The Role of Media Coverage in Explaining Stock Market Fluctuations: Insights for Strategic Financial Communication

Joanna Strycharz, Nadine Strauss, and Damian Trilling

Department of Communication Science, University of Amsterdam, Amsterdam, The Netherlands

ABSTRACT
This study investigates the reciprocal relationships between the fluctuation of the closing prices of three companies listed on the Amsterdam exchange index, namely ING, Philips and Shell and online media coverage related to these firms for a period of two years (2014–2015). Automated content analysis methods were employed to analyze sentiment and emotionality and to identify corporate topics related to the companies. A positive relation of the amount of coverage and emotionality with the fluctuation of stock prices was detected for Shell and Philips. In addition, corporate topics were found to positively Granger cause stock price fluctuation, particularly for Philips. The study advances past research in showing that the prediction of stock price fluctuation based on media coverage can be improved by including sentiment, emotionality, and corporate topics. The findings inform strategic communication, and particularly investor relations, in suggesting that media attention, sentiment, and certain corporate topics are crucial when managing media relations and with regard to securing a fair evaluation of listed companies. Furthermore, the innovative research methods are useful for researchers and practitioners alike in showcasing how media coverage related to firms and their stock fluctuations can be identified and analyzed in a reproducible, hands-on and efficient manner.

The distribution of information plays a crucial role in shaping financial markets (Da, Engelberg, & Gao, 2011; Pollock & Rindova, 2003; Tetlock, 2007). In particular, financial news, market announcements, corporate news, or analyst forecasts form expectations and opinions of investors and are reflected in volatile stock market reactions (e.g., Tetlock, 2014). However, research in finance and related fields has not yet fully scrutinized the characteristics of media coverage and their relation to the financial performance of listed companies, a main concern for practitioners working in investor relations. Most studies have only focused on investors’ recognition of a company and its influence on the fluctuation of stock market prices (Lev, 1989; Liu & Thomas, 2000; see also Lehavy & Sloan, 2008) or employ simple measurements such as the amount of news articles dealing with certain firms (e.g., Engelberg & Parsons, 2011).

Following stakeholder theory, media have no financial stake in a company, but play a crucial role in disseminating information and influence stakeholders, such as investors, and their decision-making processes (Donaldson & Preston, 1995). This is of relevance for strategic financial communication, as investor relations (IR) practitioners view media coverage as an important tool for attracting investors’ attention and for managing the stock performance of listed companies (Bushee & Miller, 2012). Furthermore, being accurately and fairly covered by financial analysts and the financial media is one of the main communication objective of investor relations officers...
(Laskin, 2016). Yet, empirical findings that support the relevance of media coverage in managing the financial performance of companies remain fairly limited.

Recently, research in communication science has started to investigate the role of news media for stock market prices from a more comprehensive perspective, looking not only at the presence of media coverage, but also at characteristics of the news media coverage. For example, Strauß, Vliegenthart, and Verhoeven (2016, 2017) have investigated emotionality of coverage in relation to stock market reactions as well as various media dimensions (e.g., the presence of expert opinion or relevance). Yet, the specific topics a listed company is associated with in the news media have not been researched so far in this context. This is, however, crucial when trying to explain stock market movements, as topics or issues might convey more information for investors than simply media attention, sentiment, or tone.

To inform research on strategic financial communication about the relative relevance of topics over sentiment and media attention when describing the reciprocal interactions between news media and share price fluctuations, three major listed companies from the Amsterdam exchange index (AEX) were chosen in this study: ING, Philips, and Shell. In the process, three different methods of automated content analysis (i.e., frequency counts, sentiment analysis, and topic modeling) were combined with vector autoregression (VAR) analyses and hierarchical regression models. This approach has enabled us to identify whether media sentiment and/or topics related to the listed firms improve the explained variance of the stock market fluctuation compared to models that only take mere media attention and/or sentiment into account. Finding out about the relative relevance of information for stock market prices is particularly important for IR professionals whose job is, among other, to engage in media relations and to assure a fair evaluation of the firm by the financial market (Laskin, 2009, 2011, 2016).

Theoretical background

Media and the financial markets: following the consensus opinion

Contradicting the efficient market hypothesis (EMH) (Malkiel & Fama, 1970), multiple scholars have found news media, and particularly financial news, to influence the stock market to various extents (e.g., Antweiler & Frank, 2004; Kleinnijenhuis, Schultz, Utz, & Oegema, 2015; Tetlock, 2007). Ostensibly, the financial markets are not efficient in a way that all available information is instantly integrated in prices as assumed by proponents of the EMH. Consequently, scholars from behavioral economics have questioned the EMH and argued that financial markets are not solely governed by rational market participants. Instead, not all investors can be assumed to be equally well informed, having enough time and attention to process and evaluate information. Thus, trading decisions are said to be shaped and influenced by emotions, herd, and irrational behavior (Nofsinger, 2005; Oberlechner & Hocking, 2004; Shiller, 2005).

In this regard, the media have been identified to play a significant role in shaping the consensus market opinion and evoking this “herdlike” behavior (Davis, 2006; Oberlechner & Hocking, 2004; Thompson, 2013). Davis (2006) contends that the widespread availability of financial information among both professional and retail investors leads market participants to react to new information in a similar way (see also Shiller, 2005). In other words, investors tend to observe how the financial market reacts to certain news, trying to anticipate how the “herd” might react, thereby taking advantage of an assumed direction of market movements.

The role of the media in shaping investor decisions has been shown in multiple contexts. Lehavy and Sloan (2008) suggest that a company’s media visibility affects its stock price to a greater extent than financial information on firm fundamentals disseminated by the company itself. Similarly, Bushee and Miller (2012) argue that firms that are less visible to investors have less chance to attract attention among market participants, even if they do disclose information on the firm. These findings can be traced back to the concept of attention-grabbing stocks (Barber & Odean, 2008) and the supposition that investors need to get to know about the firm before making an investment
decision regarding it (Merton, 1987). Increased media coverage leads to raised attention, which in turn makes the stock more attractive to the investment community.

