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Analysis of Stock Price Movement Following Financial News Article Release

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Abstract

What effect does a financial news article have on stock price? To answer this question we investigate stock price movements within the minutes following financial news releases, broken down by media outlet, time of release and article sentiment. Using a Sharpe ratio (a measure for calculating risk-adjusted return) we demonstrated an abnormal return of 1.81 versus a random dataset of -0.06, indicating significant price movement immediately following article release. Second, we found that articles released through WSJ, Reuters – UK Focus, NYT and FT experienced significant positive returns, whereas articles in Barrons, MarketWatch, Forbes and Bloomberg experienced significant negative returns. Third, we found that articles released at certain times of the day had abnormally high price movements associated with them, more so than could be attributed to random chance. Lastly we discovered a minority of positive news articles trending upwards and suddenly reversing direction following a financial news article release. In one particular case there was a several day period where IBM news articles triggered large price declines. We believe these findings could be used by companies as a form of stock price management.

Keywords: Business Intelligence, Decision Support, Textual/Financial, News Analytics

1. Introduction

The ability to identify abnormal profits in the stock market has appeal to researchers, investors and companies alike. Investment firms have poured trillions of dollars into IT infrastructure, data analytics and high frequency trading (HFT) systems in an attempt to provide a competitive advantage. One area of recent interest has been the use of news analytics to supplement trade decision making. This area became an important concern on September 30, 2004 when pharmaceutical manufacturer Merck and Co. voluntarily recalled their profitable drug Vioxx. This recall led to a 27% stock decline and a $27 billion dollar equity loss in one day (BusinessWeek, 2004). The problem was that automated HFT algorithms, oblivious to the recall, interpreted the price drop as a buying opportunity and cost brokerage firms millions before they could be stopped.

In the decade since the Merck recall, HFT trades now account for nearly half of all market activity (Gerig, 2015). It is believed that textual financial information is now used by automated systems, although the extent of which is not entirely known. Tools such as RavenPack and Thomson Reuters News Analytics (TRNA) provide news-aware capability as a push-based news sentiment service in less than a second following article release (von Beschwitz, Keim et al., 2015). Evidence of news-aware HFT systems arose in April 2013 when the Associated Press' Twitter account was hacked to report "Two Explosions in the White House and Barack Obama is injured." Within seconds of the tweet the Dow Jones Industrial Average (DJIA) dropped 100 points before correcting. The speed of which this flash-crash occurred was no doubt the actions of HFT systems (Welch, 2013). While investment firms do not publicly acknowledge news-aware HFT systems for competitive reasons, it should be possible to indirectly observe their behavior by analyzing the impact that textual financial articles have on stock prices immediately following a release.

This leads to a further question, if machines are executing trades based on textual data, can a stock price can be manipulated through carefully placed news article releases? While we cannot analyze this directly and ethics aside, our motivation is to build a system to analyze the factors a corporation could use in conjunction with a financial news article release to manage their stock price; namely the choice of media outlet, time of release and sentiment of the financial news article. Our goal is to study the correlation of factors and carefully theorize the determinants of causation to determine what link, if any, these factors may have on price movement activity.

We feel that by understanding the impacts that financial news can have on stock price, companies can carefully hone their choice of words, time releases (if they decide to release at all), choose which media outlet to release to - all based on current HFT trading behavior. This form of stock price management, using financial news articles, could have interesting implications within the FinTech community.

The rest of the paper is organized as follows. Section 2 is the literature review and will analyze high frequency trading, abnormal price movement, the role of media on pricing, sentiment analysis and prior systems and limitations. Section 3 introduces the CentralFinance system. Section 4 details the experimental design. Section 5 provides the experimental results and a discussion of their meaning. Finally Section 6 presents our conclusions and future directions.

2. Literature Review

Stock price movement is a natural function of disclosures, whether they be numeric, textual, oral or written. These disclosure-centric price movements can be action-based, trading-based or information-based (Allen and Gale, 1992). Action-based strategies can arise from unscheduled material events such as a new business deal, change in top level management, plant closures or layoffs (Iqbal and Shetty, 1995). All of which can trigger a stock repricing event. Trading-based strategies embed information within the trades themselves. Trading volume, timing, number of trades and pooling trades to induce further investment are all carefully scrutinized by larger investors for signals that might indicate new information. Information-based strategies are newly introduced facts that can create price movement. Examples include new economic data, a new product release or an unfavorable review. It is in this segment, Information, that includes both the quantitative data that computers can easily make decisions from, and the textual data that is information-rich, but requires additional processing to be of computational use.

