIEW

A brief review of the effectiveness of traditional advertising media measurement

helps clarify the problem posed by definition/measurement for the new medium of social media. Understanding the impact advertising and other marketing communications have on consumer behavior is a much discussed area of inquiry for communication researchers. From qualitative indicators to sophisticated marketing mix modeling, researchers have attempted to determine the best ways to understand and predict what impact media and messages will have on the consumer. While each method has been shown to be valuable in its own way, the ability of a company to compare how various communication activities perform over time remains an increasingly important topic. This is so important the CEO of one of the world's largest ad companies WPP Group's Marin Sorrell notes, "There is no doubt in my mind that scientific analysis, including econometrics, is one of the most important areas in the marketing-services industry" (Patrick 2005). Mr. Sorrell believes that econometrics can help solve one of the biggest challenges facing the ad industry: how to measure the effectiveness of various communication efforts.

Studies applying a rather long-standing econometric and financial procedure – time series analysis – to measure the impact of advertising expenditures by media type such as traditional electronic advertising (i.e. TV, radio), print advertising (i.e. magazines, newspapers), Internet advertising, etc. have been commonplace in the literature for decades. From Borden's (1942) to Palda's (1964) early innovative work investigating the relationship between sales and advertising, researchers have discussed the various elements and procedures for creating sales response models. For example, Clarke (1976) listed almost 70 econometric sales-advertising studies published between 1962-1975 when the interest in this subject was at an all-time high. In the early 1980s, multivariate time series was developed as a popular alternative to the pure econometric approach for modeling sales response and earned a place as a valuable research tool in marketing for the ensuing years (Leone 1983).

Social media shares many characteristics with traditional media even though it is obviously a new and a unique medium. Both traditional advertising and social media advertising have similar fundamental goals (Pavlou and Stewart, 2002), thus the existing measures of the effectiveness of advertising and other marketing communication may be cautiously applied to social media in an increasingly interactive context. Unlike traditional advertising, consumers now actively participate in the advertising and marketing process through interactive media (Stewart and Pavlou, 2002). For example, consumers using social media and other online communication have a different memory span for recalling content such as an RSS feed or a web blog, so traditional measures have become less relevant. Since social media interactivity for the emerging marketplace requires a greater understanding of the process, there needs to be an alternative way to conceptualize measures of advertising effectiveness. At the same time, traditional measures need to be viewed with caution even though they may not be fully applicable in an interactive context because they are based on a more static paradigm than social media.

Most of the academic and industry research on advertising in digital environments has focused on measuring changes in consumer behavior such as brand awareness, brand attitudes and purchase intentions as a function of exposure (Hoffman and Fodor 2010; Thorsten et al.). Such research is usually done with field surveys or laboratory experiments that use individual level data. However, this study builds on a long tradition in advertising effectiveness models with brand-level time series data. While using time series to determine the impact of advertising media expenditure on sales is a relatively commonplace procedure, the application of this technique to the measurement of social media is yet untested. Ultimately this procedure may be applied in a similar fashion using either sales or website metrics as a dependent measure and social media metrics as the predictor variables. Thus, the focus on understanding the effects of social

media marketing communication activity on the brand/organization may logically shift to website metrics. The next section provides a discussion of this exploratory methodology and theoretical underpinnings and concludes with the research questions examined in this manuscript.

Measurement and Theoretical Issues

Discussions from traditional media research models regarding advertising measurement focused on two primary concepts – reach and frequency. Reach has generally been defined as the number of individuals, households or audience members that are exposed to the media vehicle. Frequency traditionally refers to the average number of times the audience is exposed to the vehicle. Both of these terms have been measured over a specified time period such as monthly or quarterly (Sissors and Bumba, 1996).