From this perspective, media are thus seen as crucial intermediaries for the dissemination and interpretation of financial information (Deephouse, 2000; Fombrun & Shanley, 1990; Pollock & Rindova, 2003). However, previous research in finance and economics has mainly used a crude approach to operationalize the role of the media, for instance, by only looking at certain parts of newspapers (e.g., market column of the Wall Street Journal: Tetlock, 2007), merely the headlines (e.g., macroeconomic news: Birz & Lott, 2011), or simply the amount of news articles (e.g., dealing with S&P 500 firms: Engelberg & Parsons, 2011). Even though some scholars in economics and finance have also taken a more specific approach in researching the relations between news media and the stock market (e.g., investigating emotions on Twitter: Bollen, Mao, & Zeng, 2011; Reuters news: Hisano, Sornette, Mizuno, Ohnishi, & Watanabe, 2013; Internet message volume: Antweiler & Frank, 2004), most of these studies aim at constructing the best predictive financial model instead of explaining the relevance of particular news media characteristics.

However, the main research questions from a strategic financial communication perspective originate from different motives, aiming at disentangling the effects of specific news media coverage characteristics on corporations and their financial performance. In fact, financial communication professionals, such as IR officers, have to manage reputations of firms that does not only encompass fostering relationships with influential stakeholders and shareholders, but also managing media relations well. To do so, financial communication practitioners have to reach out to various media outlets and journalists, stay in close contact with them, and build trustworthy relations to assure a fair representation of the company they represent (Laskin, 2009, 2011, 2016).

IR professionals in particular view media coverage as an important tool to attract investors (Bushee & Miller, 2012) and to achieve a fair market evaluation of a listed company. Another aim for IR professionals is to increase the trading volume of shares in order to keep the firm they represent liquid (Laskin, 2011). In fact, Laskin (2011) concludes that “extensive and accurate coverage is more likely to attract the buy-side” (p. 320). However, in saying so, he also asks for more research in this field to build “a model of these co-influences” (p. 320). Hence, to inform investor relations and strategic financial communication, this study investigates media attention, media sentiment, as well as topics a listed firm is associated with to find out about the relative importance of particular media coverage characteristics for the stock performance of listed stocks.

**Media attention**

Although some scholars could not evidence a media effect on stock market prices, particularly focusing on bubble periods (e.g., Internet bubble period: Bhattacharya, Galpin, Ray, & Yu, 2009; British Railway mania: Campbell, Turner, & Walker, 2012), others have shown that attention for certain stocks or message volume can affect stock market activity to various extents (Antweiler & Frank, 2004; Fang & Peress, 2009; Xu, Jiang, Chan, & Yi, 2013). In particular, more recent research shows that the more media attention is given to a specific stock or the more financial media comment on financial markets, the higher the trading volume or share price reactions (e.g., Alanyali, Moat, & Preis, 2013; Dougal, Engelberg, García, & Parsons, 2012; Pinnuck, 2014). Correspondingly, IR practitioners have also described media coverage as “helpful in attracting and retaining buy-side investors and analysts” (Bushee & Miller, 2012, p. 874; see also; Laskin, 2011). Thus, media coverage can be seen as an important source to inform investors.

In this vein, agenda-setting theory (Carroll & McCombs, 2003; McCombs & Shaw, 1972) becomes relevant in explaining the link between media attention and stock market reactions. Following this theory, it can be assumed that topics that are salient on the media agenda are transferred to the public agenda. With regard to the corporate sector, Carroll and McCombs (2003) have shown that media visibility of
corporations can influence the public image of firms. Correspondingly, it can be expected that stocks and companies that are visible in the media are more likely to be present among investors’ perceptions and therefore are more likely to be part of their trading agenda. However, facing the existing contradicting findings on the influence of media attention on stock market prices as described previously (e.g., Campbell et al., 2012; Dougall et al., 2012), we raise an open research question:

(RQ1) How does media attention devoted to listed firms relate to their stock market prices?

Corporate sentiment

From a strategic financial communication perspective, one might argue that it is too limited to only consider media attention when trying to explain stock market reactions. In fact, not only market sentiment, but also the sentiment and analyst recommendations for certain stocks or industries and sectors have been subject of analyses in previous studies (e.g., Ahmad, Hutson, Kearney, & Liu, 2014; Tetlock, 2007; Uhl, 2014). In communication science, the relationship between media sentiment and market reactions is commonly substantiated by the second-level agenda-setting theory (Carroll & McCombs, 2003; Kiousis, Mitrook, Wu, & Seltzer, 2006). According to Carroll (2009), the evaluations and opinions that the public holds towards a company are determined by media representations. Thus, the more positive (negative) the media reports about a firm, the more positive (negative) the public (or investors) will think about this firm (see Carroll & McCombs, 2003). In turn, this optimism or pessimism directed towards a company might then be mirrored in either more or fewer acquisitions of shares of this firm through investors (see Pollock & Rindova, 2003).

Another argument underlying the relation between the tone of media coverage and investor decisions can be traced back to framing theory (Scheufele, 2000). Advocates of this theory argue that news media can affect impression formations of the audience by presenting information in a certain way (Scheufele & Tewksbury, 2007). Thus, media representations of companies might also impact how the financial audience perceives and evaluates these stocks on the market (see Pollock & Rindova, 2003).

An abundance of studies has researched this relationship, focusing on sentiment, analyst recommendations, and emotions in the media and the effects on the financial markets (e.g., Bollen et al., 2011; Gilbert & Karahalios, 2010; Kleinnijenhuis, Schultz, Oegema, & Van Atteveldt, 2013). The findings are mixed, either pointing to small influences of tonal media coverage on stocks, stronger influences for negative tone, or none at all (e.g., Strauß et al., 2016). However, the majority of research in this field does not differentiate between overall sentiment in the news and sentiment directed toward a specific firm. In this present study, we therefore advance previous research by measuring sentiment in articles that we manually identified as dealing with specific firms (i.e., ING, Philips, and Shell). Hence, given the contradicting findings from previous research and the rather new research terrain, we pose an open research question:

(RQ2a) How does sentiment directed towards listed firms relate to their stock market prices?

Furthermore, building on the second-level agenda setting as well as framing theory, we expect that adding media sentiment next to media attention to the estimation model might improve the explained variance of stock market reactions of listed firms. In so doing, the following question will be answered:

(RQ2b) To what extent does sentiment improve the predictive models of media attention explaining stock market prices of listed firms?
**Corporate topics**

Information on quarterly or annual earnings (e.g., Pinnuck, 2014), management shifts or strategy changes (e.g., Johnson & Magee, 1985), mergers and acquisitions (e.g., Davis, 2005), or the publication of new corporate developments (e.g., Wies & Moorman, 2015)—information of this kind could lead investors to rethink their investments in listed companies. Previous research has only sporadically taken this perspective into account and has investigated how specific corporate information relates to stock market movements.