Analysts forecast stock prices based on a variety of information sources: periodic filings, managerial communications (e.g., conference calls) and press releases (Ramnath, Rock et al., 2008). For publicly listed US companies, some disclosures are required such as 8K, 10K and quarterly reports. Companies can use these disclosures to present information in the most favorable manner, within reason. The 10K is an annual report that presents required information such as audited financial statements and executive compensation, however, many companies will use this opportunity to outline their strategic vision and provide their perspective for the upcoming year. Aside from required reporting, many companies will also engage in conference calls with investors and allow for some limited interaction. One well-known example that had a significant impact on trading was an August 2005 conference call with Patrick Byrne, CEO of Overstock.com, who talked about cocaine use, Star Wars Sith Lords, money laundering and arresting reporters (McLean, 2005). As a direct result of this conference call, Overstock trading volume increased nearly 400% and the stock price increased 7.1% that day. Based on disclosures, investors can react and cause stock price movements.

2.1 High Frequency Trading

To understand how news-aware trading systems work, we must first explore high frequency trading. High Frequency Trading is the intersection of systems and algorithms that can read, process and execute trades within milliseconds. HFT has rapidly gained popularity and accounts for the majority of trading in stocks, commodities and futures in the United States. To understand the extent of HFT, in 2011 HFT firms accounted for approximately 2% of the approximately 20,000 investment firms in the U.S. However, that 2% represents 73% of all U.S. equity trading volume with aggregate annual profits of $21 billion (Rose, 2011). These systems must absorb and analyze immense amounts of market data to generate millions of trades timed to the millisecond. Many of the trading strategies used by HFT algorithms are simply the automation of already proven strategies with incredible speed.

HFT usage has been mostly profitable, but not without pitfalls. One such pitfall was the Flash Crash of 2010. On May 6th, 2010, the S&P500 index declined 6.2% during a 20-minute span for a market equity loss of $862 billion. A study determined that HFTs did not trigger the crash, but as prices fell HFTs continued to sell, which led to a momentum drop in price and increased volatility (Kirilenko, Kyle et al., 2011).

2.2 Abnormal Price Movement

In analyzing the movements of stock prices, two major approaches are relevant, fundamental and technical analysis. These approaches differ in what market information is considered most valuable as well as how to treat historical data. Fundamentalists price stocks based on quantitative measures such as corporate fiscal values and the environment. Numeric values such as economic health, interest rates, return on assets, debt to equity and price to earnings are used by the fundamentalist trader. Historic and time-series data is typically not considered.

Technicians price stocks based on historical values, data patterns and market timing. Diverse arrays of charting techniques can be used to identify trends and find underlying price movements. Figures such as volume, volatility and resistance levels are closely monitored. Technical analysis can be very subjective and techniques vary between analysts.

Although the techniques differ, it is believed that the stock market is not informationally efficient and that untapped data exists to predict prices. This has led to the development of financial applications using advanced statistics, machine learning and econometric algorithms to exploit this inefficiency. However, this belief in market inefficiency and the steady trickle of profits derived is counter to two pillars of stock market research, Efficient Market Hypothesis (Fama, 1964) and Random Walk (Malkiel, 1973). Both studies concluded that markets are informationally efficient and price changes are instantaneous.

Exploring further the relationship of market efficiency versus inefficiency, a study of an artificial stock market investigating fundamental and technical trading strategies led to new insights (LeBaron, Arthur et al., 1999). In this study the authors created a simulated stock market with simulated traders, where new pieces of information were introduced into the market with varied amounts of time when an agent received it. It was found that traders with longer wait times adopted fundamental strategies while those with shorter wait times were technical. While these findings illuminated useful differences between fundamental and technical trading strategies, the most important finding was an apparent lag between the introduction of information and when the market corrected itself. Following up, it was discovered that a twenty minute window of opportunity exists before and after an information disclosure where the market adjusts and weak prediction is possible (Gidofalvi, 2001).