For companies and organizations seeking measurable results from social media, traditional advertising effectiveness models offer only fundamental guidance. Social media possess a unique characteristic not found in these traditional models – interactivity or engagement. With the emergence of online advertising in the 1990s, media researchers attempted to add this new component – interactivity – to reach and frequency. Quickly becoming a major theme of the research in advertising and marketing communication literature in the late 1990s, many scholars examined the concept of interactivity as a major construct of interactive advertising effectiveness (Coyle and Thorson, 2001; Lombard and Snyder-Duch, 2001; Macias, 2003; Cho, 1999; Cho and Leckenby, 1997). These studies illustrated the importance of interactivity or engagement in measuring communication effectiveness in an interactive advertising environment.

Sohn and Leckenby (2002) described interactivity in terms of social communication. They suggested that interactivity is a process-dependent concept, not a static attribute-based

concept: individuals' active participation in the interactive communication processes is a crucial factor for increasing the perceived interactivity of the Internet. This change from one-way communication to two-way interaction suggested that the use of traditional measures of consumer effectiveness of marketing communications must be altered in an interactive environment (Stewart and Pavlou 2002). Today the consumer who receives information via the Internet is able to interact or engage with the message and therefore the assessment of social media effectiveness must include not only elements of traditional media such as reach and frequency measures, but also incorporate an interactivity or engagement component as well. While engaging with companies or organizations may not be a user's primary reason for participating in social media, they connect many times for news and information about an organization or a company's products and promotions.

In an attempt to capture the engagement present with social media, Murdough (2010) presents an effectiveness model for social media that includes five phases: concept, definition, design, deployment and optimization. The concept phase includes the specification of the goals and measurement of desired outcomes. The definition and design phases presents where the strategy is determined and the tactics are specified. Execution of the communication program is undertaken in the deployment phase. Finally, the optimization phase examines performance indicators and identifies opportunities for program adjustment. Murdough (2010) emphasizes the importance of a commitment to social media that must include active participation in the social media space. He notes that organizations' and companies' resources should be "thoughtfully planned for and deployed" to effectively manage an organization's social media presence. Essential to this process is a continual measurement of performance indicators and subsequent adjustment of messages to achieve the communication goals.

As Murdough (2010) notes, because of the process-dependent nature of this interactivity or engagement, an ongoing measurement is necessary. Trying to capture this engagement at just one point in time is probably not the most effective and thorough strategy. Therefore, a social media measurement model must include the following dynamic characteristics measured over time: (a) frequency, which measures the rate of occurrence of the communicators' activities, (b) reach, the size of the network and (c) engagement by the audience.

Reach and frequency are terms familiar to media researchers, but interactivity or engagement is a relatively new concept especially in social media. Today, examples of social media engagement may include being a Facebook fan of a brand or organization to "following" a brand on Twitter for discounts and promotions. From a company's perspective, brand managers are obviously interested in knowing if engagement impacts sales and/or website traffic. One survey has reported that 51% of Facebook fans and 67% of Twitter followers reported that they were more likely to purchase a brand after connecting with the brand on Facebook or Twitter (Solis, 2010). Fisher (2009) also discovered that of the 70 percent of consumers who had visited a social media site to get information, 49 percent of these customers made a purchase decision with the information they found and 60 percent of the respondents reported they are likely to pass information they find online to others. Those results support that marketing efforts in social media can result in extremely effective marketing.

Research Questions

The major goal of this exploratory study is to provide an assessment of the use of a times series model as a tool for the measurement of social media effectiveness. Based on this goal two research questions were identified: (1) can the model identify reach, frequency and engagement variables that are related to audience response? and (2) can the model

provide insight in to the importance of those variables? If the model is able to identify social media activities and the relative importance of those activities that are related to audience response, then it could play an important role in the ongoing optimization phase of Murdough’s model (2010).

METHODOLOGY

Data Set

An inter-disciplinary communication department in a large southwestern university was used for testing the social media measurement model research questions. The department is one of five in a large College of Communication. The department offers undergraduate and graduate level coursework (both MA and Ph.D) and was established in the mid-1970s. The department has been operating a website since the early 1990s and has been actively engaged in social media since Spring 2010.