The influence of topics related to a listed company in the media on the stock market performance of these companies is again closely related to framing theory (Gitlin, 1980; Scheufele, 2000). As explained before with regard to corporate sentiment, frames can be defined as “persistent patterns of cognition, interpretation, and presentation of selection, emphasis and exclusion” (Gitlin, 1980, p. 8). Scheufele and colleagues (2011) in fact argue that media can serve as “a seismograph” for investors: they frame a company in a certain way, by for example reporting on it with reference to a specific topic, (e.g., financial performance), which in turn can predetermine investors’ trading decisions.

Hisano and colleagues (2013) were one of the first scholars who employed a topic modeling approach to investigate how topics reported on business news about stocks of the S&P 500 affect stock market prices. In their study, they were able to identify broad topic categories that were found to influence trading volume of S&P 500 stocks. However, given the rather descriptive findings, we want to advance Hisano et al.’s (2013) approach by focusing on three specific stocks (ING, Philips, and Shell) and investigating particular topics that are related to these firms. Hence, our third research question reads:

**(RQ3a) How does the presence of corporate topics relate to the stock market prices of listed firms?**

After having accounted for media attention and sentiment devoted to specific listed firms, corporate topics that are related to these firms should also be included in the estimation models eventually. More specifically, we ask:

**(RQ3b) How does the inclusion of corporate topics advance the predictive models of media attention and sentiment in explaining stock market prices of listed firms?**

**Reverse effects**

Media have not only been found to influence stock market movements, but some studies have also identified the media to react to stock market prices (Scheufele et al., 2011; Strauß et al., 2016). For example, Strauß et al. (2016) concluded that news media appears to react to changes in opening prices of stocks with a change of emotionality in the coverage the following days. As a result, daily media coverage has been said to rather mirror than shape stock markets.

There are several reasons for this reversed effect assumption. First, information presented in media coverage of companies is often based on market perceptions and on information that journalists receive directly from traders and the financial markets (Oberlechner & Hocking, 2004; Thompson, 2013). Thus, information might be already known among market participants and might hence be already integrated in stock market prices (Fama, 1970). Second, IR practitioners play a crucial role in informing analysts, investors, and other market participants about the financials of a listed company timely and accurately, thereby preventing strong share price fluctuations. In this vein, firsthand information provided by IR practitioners that only becomes known to the public through the general (financial) news media with a delay might explain the lagged effect of daily news media coverage on stock market prices additionally.
And third, the prevalent influence of stock market reactions on the news media can be explained by news values theory (Galtung & Ruge, 1965). The theory implies that there are several factors of stories (e.g., proximity, surprise, celebrity) that determine whether certain news or topics are selected by journalists to become news or not. It is thus likely that stocks are more likely to be covered when they are associated with novel, meaningful, and oftentimes negative information; for example, a severe slump in the stock market price. Furthermore, given that research has shown that media coverage has become more sensational (Lewis, Williams, & Franklin, 2008; Vettehen, Beentjes, Nuijten, & Peeters, 2010), it can be expected that journalists are more likely to report on such stock market movements in a sensational way (e.g., by using more emotional words).

Summing up, reversed effects, thus stock market movements influencing media reporting, are also likely to expect with regard to news media coverage related to specific listed companies. Therefore, our final research question reads:

(RQ4) How do changes in stock market prices of listed firms influence media coverage about those companies?

Method

Case selection

Three companies that were listed on the Amsterdam exchange index (AEX) during the period of analysis (01/01/2014 – 31/12/2015) were chosen to investigate the above stated research questions: ING, Philips, and Shell. The selection was based on two criteria: (1) the companies had to be large and well known enough to generate sufficient media coverage in the Netherlands, and (2) the three companies had to be situated within different sectors. The three selected companies belong to the biggest five companies of the AEX. Moreover, these selection criteria assure that the study covers companies belonging to multiple so-called top sectors in the Netherlands, such as life sciences and health, high tech and energy as well as the financial sector. This allows us to investigate the relation between media coverage and share price fluctuation in various contexts. A detailed description of the companies is offered in the online appendix.

Data collection

Stock market data

The daily closing prices of ING, Philips, and Shell were retrieved from Yahoo Finance. To draw conclusions with regard to the fluctuation of the stock market prices, the absolute values of the changes of the daily closing prices were calculated. Although this does not allow to draw conclusions about the direction of stock market movements, looking at the absolute values of the changes gives insights in the overall reactions of stock market prices. This approach is particularly useful, as positive (negative) information might mean positive (negative) news for some investors, yet for others it might mean negative (positive) news (e.g., investors who sell short).

Online news collection

Although earlier research (e.g., Kleinnijenhuis et al., 2015; Scheufele et al., 2011; Strauß et al., 2016) made use of daily coverage in printed newspapers to investigate the interrelations with stock market prices, we deliberately study online news instead. Given that online news is often the basis of news articles published the next day in print issue of news outlets, online news has the advantage of being more up-to-date. Therefore, news published online might be more indicative for stock market movements than newspapers, which have in fact been found providing rather outdated information for investors (e.g., Davis, 2005; Scheufele et al., 2011; Strauß et al., 2016).
We decided to include news articles from the websites of the two largest quality newspapers, *de Volkskrant* and *NRC Handelsblad*, as well as the website of the newspaper with the highest circulation, the popular daily *De Telegraaf*. This selection covers the most popular outlets in the Netherlands, both broadsheet and tabloid. We focus on the online news of popular newspaper outlets with a large range and broad audience, as we argue based on herd behavior and the third-person effect (Paul, Salwen, & Dupagne, 2000) that shareholders and investors are more likely to follow the consensus market opinion and what they believe other market participants will sell or buy (Nofsinger, 2005; Prechter, 2001). Thus, our selection of news will allow us to draw conclusions about media effects on stock market prices from a macrolevel perspective (see Scheufele et al., 2011).

To retrieve the articles from the official news websites, a self-written set of Python scripts was used, which was run on a server. During the whole period of analysis, these scripts queried the RSS-feeds of the outlets once an hour to find out whether new articles had been published. If so, the articles were immediately downloaded using the link provided in the RSS-feed and stored along with their metadata from the feed. Ultimately, the scripts parsed the articles to separate the main text and other elements from boilerplate content and formatting code. All data was stored in a MongoDB database.