2.3 Role of Media

The role of media and its part in stock price movement has been explored in finance literature, but only in terms of long-term effects on price using daily/monthly closing prices or focused on limited media sources and/or hand-picked companies to study. While many of these studies acknowledge news events can cause price changes, one study argues that by the time a story goes to press it is old news and that price adjustments were already made (Fang and Peress, 2009).

One study questioned whether media coverage influences or is influenced by price movements. Scheufele et. al. investigated the price and volume movement of 8 German companies using daily closing prices and found that media coverage was influenced by price movement within a two month horizon (Scheufele, Haas et al., 2011). Others questioned whether news had any impact. Chan looked at monthly returns following news or no news and found a sustained price drift following bad news (Chan, 2003). Another study examined the amount of media coverage as a factor for price movement and found that smaller stocks with low analyst following were more susceptible to price shocks (Fang and Peress, 2009).

Lastly there is the question of whether it is the media or the story. A study examined the stock EntreMed following the May 3, 1998 New York Times article that they had achieved a cancer breakthrough (Huberman and Regev, 2001). This article had an immediate and sweeping impact on EntreMed’s price, increasing from $12.06 to $85 a share in afterhours trading, as well as uplifting the whole biotechnology sector. The only problem was that the NYT was reporting an announcement made five months earlier, in the Times itself, and that no new news was communicated. From these studies and the last one in particular, it is clear that the media can influence stock price movement.

2.4 Sentiment Analysis

Diving further into media and articles, the way an article is written can also be important. Sentiment analysis is the examination of text for opinions and emotions (Abbasi, Chen et al., 2008). Sentiment classification studies attempt to determine tone, whether text is objective or subjective, as well as polarity, whether the text is positive or negative.

The relationship between sentiment analysis and stock market movement has been examined in several studies. One study focused on financial press releases and news articles using daily content from the Wall Street Journal (Tetlock, 2007). It was found that negative sentiment generally led to downward movement in stock price.

A second study used 1.5 million message board posts on the 45 companies in the Dow Jones Industrial Average to measure the "bullishness" of user-generated content compared to the Wall Street Journal (Antweiler and Frank, 2004). They found that the bullish content was helpful in predicting market volatility. The predictive abilities were statistically significant but the economic value was small.

A third study investigated the sentiment of 2,802 financial news articles and found a 3.30% return on subjective news articles and 3.04% return on articles with a negative sentiment using a simulated trading engine (Schumaker, Zhang et al., 2012). However, this system relied on zero transaction costs and made a significant number of trades.

Sentiment analysis can be used to help understand the role that financial news articles have on stock price. If the signal is strong, the sentiment could reveal unique opportunities to manage stock price with greater precision. One well-known tool to measure sentiment is OpinionFinder. OpinionFinder can identify subjective text and positive or negative sentiments (Wilson, Hoffmann et al., 2005). When compared against the MPQA Opinion Corpus, OpinionFinder had an accuracy of 74%, subjective precision of 78.4%, subjective recall of 73.2% and a subjective F-measure of 75.7%, as compared to baseline accuracy of 55.3%.

2.5 Research Gaps

From our study of the literature, a few gaps emerge. First, the relation between financial news article release and its impact on stock price within minutes of release has not been fully studied. Much research has analyzed daily or monthly price impacts from news, but not much on intraday movements. Second, prior research examined media's role in price movements, however, many studies restricted either the number of media outlets or the number of stocks studied, as well as used long timeframes (e.g., a day or longer) which would be unsuitable for HFT analysis. Third, we found no literature that examined the time an article is released with respect to price movement. Lastly, not much sentiment analysis has been done on financial news articles with the intent of determining price movement immediately following article release.

To address the gaps in knowledge and provide a fuller understanding of the interplay between financial news articles and stock price movement, we ask the following research questions.

1. *What is the correlation between stock price movement and financial news article release?*

Prior studies have established a twenty-minute window of weak predictivity following a financial news article release. We seek to evaluate this connection statistically using price-related finance measures. The results obtained can be used as a type of baseline to test additional datasets.

2. *Does the media outlet impact stock price?*

Articles released in different media outlets may show differing degrees of price movement. We seek to analyze the price movements of stocks for articles released exclusively through a media outlet within a twenty-minute window and believe that given the differences in editorial content, writing styles and audiences that a price movement difference may exist.