Social media vehicles included in this project were Facebook and Twitter. Facebook and Twitter data were collected and tabulated by Spredfast, a social media management company

(Spredfast 2012). The data were collected on a daily basis beginning October 2010 and ending April 2011. Two hundred and twelve days of continuous data was used in the sample. At the beginning of the period, there were 970 Facebook Friends and 984 Twitter Followers. At the end of the period, there were 1271 Facebook Friends and 1708 Twitter Followers.

Two website metrics were employed as the dependent variables in the analyses – website pageviews and website visitors because of the unavailability of sales information for the non-profit organization used in this study. A pageview is an instance of a page being loaded by a browser. A visitor is uniquely identified by a Google Analytics visitor cookie which assigns a random ID to the user and combines it with a time stamp of the visitor’s first visit (Google 2012). While these metrics are not equivalent to sales, both pageviews and visitors are two of the first commonly used metrics employed by companies around the world to track how much interest there was in their website. (Kaushik 2010). During the period examined the department website averaged almost 2000 pageviews per day (Figure 1) with an average of 613 visitors per day (Figure 2).

**FIGURE 1:
Website Pageviews**

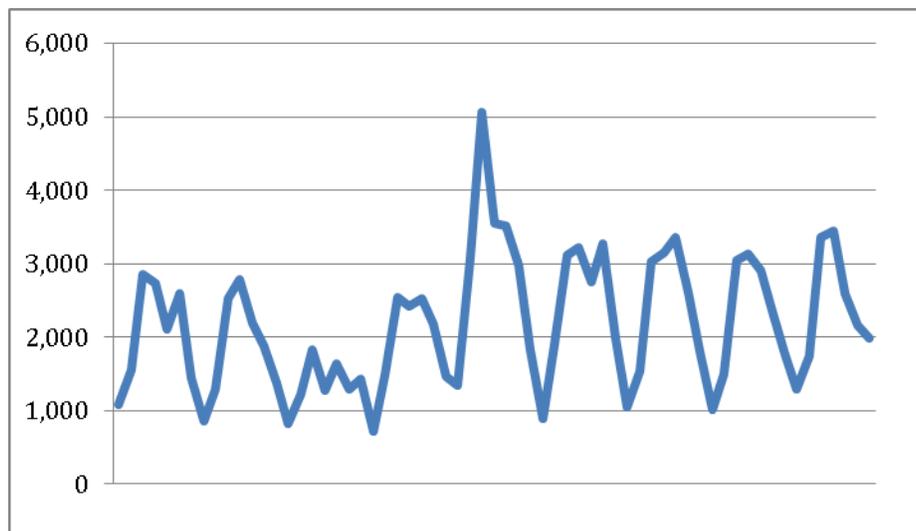
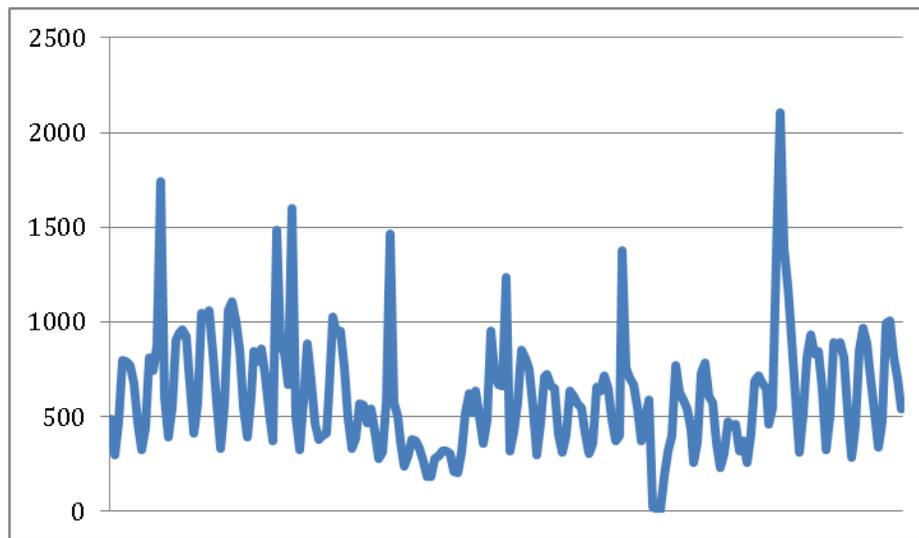