**Retrieval of relevant articles.** To filter out the articles that were relevant for the three companies (ING, Philips and Shell) within our period of analysis, another script was written that retrieved all articles that (1) were published in one of these outlets between 1st January 2014 and 31st December 2015 and (2) contained one of the following sequences of characters (regular expressions): `\bING (?::.*?|b`, `\bShell(?::.*?)?\b`, or `\bPhilips(?::.*?|b`. These expressions essentially mean that the name of the companies had to be mentioned, but not in the middle of a word. In so doing, it was possible to avoid false positives. In total, we retrieved 2,059 articles mentioning ING, 1,075 articles mentioning Shell and 959 articles mentioning Philips.

**Manual filtering.** In a second step, the script presented short paragraphs of the retrieved articles (100 words before and after the company name occurred in an article) to human annotators (the first two authors of the study). The annotators then decided whether the article was indeed relevant for the purpose of the study. Relevant was defined based on three criteria: First, the article had to deal with ING, Shell, or Philips as a company or stock, and not in a deviated context (e.g., Philips used as part of a name: *Philips Arena*). Second, the article had to deal with a topic that can be considered as economically relevant for the stocks (e.g., corporate crisis, performance, products, management, etc.). Third, the article had to be of geographical relevance, meaning that articles that dealt with regional news (e.g., the opening hours of an ING branch) were excluded. In this way, false positives could further be eliminated. In the course of the manual annotation, a tag indicating its relevance was added to each article in the database to facilitate easy retrieval for subsequent analyses. As a result, we decided to keep 1,257 articles about ING, 992 articles about Shell and 610 articles about Philips.

**Construction of the dataset**

Given that the retrieved articles only contained text, accompanied by some metadata, useful variables had to be created using techniques of automated content analysis for journalistic texts (see Boumans & Trilling, 2016).

**Media attention**

To determine the number of articles per day and per company after aggregation (see next subsection), a variable containing the constant ‘1’ was created for each article. For each firm (ING, Philips, Shell) a time series was created, presenting the sum of articles released per day and per firm between 2014 and 2015.
**Sentiment**

SentiStrength, a method that estimates the strength of positive and negative sentiment in texts (Thelwall, Buckley, Paltoglou, Cai, & Kappas, 2010), was used to determine the sentiment of the articles. This sentiment analysis tool is broadly used in information science and performs well compared with other automated analysis tools (e.g., Gonçalves, Araújo, Benevenuto, & Cha, 2013; Gonzalez-Bailon & Paltoglou, 2015). Although SentiStrength has mostly been used for the English language, it is also available for the Dutch language and has been employed in previous studies (e.g., Trilling, Tolochko, & Burscher, 2017).

In general, Sentistrength is optimized for the use in short texts and returns two values: *positivity*, ranging from 1 (not positive) to 5 (extremely positive) and *negativity*, ranging from −1 (not negative) to −5 (extremely negative). It takes the value of the most positive (negative) sentence in a text and creates the positivity (negativity) value for the entire text. However, to overcome biased estimates for very long texts, SentiStrength was not applied to the whole text in this study, but to each sentence of an article separately. For the analyses, we calculated mean negativity and positivity scores per article, which we subsequently added up, resulting in a scale ranging from −4 to 4 (ING: $M = -1.15, SD = 0.11$; Philips: $M = -0.55, SD = 0.06$; Shell: $M = 0.92, SD = 0.1$). Furthermore, an emotionality score was calculated that shows the strength of the sentiment, disregarding the direction (positive vs. negative). Hence, the positivity scores were added to the absolute values of the negativity scores resulting in a scale ranging from 2 to 10 (ING: $M = 2.74, SD = 0.63$; Philips: $M = 5.9, SD = 0.37$; Shell: $M = 4.66, SD = 0.5$).

**Topics**

In line with the exploratory character of the current study, an unsupervised approach, the so-called Latent Dirichlet Allocation (LDA), was employed to identify topics. LDA is an unsupervised machine learning algorithm that assumes that texts (in this case articles) consist of a distribution of topics. Each topic in turn consists of a distribution of words. The importance of a specific word for a topic is determined by co-occurrences with other topic-related words and the relevancy of the word for the specific topic (Blei, Ng, & Jordan, 2003). In particular, the Python module gensim (Řehůřek & Sojka, 2010) was used to extract 50 topics per company based on all articles dealing with ING, Philips, or Shell, respectively. For each of the three subsets, we created a tf-idf-representation of a cleaned dataset in which only nouns, adjectives, and adverbs were included (using the pattern.nl part-of-speech tagger by De Smedt & Daelemans, 2012).

In line with the approach by Tsur, Calacci, and Lazer (2015), human annotators (the first two authors) merged topics from the list of 50 topics. To do so, we started with considering the first word of each identified topic, given that they have the highest loading per topic and thus can be considered as most important. Based on the first word, an initial code was assigned to each of the topics. After assigning the initial codes, we looked at the second word in each topic and assigned a second code. In case a word could not be clearly identified as a topic, we looked at the following words. For the topics that could not be identified based on the first five words, we looked at the following words to see whether they could be fit to other (already defined) topics; otherwise, we defined a new topic.

This procedure allowed us to reduce the number of topics to 12 for Philips (*products, stock-related issues, social activities, business, organizational change, sport, Philips watch, Philips Lighting, Philips Healthcare, culture, society*), 14 for Shell (*activist actions, pollution, takeovers, production, stock-related issues, prices, transportation, unions, fires, patents, safety, sanctions, North Sea operations, business*) and 11 for ING (*business, clients, mobile banking, banking activities, products, stock-related issues, employees, voting, environment, politics, stress test*). Table 1 in the online appendix shows the number of subtopics as well as example words for each identified topic.

**Data aggregation and merging**

The Python module pandas (McKinney, 2010) was used to aggregate and merge the stock data with the online news data. To do so, the news data was aggregated per business day, whereby articles published
on Saturday or Sunday were treated as if they were published on the following Monday (see Scheufele et al., 2011). Days on which no article was published were treated as zero values in the news data series.

**Data analysis**

**VAR models**

Following previous research investigating the interrelationship between media and the stock market (Kleinnijenhuis et al., 2015; Scheufele et al., 2011; Strauß et al., 2016), vector autoregression models (VAR) were used for the analyses. Given the open research approach, this method of analysis is particularly adequate as it takes the interdependence of variables into account. In that way, both media variables and the stock market fluctuation variable are considered as dependent and independent variables at the same time in the estimation models (cf. Vliegenthart, 2014). Hence, for each of the three companies (ING, Philips and Shell) a VAR model was constructed with the variable measuring stock market fluctuation as well as one of the respective media variables (e.g., attention, sentiment, emotionality, topics). In so doing, 50 models were specified in total.