3. *What effect does article release time have on excess returns?*

Another aspect is to analyze whether the time of day an article is released has relation to abnormal stock price movement. In a perfect market we would not expect to see a difference.

4. What is the role of sentiment in price movement?

We know from previous research that the emotive content of an article has potential to influence stock price. The addition of sentiment classifications should provide further insight.

3. System Design

To answer our research questions we designed the CentralFinance system that uses textual financial news articles and intraday stock quotes to predict stock prices twenty minutes after an article is released. An example of CentralFinance is shown in Figure 1 with an explanation to follow.

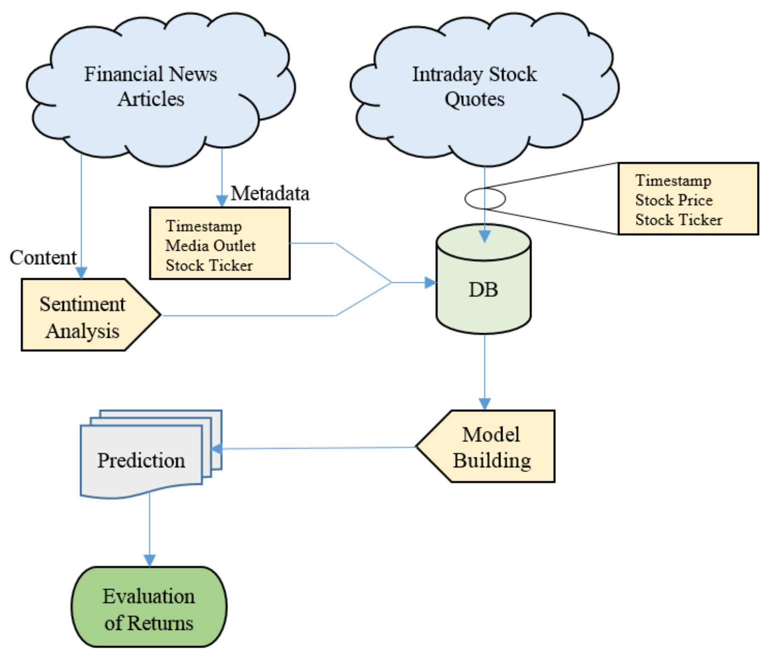

Figure 1. CentralFinance System

Financial news articles and intraday stock quotes are automatically collected and input into the system. Collection of financial news articles is performed using a web scraper that queries financial news articles from Yahoo! Finance by their stock tickers. Article metadata is then parsed for the timestamp of article release and media outlet. Article content is analyzed using OpinionFinder for sentiment polarity before migrating to the database. Intraday stock quotes gather stock quotes in one-minute increments from Google Finance retaining the time, stock price and stock ticker.

Once the data has been collected, Model Building creates the models necessary to answer the research questions. At their base each member of the model (e.g. financial news article) will contain the article timestamp, stock ticker and per minute price data over the prior twenty minute period. Additional models utilize media outlet, timestamp and sentiment information. For each article release time, stock price data over the prior twenty minute period is normalized and a regression estimate of price twenty minutes after article release is computed. While we acknowledge the idealness of using a longer regression window, the amount of usable data would be decreased. Through experimentation the twenty minute prior to release regression window was performing adequately and balanced our usable data needs. The slope of the regression estimate is then retained as the predicted price slope.

To determine how well the prediction estimate was, the actual stock price twenty minutes after the article release is used along with the actual stock price at article release to calculate the actual price slope. The predicted price slope and the actual price slope are compared to calculate a deviation in slope (ΔSlope). The ΔSlope variable is a measure of abnormal price movement following an article release. A change in slope value is calculated for each article.

4. Experimental Design

For the experiment we chose a forty day trading period from February 12 to April 10, 2014. This eight week period appeared stable and did not show any unusual market conditions. We also chose to use companies listed in the S&P 500 as of February 7, 2014. Because financial news articles could be released at any time including outside of trading hours, we restricted our data to only include those articles between 9:50am and 3:40pm. Even though trading occurs between 9:30am and 4:00pm the twenty minute period after market start and before closing was required for regression estimation. Data was further constrained to use only one article per company within the twenty minutes before and after the article was released. If two or more articles on the same company were released within that timeframe both would be discarded. This was done to eliminate the effects of confounding variables and to provide a clean dataset to measure price differences. These rules resulted in 12,903 articles from 62 financial news sources and 5,598,569 stock quotes available for the experimental period.