FIGURE 2 :
Website Visitors



The predictor variable categories were reach, frequency and engagement and are listed in Table 1 as described below. Reach is defined as the size of the community accessed through social media activity (Kaushik 2010). A key aspect of reach in the social media context is the multi-level characteristics whereby a company is able to reach a secondary level of users when people from the first point of contact share information in their networks. However, in this paper, the focus is on only the primary level of users, which would include Facebook friends/fans and Twitter followers.

Frequency is defined as the specific amount of outbound activity that was published to online users (Kaushik 2010). In a social media context, frequency includes reactive and responsive activity that is sent to and from social media channels such as Facebook and Twitter. Frequency includes posting Facebook messages, tweeting department information, responding to questions, or acknowledging users for sharing feedback. For the purposes of this paper, frequency is measured by counting the total number of Facebook posts and Twitter tweets on a daily basis.

TABLE 1:
Summary of Data Sources (Oct 1, 2010 – April 30, 2011)

Variables	Indicators	Data Description	Sources of Data
Page views	Pageview	Total Pageviews	Google web analytics
Visitors	Visitors	Total Visitors	Google web analytics
Frequency	FB Posts	Number of Posts	Facebook
Engagement	FB Like	Clicks of Like Button	Facebook
	FB Comments	Number of Comments	Facebook
	FB Bit.ly	Clicks of Bit.ly link	Facebook
	TW Replies	Number of Replies	Twitter
	TW Retweets	Number of Retweets	Twitter
	TW Bit.ly	Clicks of Bit.ly link	Twitter
Reach	FB Friends	Number of Friends/Fans	Facebook
	TW Followers	Number of Followers	Twitter

Engagement is defined as the overall interactions that department is experiencing in social channels (Kaushik 2010). The measurement of engagement included sources such as comments, the Like button, the number of click-throughs that include a Bit.ly link in posts on Facebook, the number of replies and retweets, and the number of Bit.ly link click-throughs in tweets on Twitter. Varieties of sources were used to obtain daily data for as many variables as possible and all data used in this study are presented in Table 1 as well as the data sources.