We followed the procedure recommended by Vliegenthart (2014): First, the Augmented Dickey-Fuller (ADF) test was estimated to assure that all time series were stationary. If this was not the case, the series had to be differenced. Second, to select the optimal number of lags for each VAR model, selection-order statistics were consulted (e.g., Akaike’s information criterion) looking at maximum of 21 lags. Third, Granger-causality tests were performed to identify whether one series predicts another series above and beyond the past values of its own series. In the final steps, cumulative impulse response functions (CIRF) and forecast error variance estimations (FEV) were carried out. Although CIRF gives the reader more information about the endurance of a response in one variable (e.g., stock fluctuation) after a shock in another variable (e.g., media attention), FEV is a useful indicator to see how much of the variance in one variable (e.g., stock fluctuation) is explained by the shock variable (e.g., media attention) or its own past.

We performed several tests to rule out common estimation errors. The Portmanteau (Q) test was used to rule out serial correlation of the residuals up to the lag order of 20. Next, the Lagrange Multiplier test was conducted to assure that the right lag order was chosen. Furthermore, the Portmanteau (Q) test was applied to the squared residuals of the series to check for heteroscedasticity. The stability of the models was checked with eigenvalue tests for each model. Besides the heteroscedastic error structure, the results of the tests indicated robustness of the VAR models.

---

**Table 1.** Significant Granger causality findings for media attention and sentiment.

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Absolute closing price as dependent variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ING</td>
</tr>
<tr>
<td></td>
<td>Philips</td>
</tr>
<tr>
<td></td>
<td>Shell</td>
</tr>
<tr>
<td>Media attention</td>
<td></td>
</tr>
</tbody>
</table>
| Granger Causality Test | L(8) $\chi^2 = 2.111^{**}$  
                      |                                               |
|                      | L(9) $\chi^2 = 3.399^{***}$                  |
|                      | L(14) $\chi^2 = 1.745^{**}$                  |
|                     |                                               |
|                      | CIRF                                           |
|                      | 0.006 [-.005; .017]                            |
|                      | 0.043 [.019; 0.067]                            |
|                      | 0.063 [.024; .101]                            |
|                      |                                               |
|                      | FEV                                             |
|                      | 2.9%                                           |
|                      | 5.7%                                           |
|                      | 4.5%                                           |
| Emotionality         |                                               |
| Granger Causality Test | L(11) $\chi^2 = 3.70^{***}$               |
|                      |                                               |
|                     | CIRF                                           |
|                      | 0.019 [.010; .029]                            |
|                      | 0.035 [0.015; 0.055]                          |
|                     |                                               |
|                     | FEV                                             |
|                      | 6.6%                                           |
|                      | 5.8%                                           |

Note. Cumulative impulse response function (CIRF) and forecast error variance (FEV) after selected number of lags; 90% CI [LL, UL] in brackets; Significances for Granger causality tests: *$p < .05$. **$p < .01$. ***$p < .001$.

---

$^1$For the stock price fluctuation series, we found autocorrelation of the squared residuals, indicating a heteroscedastic error structure.
**OLS modeling**
Hierarchical OLS regressions were employed to investigate whether the inclusion of more news media variables in the models improves the explained variance of stock market fluctuations of ING, Philips, and Shell. In the first step, the OLS models were estimated with media attention for each stock as independent and the stock market fluctuation for each stock, respectively, as dependent variable. In the second step, the corporate sentiment variables (average sentiment and emotionality) were included as independent variables. In the third step, the variables that measured the presence of corporate topics in the news media were added. However, only the topics that were found to significantly Granger cause stock market fluctuation of ING, Philips, and Shell were used here. To make inferences whether the inclusion of more news media variables as predictors improves the explained variance of stock market fluctuation of ING, Philips and Shell, the Bayesian information criterion (BIC), and the Akaike information criterion (AIC) were compared between the hierarchical models.

Each OLS model was tested for robustness after entering each set of variables. This included the test of normality for both the independent and dependent variables, a test for identifying outliers in the dataset, a test for multicollinearity as well as for heteroscedasticity and omitted variables. Except for the test of multicollinearity (due to the inclusion of lagged variables), all tests were satisfying.

**Manual examination of most relevant articles**
To gain a better understanding of the relation between news media and the stock market reactions, articles dealing with those topics that were found to Granger cause stock market fluctuation were manually examined in depth. More specifically, we read 30 articles that had the highest loadings for each of the topics dealing with ING, Philips, and Shell to be able to describe these topics in detail.

**Results**
To achieve stationarity of the time series, all series needed to be differenced. After differencing, 50 VAR models were constructed—for each firm one model with news volume, one model with average sentiment, one with emotionality and multiple models for each topic extracted for the three firms. Due to space restrictions, only significant findings will be reported here (see Table 1 and Table 3). In each table the results of the Granger causality tests with the number of lags included for each model estimation, the cumulative response function (CIRF) and the forecast error variance (FEV) are displayed.

**Media attention**
RQ1 dealt with the influence of media attention on the fluctuation of stock prices. Table 1 presents an overview of the significant results per stock. When inspecting the CIRFs and FEVs, it can be deduced that an increase in media attention for ING, Philips and Shell results in higher fluctuations of the stock prices. The strongest relationship exists for Shell where each additional article results in a 0.063 increase fluctuation of the share price after 14 days. For Philips, a similar positive association can be observed after nine days (CIRF: 0.043). However, although the Granger causality finding for ING is significant, the CIRF is not significant, pointing to an unstable relationship. The results for the FEVs show that the explained variance ranges from 4.5% for Shell to 5.7% for Philips. This suggests that a change in media attention explains only a small portion of fluctuation for the two stocks.

**Corporate sentiment**
RQ2a asked how sentiment relates to the stock market prices of listed firms. The significant results of the VAR models for the sentiment variables (average sentiment and emotionality) can be found in
Table 1. The analyses show no causal relationships between average sentiment and stock market fluctuation for any of the companies. However, emotionality was found to have a positive effect on the fluctuation of share prices for Philips and Shell. Although for Philips, an additional one-unit increase in emotionality leads to a positive change of the fluctuation of the share price by 0.019, for Shell the CIRF indicates an increase by 0.035. The explained variance ranges from 5.8% for Shell to 6.6% for Philips. Thus, it can be concluded that emotionality in media coverage—hence, positive and negative sentiment taken together—has a positive influence on the fluctuation of share prices of Shell and Philips.