For our models, we built a baseline, media outlet, time of release and sentiment models. Baseline examines the +20min abnormal price movement of the 12,903 financial news articles and compares it to a random dataset consisting of 1,000 random stock and date/time combinations. Our belief is that if financial news articles are creating an abnormal price movement, a statistical difference would occur between the two datasets.

To measure abnormal price movement activity, we used ΔSlope (a linear regression estimate) and a financial metric of Sharpe ratio which calculates the average return earned in excess of the baseline return as shown in Equation 1.

$$\text{Sharpe Ratio} = \frac{R_A - R_B}{\sigma_A} \qquad \text{(Equation 1)}$$

The asset return variable R_A is the stock price at t=20 minus the price at t=0. The baseline return R_B is the average stock price within the prior twenty minutes with respect to article release. The σ_A variable is the standard deviation of prices over the t=-20 to t=0 period. A criticism of the Sharpe ratio is that it assumes a normal distribution of expected returns which can be a problem with assets or portfolios with a high degree of negative skew or significant non-linear risks. Many of these issues become less of a concern as the size of the portfolio increases and almost entirely disappear when looking at the entire S&P500 as is the case of this experiment.

We also examine the effect of abnormal price movement through various media outlets. Using the same metrics as before, we look at whether some media outlets are more prone to abnormal price movements.

A third model tested the time of day that a financial news article was released. We partitioned the market into discrete buckets of time to analyze if certain times of the day would lead to greater abnormal price activity.

The last model tested was that of sentiment content. By analyzing the polarity (e.g. whether the article is more positive or negative) further insight into price movements could be obtained. A third category of neutral was used in cases where OpinionFinder was divided in its assessment or unable to make a distinction.

Examples of articles marked Positive and Negative are provided below.

Positive Article

Microsoft's executive vice president Tami Reller announced today that the company has sold more than 200 million Windows 8 licenses.

TechCrunch confirmed the data point with Microsoft. The company provided greater detail on the figure stating that it does not "include volume license sales to enterprise" while it does take into account upgrades to Windows 8 along with normal inclusion on new personal computers.

Microsoft has been incredibly tight-lipped about Windows 8 sales in recent months providing essentially no guidance since disclosing 100 million copies sold in May of 2013. Windows 8.x both Windows 8 and Windows 8.1 have enjoyed the regular momentum of the PC market as sustenance to their sales figures. (Courtesy PR Newswire, Feb 13, 2014)

Negative Article

EBay last month said activist investor Carl Icahn had proposed spinning off PayPal and was nominating two of his employees to join the board. In an interview on Bloomberg TV at the time Icahn said eBay hasn't done as well as it should have and called a separation of PayPal -- which is one of eBay's faster-growing businesses -- a no-brainer that would boost value.

Today Donahoe said San Jose-based eBay isn't working at odds with Icahn.

EBay shares rose less than 1 percent to $55.15 at the close in New York. They have gained 1.4 percent since the company disclosed Icahn's proposals. (Courtesy Noodls, Feb 19, 2014)

5. Experimental Results and Discussion

5.1 What is the correlation between price and financial article release

To answer our first research question of *what is the correlation between stock price movement and financial news article release*, we analyzed the stock price of companies before and after the release of financial news articles to detect if any statistically significant (i.e. abnormal) price movement occurred. We compared our dataset following a news article release against a dataset containing 1,000 random date/time and stock combinations. If a change in the slope of stock price twenty minutes after an article was released varied from the change in price slope of the random dataset, then we could reasonably assume financial news articles had an effect on stock price.

The ΔSlope of the article dataset, measured in absolute values, was 2.06% versus the random dataset of 1.98%, p-value < 0.2. This is a weak connection between article release and price movement but ΔSlope is not necessarily discriminatory enough to measure short-term price fluctuations and does not take into account the natural market deviations in price.

To further fine-tune the effect of news articles on price, we also implemented the Sharpe ratio using the same datasets. Recall that the Sharpe ratio takes into account price volatility in the form of standard deviation in the divisor. This means that stocks exhibiting abnormal price movements with low volatility (e.g., low standard deviation) will have greater Sharpe ratios.