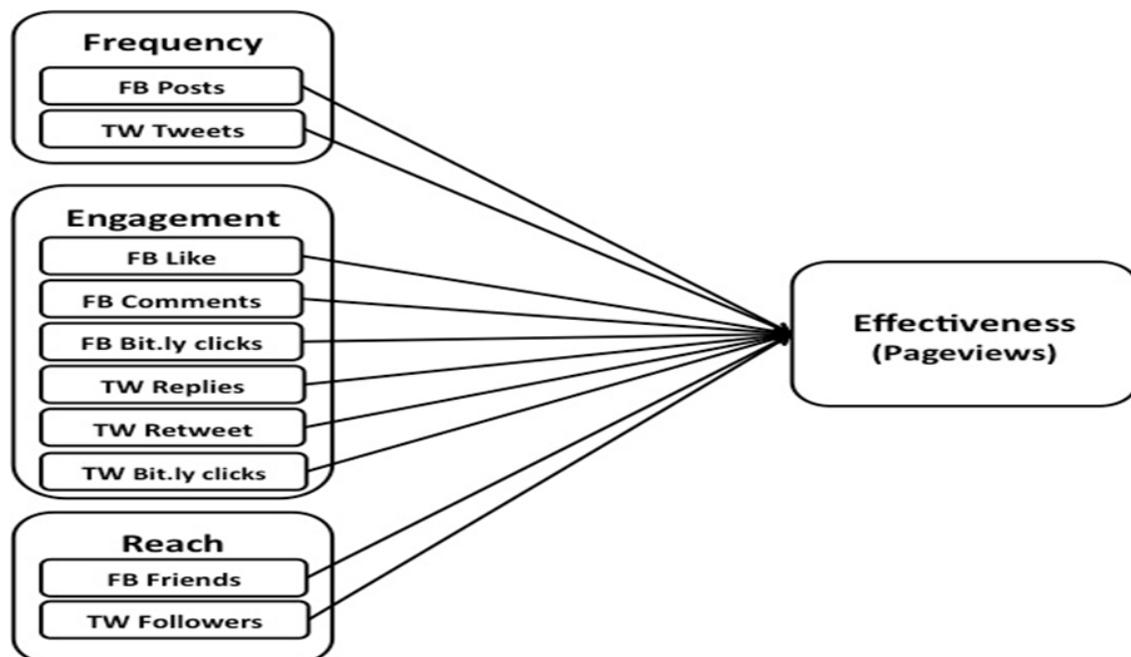
Empirical Model

Time Series analysis is used by many different disciplines from economic forecasting to census analysis to theoretical biology. Time series is an ordered sequence of values of a variable at equally spaced time intervals. There are generally two uses of time series analysis: (1) to obtain an understanding of the underlying forces and structure that produced the data and (2) fit a model and proceed to forecasting or monitoring (U.S. Commerce Department 2010). Times series analysis began with univariate

modeling based on a single variable and has advanced to multivariate models that examine the interrelationships between several variables. In this manuscript, a multivariate approach is used to determine the relationship of two social media – Facebook and Twitter on website pageview and website visitors.

Two time series models were created to examine the relationship of frequency, engagement and reach to website pageviews and visitors. In the first model, the database consisted of one pageview variable expressed in the actual number of pageviews and ten social media variables – Facebook Posts, Twitter Tweets, Facebook Friends, Twitter Followers, Facebook Comments, Facebook Likes, Facebook Bit.ly Clicks, Twitter Bit.ly Clicks, Twitter Replies and Twitter Retweets. In the second model, visitors were used in place of pageviews with the ten social media variables. Each of the ten social media variables was reported in actual number of occurrences or clicks. Although these variables may not reflect total social media efforts, they are the best measures that were currently available (See Figure 3).

**FIGURE 3:
Empirical Model**



The model may be represented by the following form: $P = f$ (Frequency (FB_{Post} , TW_{Tweets}), Engagement (FB_{Like} , $FB_{Comments}$, FB_{Link} , $TW_{Replies}$, $TW_{Retweets}$, TW_{Link}), and Reach ($FB_{Friends}$, $TW_{Followers}$). P represents numbers of pageviews, FB_{Post} , TW_{Tweets} represent the frequency variables, FB_{Like} , $FB_{Comments}$, FB_{Link} , $TW_{Replies}$, $TW_{Retweets}$, TW_{Link} represent engagement variables, and $FB_{Friends}$, $TW_{Followers}$ represent the reach variables. In order to transform this model into a regression equation format the following was used:

$$P = b_0 + b_1 FB_{Post} + b_2 TW_{Tweets} + b_3 FB_{Like} + b_4 FB_{Comments} + b_5 FB_{Link} + b_6 TW_{Replies} + b_7 TW_{Retweets} + b_8 TW_{Link} + b_9 FB_{Friends} + b_{10} TW_{Followers}$$

Data Analysis

The predictor variables described above were used in two different generalized least-squares regression equations with website pageviews and website visitors as the dependent variables. A stepwise regression analysis with backwards elimination of non-significant predictors was used in determining which variables were significant predictors of the pageview and visitor series. For each model, the least significant predictors were dropped and additional regression analyses were performed until a final model for each dependent variable was obtained with all variables significant ($p < .05$).