To answer RQ2b, we conducted hierarchical regressions. Model 1 consisted of (lagged) variables for stock market fluctuation and media attention. In Model 2, we added average sentiment and emotionality as independent variables. The inspection of the $AIC$ and $BIC$ of the two nested models indicates that adding emotionality improves the predictive power of the extended model for all companies (Table 2). For ING, the improvement is marginal with a $R^2$ change of 1.94%, for Philips the explained variance improves by 2.97% and for Shell 4.46%. The results for all variables in the hierarchical regression models can be found in the online appendix.

### Corporate topics

In asking RQ3a we wanted to know how the presence of corporate topics in the media dealing with listed firms relates to the stock market prices of these firms. The significant results of the VAR models can be found in Table 3. For ING, none of the identified topics mentioned in the news media has a significant Granger-causal relationship with the fluctuation of the ING share price. However, for both Philips and Shell significant effects for the topic stock market on the fluctuation of share prices can be detected. CIRFs for Philips indicate that one additional increase in the presence of the topic dealing with the stock market results in increase of the fluctuation of Philips’ share price by 0.001 within 5 days. Similarly, an additional increase of the presence of the topic stock market in articles dealing with Shell leads to a 0.003 increase in fluctuation of its share price within 13 days. Although the relations are significant, the amplitude of these effects is rather weak. Although for Philips the presence of the topic related to the stock market explains 4.8% of variance of its stock price fluctuation within 5 days; for Shell the explained variance amounts to 5.6% within 13 days.

Furthermore, an additional one-unit increase of the topic social activities in articles dealing with Philips results in a 0.006 increase of the stock price fluctuation of Philips within 17 days.

### Table 2. Hierarchical regression models predicting fluctuation of stock price.

<table>
<thead>
<tr>
<th>Stock</th>
<th>$AIC$</th>
<th>$BIC$</th>
<th>$R^2$</th>
<th>$\Delta R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ING</td>
<td>−619.806</td>
<td>−599.195</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>−543.446</td>
<td>−454.960</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>.0859</td>
<td>.1059</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td></td>
<td>.0194</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Philips</td>
<td>−120.490</td>
<td>−97.500</td>
<td>−91.112</td>
<td>−105.279</td>
</tr>
<tr>
<td></td>
<td>100.516</td>
<td>369.365</td>
<td>.1328</td>
<td>.3102</td>
</tr>
<tr>
<td></td>
<td>.0297</td>
<td>.1775</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>Shell</td>
<td>19.287</td>
<td>47.088</td>
<td>60.529</td>
<td>.1736</td>
</tr>
<tr>
<td></td>
<td>146.202</td>
<td>292.456</td>
<td>365.124</td>
<td>.2183</td>
</tr>
<tr>
<td></td>
<td>.0446</td>
<td>.2404</td>
<td>.0221</td>
<td>−</td>
</tr>
</tbody>
</table>

Note. ‘−’ indicates that there were no significant findings for topics related to ING; Model 1 includes lagged values of the dependent variable and lagged values of media attention; Model 2 includes additionally sentiment variables; In model 3 corporate topics that have been found to Granger cause fluctuation of stock price are added; Significances for $B$ values: *$p < .05$. **$p < .01$. ***$p < .001$. 

Table 1.
Second, an additional increase in the presence of the topic dealing with products by Philips leads to a 0.003 increase in the fluctuation of Philips share price within 2 weeks (the presence of this topic explains 7.4% of variance of its stock price fluctuation within 14 days). Third, an additional increase in the presence of the topic Philips Lighting leads to an increase of the fluctuation of Philips’ share price by 0.002 after 9 days (explaining 6.2% of the variance). Finally, one additional increase in the presence of the topic business activities comes with a 0.002 increase in the fluctuation of its stock price within 11 days (explaining 8.5% of the variance). Answering RQ3a, it seems that particularly for Philips, corporate topics in the news media have an influence on the fluctuation of its stock price. However, the relations found are rather small.

RQ3b concerned the improvement of predicting stock market prices by including corporate topics in the OLS models. A third model of hierarchical regressions was constructed by adding the topics as independent (lagged) variables that were found to Granger cause the fluctuation of the share prices of Philips and Shell (Table 2). Once again, the inclusion of the additional predictors leads to an improvement of the BIC and AIC for Philips and Shell. When it comes to Philips, the inclusion of the topics stock market, products, Philips Lighting, corporate social responsibility and business activities leads to a $R^2$ change of 17.75%. The final and full OLS model for Philips including media attention, sentiment and corporate topics explains 31.02% of the variance in stock market fluctuation of Philips. Rather smaller in its impact is the inclusion of the topic stock market in the OLS model predicting stock market fluctuation of Shell. This only leads to an increase of $R^2$ by 2.21%. As none of the corporate topics was identified to Granger cause stock fluctuation of ING, no additional hierarchical regression was constructed for this company.

To facilitate a deeper understanding of the VAR results described above, we examined 180 articles (30 articles with the highest loadings per topic) dealing with the three companies in our dataset. The close reading of articles that concerned the topic stock market showed that for both Shell and Philips, they were related to stock purchase advice, reactions of the stock market to announcements of quarterly and annual figures as well as announcements of new investments made by those

<table>
<thead>
<tr>
<th>Independent variable</th>
<th>Absolute closing price as dependent variable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Philips</td>
</tr>
<tr>
<td>Topic</td>
<td>Granger Causality Test</td>
</tr>
<tr>
<td>Stock Market</td>
<td>CIRF</td>
</tr>
<tr>
<td></td>
<td>FEV</td>
</tr>
<tr>
<td>Topic</td>
<td>Granger Causality Test</td>
</tr>
<tr>
<td>Products</td>
<td>CIRF</td>
</tr>
<tr>
<td></td>
<td>FEV</td>
</tr>
<tr>
<td>Topic</td>
<td>Granger Causality Test</td>
</tr>
<tr>
<td>Lighting</td>
<td>CIRF</td>
</tr>
<tr>
<td></td>
<td>FEV</td>
</tr>
<tr>
<td>Topic</td>
<td>Granger Causality Test</td>
</tr>
<tr>
<td>Social Activities</td>
<td>CIRF</td>
</tr>
<tr>
<td></td>
<td>FEV</td>
</tr>
<tr>
<td>Topic</td>
<td>Granger Causality Test</td>
</tr>
<tr>
<td>Business</td>
<td>CIRF</td>
</tr>
<tr>
<td></td>
<td>FEV</td>
</tr>
</tbody>
</table>