From these calculations, the Sharpe ratio was found to be 1.81 for the article set and -0.06 for the random set, p-value of < 0.001. At the outset this indicates a strong correlation between article release and abnormal price movement within the twenty minute release window as shown in Table 1.

# Articles	# Stocks	$\Delta\text{Slope}_{\text{Articles}}$	$\Delta\text{Slope}_{\text{Random}}$	$\text{Sharpe}_{\text{Articles}}$	$\text{Sharpe}_{\text{Random}}$
12,903	497	2.06%	1.98%	1.81	-0.06

Table 1. ΔSlope and Sharpe ratio comparison between article and random datasets

From these results we found that news article release did create a statistically significant price movement. Stock prices immediately following article release exhibited less price volatility within the twenty minute release window. This finding opens the possibility that financial news article releases could be used as a form of price management.

5.2 Does the media outlet impact stock price?

To answer our second research question of *does the media outlet impact stock price*, we examined the abnormal price movement for each news source that had 30 or more articles. The results of the top and bottom five media sources, as sorted by $\text{Sharpe}_{\text{Article}}$, are presented in Table 2.

News Source	# Articles	# Stocks	$\text{Sharpe}_{\text{Article}}$	$\text{Sharpe}_{\text{Random}}$	$\text{Volume}_{\text{Article}}$	$\text{Volume}_{\text{Random}}$
Associated Press	815	49	43.04 ***	1.61	66,714	25,200
The Wall Street Journal	67	35	1.22 ***	0.10	32,605	25,373

Reuters – UK Focus	139	41	0.87 ***	0.84	54,476	54,218
New York Times	50	16	0.84 ***	0.14	45,616	45,868
Financial Times	367	105	0.80 ***	-0.35	37,057	31,401
Barrons.com	119	46	-1.45 ***	0.86	25,190	22,063
MarketWatch	120	48	-1.41 ***	-0.34	23,122	24,464
Forbes	251	82	-1.36 ***	0.02	49,582	62,313
Bloomberg	197	68	-1.11 ***	-0.04	49,184	47,080
Fortune	39	19	-0.88 ***	-0.96	63,278	64,656

Table 2. Media outlet Sharpe ratio results (*** p-value < 0.01)

From the data, each $Sharpe_{Article}$ value was statistically different from $Sharpe_{Random}$, p-value < 0.01. Articles released through the top five media outlets; Associated Press, The Wall Street Journal, Reuters – UK Focus, New York Times and Financial Times, experienced increased returns in excess of their random counterparts. Digging further into the large $Sharpe_{Article}$ value for the Associated Press, 43.04 versus $Sharpe_{Random}$ of 1.61, it was found that JM Smucker (SJM) was causing price volatility over earnings concern and quality control issues. As for the other media sources such as The Wall Street Journal, higher $Sharpe_{Article}$ to $Sharpe_{Random}$ ratio indicated abnormal returns following an article release, beyond what was expected. It is also interesting to note that the Wall Street Journal, Reuters, New York Times and Financial Times are among the most widely circulated media sources.

The top five media outlets that experienced decreased returns in excess of their random counterparts was Barrons.com, MarketWatch, Forbes, Bloomberg and Fortune. Companies whose financial news articles were featured by these media companies had statistically significant lower stock prices following news article release than could be accounted for by random chance.

We further noted that six of these ten media outlets also demonstrated higher trading volumes following article release. This volume increase means that investors and algorithms alike are reacting to the release of financial news articles with increased trading volume. Applying this with the $Sharpe_{Article}$ and $Sharpe_{Random}$ statistical differences, the media sources appear to demonstrate abnormal price movement.

5.3 *What effect does article release time have on excess returns?*

To further analyze the effect financial news articles have on the market, we asked *what effect does article release time have on excess returns*? We grouped articles by their hour of release and examined the Sharpe ratio. Results are shown in Table 3.