Because of the serious problems autocorrelation can present in analysis of time-series data, a generalized least-squares regression approach that uses estimates of autocorrelation in the model's residuals in estimating structural parameters and significance levels was used. The SAS AUTOREG procedure (SAS Institute 2010) was used taking into account significant autocorrelation at lags of one and two days.

RESULTS

Both of the full regression models using all social media variables and the final regression models with the statistically significant variables are presented in Table 2 (Website

Pageview) and Table 3 (Website Visitors). Because interpretation focuses on the final models with the non-significant predictors dropped, the full models with all predictors are not discussed.

Taking into account significant autocorrelation at lags of both one and two days, for Website pageviews, one frequency variable – Twitter Tweets, one reach variable – Twitter Followers, and three engagement variables – Facebook Clicks, Twitter Replies, and Twitter Retweets – exhibited a statistically significant relationships with pageviews. The direction of all of the relationships was positive except Twitter Replies, which was negative. The final model explained 57% of the variance of the given predictor variables ($R^2=.57$) for Website Pageviews.

Taking into account significant autocorrelation at lags of both one and two days, for Website Visitors, two reach variables – Facebook Friends and Twitter Followers and one engagement variable – Twitter Retweets – exhibited a statistically significant relationship with visitors. The direction of all of the relationships was positive except Facebook Friends, which was negative. The final model explained 37% of the variance of the given predictor variables ($R^2=.37$) for Website Visitors.

The intercept represents the baseline pageviews and visitors when all independent variables used in the analysis assume the value zero. Since none of the independent variable parameters assumed the value zero in the current study, interpretation of the intercept has no substantial relevance to understanding the relationship and is thus not discussed.

DISCUSSION

The results of the exploratory analysis are encouraging and suggest that the reach, frequency and engagement variables were all significantly related to the website pageviews and visitors. The findings of the study support the first research question in that the model

TABLE 2:
Full and Final Model – Website Pageviews

Predictor	Full Model (R ² =0.28, df=201)			Final Model (R ² =0.57, df=203)		
	B Value	t-ratio	p-value	B Value	t-ratio	p-value
Intercept	4951	7.96	.0001	3540	4.56	.0001
FB Posts	46.5	.91	.3665			
TW Tweets	37.3	3.02	.0029	21.9	2.93	.0002
FB Friends	-14.6	-6.18	.0001			
TW Followers	1.9			1.1	3.48	.0006
FB Comments	-14.6	.40	.0001			
FB Likes	-3.8	-.53	.5990			
FB Bit.ly	5.6	-.83	.4070	4.7	2.84	.0049
TW Bit.ly	-.04	1.54	.1242			
		-.04				
			.9644			
TW Replies	-39.8	-		-43.5	-2.50	.0130
TW Retweets	96.4	1.26	.2101	42.6	2.92	.0039
		4.51				
			.0001			

TABLE 3:
Full and Final Model – Website Visitors

Predictor	Full Model (R ² =0.26, df=201)			Final Model (R ² =0.37, df=207)		
	B Value	t-ratio	p-value	B Value	t-ratio	p-value
Intercept	1745	7.84		1368	4.49	.0001
FB Posts	13.2	.72	.0001			
TW Tweets	9.4	2.13				
			.4736			
			.0345			
FB Friends	-2.0	-6.25		-1.29	-3.90	.0001
TW Followers	.64	4.44	.0001	.43	3.22	.0015
FB Comments	.08	.01				
FB Likes	-.08	-.49	.0001			
FB Bit.ly	1.9	1.44				
TW Bit.ly	-.13	-.47	.9939			
			.6240			
			.1510			
			.6420			
TW Replies	-10.8	-.96				
TW Retweets	40.6	5.32	.3398	33.3	5.22	.0001
			.0001			

successfully identified reach, frequency and engagement variables related to website pageviews. When relating to website visitors, the model identified two reach variables and one engagement variable.