Note. ‘-’ indicates that the topic was not present for the specific stock. Cumulative impulse response function (CIRF) and forecast error variance (FEV) after selected number of lags; 90% CI [LL, UL] in brackets; Significances for Granger causality tests: *$p < .05$. **$p < .01$. ***$p < .001$. **
companies. Furthermore, for Shell multiple articles dealt with the influence that the fluctuating oil prices had on investors. For Philips, the topics business and Philips Lighting included articles dealing with the split of Philips in two businesses: lighting and healthcare and consumer lifestyle. Moreover, for Philips the topic business related to articles reporting on revenues and losses made by the company, whereas the topic Philips Lighting dealt with new innovations introduced by the company on the market such as Hue lights and green technologies. When it comes to the topic products related to Philips, the news media reported on healthcare products, Hue lights produced by the Lighting division and consumer products such as TVs and vacuum cleaners. Finally, the articles dealing with Philips and the topic corporate social responsibility concerned multiple projects of the company, such as improving conditions for employees of the company, changing work systems in factories in Bangladesh and its struggle to improve healthcare, particularly for older patients.

Reversed effects

In RQ4 it was asked how stock market prices of listed firms relate to media coverage of them. In other words, the nature of VAR models also allowed us to inspect the extent to which stock market fluctuation of the three firms ING, Philips and Shell affects media attention, media sentiment, emotionality or the presence of certain topics in the news. Although the analyses yield significant Granger causality effects for the reversed order, the CIRF and FEV were not found to be stable.

Discussion

The aim of this study was to explore the interrelationships between stock market fluctuations of specific companies and media coverage characteristics, particularly the association of these companies with sentiment, emotions, and corporate topics. Furthermore, we wanted to find out whether sentiment, emotionality, and corporate topics in media coverage can improve the prediction of stock market fluctuation above and beyond predictive models that are merely based on media attention or sentiment. Particularly for investor relations and strategic financial communication, it is important to know how media coverage of companies triggers share price reactions, and if so, what kind of coverage impacts the evaluation of the company on the stock market most. The results of this study do not only inform investor relations practitioners about the relevance of media coverage for the share price of the companies they work for, but also what they should focus on when managing media relations and media reputation (see Deephouse, 2000). Furthermore, the study showcases hands-on and efficient methodological tools that can be used to assess content of media coverage and its influence on share price fluctuations on a large scale and both in academia and practice.

The results of our VAR models confirm findings from earlier research that showed that the amount of media attention is related to stock market prices (e.g., Alanyali et al., 2013; Kleinnijenhuis et al., 2015; Strauß et al., 2016). We found that media attention positively influences stock market fluctuation for both Philips and Shell. However, the magnitude of the relationships identified was rather small, or in the case of ING, not stable. As past studies have argued, exclusively looking at the amount of coverage in relation to stock reactions is rather limited. Therefore, we tested whether sentiment, emotionality, and/or topics related to firms could improve predictive models for stock market fluctuation.

In fact, emotionality was found to predict stock market fluctuation for both Philips and Shell. More specifically, the results suggested that higher emotionality of media coverage—hence, disregarding the direction of sentiment (positive vs. negative)—led to an increase of the fluctuation of stock prices.

Besides sentiment and emotionality, this study has also investigated the presence of corporate topics in articles dealing with the three companies. Although the identified topics did not seem to matter for ING and its stock market fluctuation, for Shell and Philips the identified topics appeared to be influential. The inspection of the actual news articles dealing with the topics that were found to
have a significant influence on the share prices of Shell and Philips (stock market, business and Philips Lighting) implied market-relevant news for investors. For example, the topic Philips Lighting can be traced back to the split of Philips in two businesses (Philips, 2016a). Splits as well as mergers and acquisitions can indeed be considered market-moving events that previous research has already found to trigger stock market prices considerably (e.g., Gaur, Malhotra, & Zhu, 2012; Strauß, Vliegenthart, & Verhoeven, 2017). Hence, in the event of mergers and acquisitions or restructuring processes, media coverage can be considered influential in the financial context (see also Donaldson & Preston, 1995) and should thus also be regarded as such by IR professionals.

Moreover, the presence of the topic products has been found to significantly impact the fluctuation of the share prices of Philips. Philips is a consumer-oriented technology company that specializes in a wide range of products that are also targeted to the end customer. Thus, media coverage about products of the company might not only impact how consumers think about the products by Philips, thereby maybe also affecting their buying behavior; but it might also drive investors to reallocate their assets accordingly (i.e., either buying or selling their Philip shares in anticipation to the media coverage).

Eventually, the finding that the topic corporate social responsibility influenced the fluctuation of the share price of Philips can be put in light of the company’s sustainability approach, proclaimed on its website: “Sustainability is at the core of our company’s vision” (Philips, 2016b). A closer reading of articles dealing with this topic showed that Philip has been covered in the media in relation to its social projects, such as improving the situation of children living in favelas or workers in Bangladesh. Moreover, it was reported that Philips aims at improving its healthcare sector by, for example, developing pain-reducing lamps or other healthcare technologies.

All in all, the findings show that topics covered in the media should not only be considered influential for stock market reactions when referring to financial topics but particularly regarding consumer-oriented themes. Hence, for investor relations professionals this means that both communication about corporate financial news (e.g., quarterly earnings announcements) and communication related to the consumer (e.g., products or corporate social responsibility) might also be relevant when managing communication with stakeholders and a fair evaluation of the share price of companies they represent.

**Limitations**

The vast differences across the three companies investigated raise the question whether the sector was a determining variable for the media effects found in this study. In particular, the influence of media coverage on stock price fluctuations was much more prevalent for the energy and petrochemical company Shell and the technology firm Philips, whereas ING appeared to be rather unaffected by media coverage. Although the share prices of Philips might be more affected by media coverage due to its familiarity among customers and its dependence on sales in the consumer industry, Shell can be considered a corporation that is highly visible in the media and exposed to public criticism and activists due its impact on the environment (cf. Strauß & Jonkman, 2017). In turn, the lack of media effects found for ING could have something to do with the fact that the topics identified (e.g., clients, mobile banking, employees, politics) were not influential in moving its share price after all.