Time Frame	**# Articles**	**# Stocks**	**Sharpe$_{Article}$**	**Sharpe$_{Random}$**
9:50 – 9:59am	310	202	2.58 ***	1.32
10:00 – 10:59am	2,505	449	0.04	0.00
11:00 – 11:59am	2,126	457	-0.27 **	-0.15
12:00 – 12:59pm	1,990	428	0.53	0.55
1:00 – 1:59pm	2,626	463	-0.11	-0.04
2:00 – 2:59pm	1,913	422	-0.16 ***	-0.65
3:00 – 3:40pm	1,366	387	-0.08 *	-0.19

Table 3. Article release time Sharpe ratio results
*** p-value < 0.01, ** p-value < 0.05, * p-value < 0.1

Only four of the time periods exhibited statistically significant results; 9:50-9:59am, 11:00-11:59am, 2:00-2:59pm and 3:00-3:40pm. Calling attention to the 9:50-9:59am time period, both Sharpe$_{Article}$ (2.58) and Sharpe$_{Random}$ (1.32) exhibited markedly increased values versus other time periods. We believe this represents the continued correction of the market as it reacts to overnight news as demonstrated by the increased Sharpe$_{Random}$ value. Had markets corrected, we would expect Sharpe$_{Random}$ values near zero as noted in the 10:00-10:59am time frame. However, the increased Sharpe values during early morning trading was not unexpected as prior research found similar results of an adjustment period due to overnight news (Schumaker and Chen, 2008). The statistically larger Sharpe$_{Article}$ (2.58) suggests that traders may be more sensitive to financial news during this period. This led to abnormal returns in excess of random chance immediately following the release of a financial news article. The rest of the trading day shows less price volatility with the exception of a slight peak around noon before decreasing for the rest of the day.

Given this finding, companies that release financial news articles during the 9:50-9:59am time period have the potential of receiving abnormal positive price returns.

5.4 *What is the role of sentiment in price movement?*

To answer our last research question of *what is the role of sentiment in price movement*, we examined individual article content and partitioned articles as positive, negative or neutral based on their sentiment. The results are presented in Table 4.

Sentiment	**# Articles**	**# Stocks**	**Sharpe$_{Article}$**	**Sharpe$_{Random}$**
Positive	1,456	426	-0.00	0.10
Negative	494	223	-0.47	0.40
Neutral	10,886	495	-0.06	0.08

Table 4. Sentiment analysis results

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Negative articles, while the least number in the collection, had the most adverse Sharpe$_{Article}$ value of -0.47. Neutral articles were -0.06 and positive articles showed minimal to no change with respect to price movements. It would appear that articles written in a negative manner impact stock price more so than other sentiments, which is not entirely surprising.

Looking closer at the price trends before and after an article is released with respect to sentiment categories, we present Table 5.

Negative articles, while the least number in the collection, had the most adverse Sharpe$_{Article}$ value of -0.47. Neutral articles were -0.06 and positive articles showed minimal to no change with respect to price movements. It would appear that articles written in a negative manner impact stock price more so than other sentiments, which is not entirely surprising.

Looking closer at the price trends before and after an article is released with respect to sentiment categories, we present Table 5.

Positive Sentiment	**# Articles**	**Increased**	**Continued**	**Reversed**
Trending Up	744	7	721	16
Trending Down	704	10	679	15
Negative Sentiment	**# Articles**	**Increased**	**Continued**	**Reversed**
Trending Up	236	4	224	8
Trending Down	255	6	245	4
Neutral Sentiment	**# Articles**	**Increased**	**Continued**	**Reversed**

Trending Up	5,382	90	5,186	106
Trending Down	5,438	82	5,251	105

Table 5. Article sentiment and its effect on price

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From this table we examined at the number of articles in each of the positive, negative and neutral sentiment categories and broke it apart by the price trend before the article was released (e.g., *Trending Up* and *# Articles* refers to the number of articles in which the stock price was trending upward before article release). For the categories of *Increased*, *Continued* and *Reversed*, we counted the number of articles in which the trend shown a 5% increase in slope, stayed within -5% to +5% or reversed trajectory by more than 5%, respectively, following article release. The 5% value was chosen empirically to isolate those stocks experiencing sudden price swings following article release. From these findings, the release of a news article did not significantly change the majority of stock prices as noted by the large *Continued* value which is to be expected for a 5% difference.

It was interesting to note the largest percentage of change for articles with negative sentiment. In particular, 8 times articles that were trending up reversed by 5% or more (3.4% of negative trending up articles) and 6 times articles trending down increased their trend by 5% or more (2.4% of negative trending down articles). Both follow expectations that negative articles should decrease price, however, the rate of change is surprising.