The direction of the relationships were positive in all but two cases – for pageviews – Twitter Replies demonstrated a negative relationship with pageviews and Facebook Friends demonstrated a negative relationship with visitors. Also, the R² values associated with

each model indicate that the explanatory variation in the time series data is robust given the organization's use of other factors used to drive website pageviews. For example, this analysis would exclude website pageviews and visitors that were generated with reference to search engines and other referring sites.

For website pageviews, one of the predictor variables was related to frequency, one to reach, and three to engagement. For website visitors, two of the predictor variables were related to reach and one related to engagement. Twitter Followers and Twitter Retweets were the only two variables that were significantly related to both pageviews and visitors indicating that both reach and engagement are important predictor variables. It is also interesting to note that in this case Twitter outperformed Facebook for both dependent measures.

The B (beta) value produced by the regression analyses provides insight by revealing the importance of each of the significant predictor variables on website pageviews and was used to answer the second research question – can the model provide insight into the importance of the variables? The beta value is a measure of how strongly each predictor variable influences the dependent variable and is measured in units of standard deviation. The higher the beta value the greater the impact of the predictor variable on the dependent variable. As an example for Website Pageviews, Twitter Tweets and Twitter Retweets clearly exhibited the most impact on pageviews while Twitter Retweets showed the most impact on website visitors.

Two of the variables in the model exhibited negative relationships with the dependent variables. The relationship of Twitter replies to pageviews was negative indicating that increases in Twitter replies were related to decreases in pageviews. Facebook friends exhibited a similar relationship with website visitors suggesting as Facebook friends increased, website visitors would decrease although the relationships strength was weak.

MANAGERIAL IMPLICATIONS

As noted in Murdough's (2010) model of social media effectiveness, the active measurement of the social media space is critical to the success of the communication effort. Performance indicators must be identified and adjustments made to maximize an organization or company's social media presence. The specification of the multivariate time series model described in this manuscript has demonstrated the ability to isolate reach, frequency and engagement variables associated with the specific website metrics. The pageview model exhibited the best-fit explaining 57% of the variation in pageviews even though the visitor's model explained a satisfactory 37%. Considering other contributors to pageviews and visitors such as search and external website links, the R-square levels were encouraging.

One reach, one frequency and two engagement variables were positively associated with increased website pageviews. This finding implies that the traditional media variables of reach and frequency are still important in the social media space. As expected, the two engagement variables are also a critical part of the social media experience. From a media strategy perspective, all three components – the number of messages and the size of the audience appear to work with active audience participation to produce effective communication in the social media environment.

Managing the social media presence by altering messaging tactics based on performance measures may be accomplished using results from the model as well. For example, when website pageviews are the primary goal, a strategy that included increased emphasis on Twitter messaging instead of Facebook would make sense given the significance and Beta values of Tweets and Retweets. A similar strategy might also be applied if the goal was website visitors as Retweets exhibited a strong, positive relationship with website visitors.

The model also identified one Twitter variable (replies) and one Facebook variable (friends) that were negatively related to the desired metrics of increased pageviews and website visitors. Managerial implications of this finding would likely lead to a re-examination of use of these tactics for future social media efforts. This analysis examined what occurred on a daily basis over a seven-month period using both Twitter and Facebook messaging and appears to be useful as an evaluation tool of executed social media strategy. It also provides a scientific understanding that would be useful for future direction and strategic discussions of the social media planning process that Murdough has identified.

The objective of this exploratory research was to produce good explanations of the dependent variable so future research can build on these findings by examining 1) a longer time period, 2) additional organizations or companies and 3) evaluating possible control strategies and/or hypotheses testing. Additional analyses should be conducted with several types of companies and organizations in the future to determine if the social media measurement model is valid and reliable. It would also be interesting to use the model in a setting where the dependent measure is sales, similar to the traditional advertising research that has been conducted so successfully in the past. With more research being conducted in this area and the social media community having an opportunity to gain an understanding of the process, the multivariate time series model approach shows promise for future social media measurement.

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