Acknowledging the characteristics of the companies, it also has to be noted that the selection of mere three companies is a major limitation of this study. In this vein, the findings can neither be seen representative for the entire Dutch stock market, nor for any other international stock market floor. The differences found between the investigated companies imply that the relations may depend on the sector or might be purely company-specific. Future studies are invited to try to systematically investigate the moderating role of company characteristics in explaining stock market fluctuations related to media coverage.
Furthermore, one could question the selection of sources that we used for this study. Certainly, it is impossible to trace back what kind of investors use what kind of news sources to make their investment decisions. Our choice to opt for the most popular Dutch newspapers was driven by theories such as herd behavior and the third-person effect (Paul et al., 2000; Prechter, 2001), assuming that the consensus market opinion is conveyed in leading news media sources of a country. Nevertheless, difficulties in linking individual news consumption to trading behavior and distinguishing between individual and private investors have been stressed previously. In particular, Scheufele et al. (2011) named the micro–macro difficulty as one of the main challenges for such studies: “media effects on small investors and on professional investors can neutralize each other” (p. 64). In this context, exploring media effects on the micro (investor) level, for example by means of experiments, could be a future direction for research.

We manually verified that all analyzed articles directly dealt with one of the three companies in question, which is why we are confident that our measure of attention is an accurate one. Regarding sentiment and emotionality, however, one could object that the SentiStrength algorithm provides a rather crude measure. Given that it only estimates sentiment on an article/sentence basis, but not relating sentiment directly to the objects of a news story, the measurement might have been not targeted enough. Therefore, future research should re-test these findings by using more advanced techniques, for instance, by means of an algorithm that links sentiment directly to named entities (e.g., company names) or through Supervised Machine Learning. Regarding topics, the identification of the topics in this study might not have been specific enough to actually identify the exact topics that did have an effect on the share prices of the three companies after all. Given the rather interpretative approach in synthesizing topics based on word clusters, specifics of language, messages, and the nuances in news coverage become neglected. Therefore, future research could take a closer look at the topics companies are associated with in the media by for example using manual analyses (e.g., qualitative framing analysis; Strauß, 2015).

**Implications**

This study has contributed to strategic financial communication research in three ways: First, from a theoretical viewpoint, the findings confirm previous research that has found media attention to be an important factor in understanding stock market reactions (e.g., Dougal et al., 2012; Pinnuck, 2014; Tetlock, 2007) and emotions to play a crucial role for market movements (Nofsinger, 2005; Strauß et al., 2016). Furthermore, the finding that corporate topics should be considered as relevant (additional) explanatory variables in explaining stock market fluctuation extends previous research in arguing for a more comprehensive analysis when studying the interrelation between media and the stock market.

Second, for practice, and particularly investor relations (IR), this study has provided important insights for strategic financial communication and the role of news media in managing the evaluation of firms on the stock market (see also Laskin, 2009). First, the findings imply that increasing media coverage enhances trading activity for listed firms, supporting the claim that generating media coverage of companies is an important function of IR practitioners to attract investors (see also Bushee & Miller, 2012). Furthermore, it can also be concluded that not only visibility in the media, but also emotionality as well as the topics the firms are associated with raise the awareness of traders to buy or sell. Hence, IR officers are advised to pay close attention to the content of media coverage, securing a fair and honest representation of the company they represent without too much emotionality or topics that put the company in a bad light.

In this sense and following Laskin (2009), IR practitioners should not only have a financial, but also a communication function. This does not only relate to securing a stable stock market price by managing relations with financial analysts and financial journalists, but it also entails communicating openly and transparently about the company they represent. As shown in this study, increasing media coverage about listed companies, emotionality in news coverage and the association with
certain topics (e.g., corporate social responsibility, products) can increase the fluctuation of share prices of companies covered. In this sense—and as far as controllable—IR practitioners are advised to carefully think about their media relations efforts (e.g., press releases, interviews, contact with journalist) and to keep in mind that the stock market prices of the represented company might react to the information conveyed in the popular news media more or less severely.

Third, from a methodological perspective, this study illustrates how the use of state-of-the-art techniques of automated content analysis can contribute to the understanding of the interrelationships between media coverage and the stock market. In particular, the strength of this approach lies in combining a coherent workflow that incorporates web scraping, semi-automated information retrieval, sentiment analysis, topic modeling, and time series analyses. By having programmed all parts of this workflow in one open source environment, the procedure of the analyses can be repeated, extended, and scaled up for future research. In this sense, the approach used in this study does not only account for the need of more case-related research in this field of research (e.g., Kleinnijenhuis et al., 2015), the methodological rigorousness of the data collection and analysis, but it also counteracts common criticism expressed towards automated content analysis (Kalampokis, Tambouris, & Tarabanis, 2013). In addition, the methodological advancement as put forward in this study might also be of interest for investor relations officers as well as practitioners from other fields of strategic communication. We did not only demonstrate how articles of an undefined sample can efficiently and manually be examined and classified for their relevance by means of a simple programming technique, but it also showcased how large amounts of media coverage can be analyzed in relation to stock market movements through simple, reproducible analytical steps.

To conclude, the study has contributed both, practical implications for the field of strategic financial communication as well as methodological insights for large-scale automated news media analyses for corporate communication scholars and practitioners in general.

Disclosure statement
The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the article.

Funding
This study was carried out on the Dutch national e-infrastructure with the support of the SURF Foundation.

ORCID
Damian Trilling http://orcid.org/0000-0002-2586-0352

References


Philips. (2016a). All news. Retrieved from http://www.philips.co.uk/a-w/about/news/all-news.html#&/wEXDAUQO3BIZWNoXZNDaGvj0jveAFRMFscUFCEzyb12ZWWFyBQQyMDE0BRBBc1Ryx0cNoZWnRQm9dBQVGYWnzZQUOUmVzdWx0c1BldBzZ2UFJaJ1BRVWYnRZ3ydvW5kZXJzQ2hlY2tCh3gFBUZhBHNI8RRQcmVzc1JlbGVhc2VDaGj0jveAUEVHJ1ZQULQW55Q2hlY2tCh3gFBUZhBHNI8QBZUb1llYXIFBDIwMTYFBIrvTW9u