Looking at trading activity that went against expectations for positive sentiment, 16 times articles that were trending up reversed by 5% or more (2.2% of positive trending up articles). Of those 16 times, 13 companies were affected and for IBM it occurred on 3 separate occasions (March 28, April 2 and April 4, 2014). The first media source was theflyonthewall.com and the other two were PR Newswire. Diving deeper, the content of the articles were on a former CEO providing business school leadership training, German manufacturer Sto SE & Co. signing a deal with IBM, and a patent on secure mobile notifications from the cloud. For the first article the stock was trending up 0.19% before declining by 5.73%. For the second article the stock was trending up

0.03% before declining 5.94%. For the third article the stock was trending up 0.25% before declining 6.09%.

Backing up and looking at all IBM stock activity with respect to article release, Table 6 analyzes the 13 news articles between March 28 and April 4, 2014 by their trend before and after article release.

	# Articles	Increased	Decreased
Trending Up	5	0	5
Trending Down	8	4	4

Table 6. IBM News Articles between March 28 and April 4, 2014

From the table there were 13 financial news articles for IBM during this period. Five of them were trending upwards prior to release, by an average of 0.06%, before decreasing after article release, by an average of -2.58%. Eight articles were trending downwards prior to release, by an average of -0.07%, before splitting evenly after release, by an average of -0.31%. The trending up portion is more interesting as all articles during this period decreased. Looking at the sentiment profile of the five articles, two were marked positive and three were neutral. It would suggest that if IBM were able to recognize this pattern in market behavior, they may have been able to better manage their stock price through not releasing any financial news articles during this time.

6. Conclusions and Future Directions

From our investigation we found several interesting results. First, CentralFinance was able to identify a strong correlation between the period following the release of a financial news article and abnormal price movement. This was represented by a large difference in $Sharpe_{Article}$ of 1.81 and $Sharpe_{Random}$ of -0.06 (p-value < 0.001) which is the average return earned in excess of the baseline return for the article set and random set respectively. It indicates significant abnormal price movement following article release and opens the possibility of companies managing their stock price through article releases.

Our second finding was a link between media outlets and price movement. In many of the media outlets, article release led to an abnormal return, more so than their random dataset counterparts could explain. Likewise an increase in stock volume also occurred following article release leading us to speculate that traders were reacting to financial news articles. Furthermore, we found that The Wall Street Journal, Reuters – UK Focus, New York Times and Financial Times all demonstrated abnormal returns, beyond what was expected.

Our third finding analyzed the time of news article release and how it relates to abnormal price movement. We found that articles released at market opening had significantly higher $Sharpe_{Article}$ to $Sharpe_{Random}$ (2.58 to 1.32 respectively, p-value < 0.01). We believe that this represents the market price correction as it reacts to overnight news.

Our fourth finding was the correlation between article sentiment and abnormal price movement. Articles marked negative polarity had the highest $Sharpe_{Article}$ value of -0.47 versus positive (-0.00) and neutral (-0.06). Looking further we noted that IBM was experiencing abnormal price movements between March 28 and April 4, 2014 with respect to news article releases. Five of the thirteen articles released during this period were trending up prior to release (average 0.06%) before decreasing after article release (average -2.58%). Perhaps if IBM were able to recognize this market activity occurring they could have managed their stock price through careful press release engineering.

There are some caveats to impart to the reader regarding this research. First, we followed prior research that assumed the information contained within a financial news article was not made public until the release of a news article. While there exists the possibility of insider trading and other ethical considerations, we chose to discount these factors for simplicity. Second, stock price movement is not wholly dependent on financial news articles. A variety of inputs other than financial news articles could cause stock price changes. Third, the customer-base of media companies is not equivalent across all media companies and hence may influence the magnitude of stock price change. It may be interesting to pursue this aspect further. Further, while the results presented are certainly interesting, they depend on the dataset used. Perhaps other time periods would yield different results.

Future directions include looking at other types of press release inputs that might affect stock price movement. Perhaps other variables are more adept than the ones investigated here. Another avenue of research would be to adjust the timing window granularity. While our research implemented a twenty minute window following article release, perhaps it might be of interest to investigate shorter windows with richer quote data to the second or better. A third research direction is to follow-up on identifying similar market patterns as observed in the IBM case. We feel this may be a promising direction that would have direct and immediate implications on price management.

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