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THE IMPACT OF INVESTORS' PRESS READING TIME ON HETEROSCEDASTICITY OF STOCK RETURNS: THE CASE OF INTERCONTINENTAL EXCHANGE

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ABSTRACT

This paper examines the impact of ICE press reading time on the information flow interpretation of conditional volatility using the framework of Lamoureux and Lastrapes (1990). The intraday press reading time aggregated over a monthly time horizon is shown to provide a significant explanatory power of heteroscedasticity in Intercontinental Exchange return data. The ARCH and GARCH effects vanish when the aggregate press reading time is included in the conditional variance equation of EGARCH model. This finding suggests that the residual heteroscedasticity of ICE returns reflects the time lag between press reading and the equilibrium price determination of ICE stock. Further, the aggregate press reading time is positively and significantly related to the conditional volatility, which indicates that the amount of textual contents of news is positively related to the equilibrium price change variance. The economic importance of these findings for policymaking and government initiatives are discussed.

Keywords: Press reading time, News consumption, Efficient Market Hypothesis, Information flow, EGARCH, Trading volume

JEL Classification: C58, D53, E51, G12, G14, G17; Z19

Introduction

Since the concept of efficient market hypothesis was first put forward by Fama (1965), several empirical papers test the validity of the assumptions concerning stock market efficiency. According to the theory, stock market operations are assumed to be rational and stock prices are expected to fully reflect all available information at any given point in time. In response to new information, prices quickly adjust to reflect the impact of new information on the value of stocks. As such, the current market prices provide the most realistic valuation of the securities trading in the stock market. On the other hand, information arrives at the stock market in a variety of forms (e.g. media release, exchange announcements etc) and the investors require a certain amount of time to read, comprehend and understand the implications of information for stock price changes. Information processing skills and abilities vary from investor to investor and context to context. It may be affected by the environment, investors' experience, investor relationship and the mood state of individual investors etc. Hence, the information may not, that instantly, be reflected in the stock market prices as the theory assumes. The efficient market hypothesis has therefore been debated on its application in the real world.

Not only time spent on reading and comprehending impacts stock price changes but also the experience encountered (e.g. mood) during the reading of announcements and press release can help predict the direction of stock price movements (See especially Cohen-Charash 2013). As such, the psychological state of mind of investors—in the course of information processing—is likely to impact the common market perception about the stock price direction. The content and timing of announcements and press release may be manipulated by firms in order to appreciate their stock prices (See Ahern and Sosyura 2014). Therefore, the investors have to spend a considerable amount of time to understand the content and its accuracy to determine any possible impact of information on the value of common stocks and the stock prices may not fully reflect the underlying information during the information processing timeframe. Therefore, it is highly likely that the information processing time (e.g. press reading time) may significantly impact the magnitude of stock price changes.

The objective of this paper is to examine whether the aggregate exchange press reading time could be recognized as a mixing variable for the time dependence in the rate of new information arrival at the market. Using press reading time data from the Intercontinental Exchange (ICE), this paper examines the impact of underlying information arrival process attached to press reading time on the heteroskedasticity in ICE returns using the framework of Lamoureux and Lastrapes (1990). The paper is organized as follows. Section 2 provides a review of current literature. Section 3 provides the conceptual framework. Section 4 describes the data set used. Section 5 discusses the findings and section 6 provides the concluding remarks.

Literature Review

The Efficient Market Hypothesis (EMH) of Fama (1965) suggests that the stock prices should reflect all available information at any given point in time. As such, the stock price changes occur only when the new information arrives at the stock market. The theory assumes that the new information arrives at the market in a random fashion, independently from other news. The assumptions concerning information are crucial for the acceptance of this hypothesis. Fama (1965) and many others argue that, when the new information events (i.e. segments) occur, the corresponding information quickly spreads and incorporates into the stock prices without delay. This implies that there is no delay (i.e. time lag) in processing information (e.g. reading, understanding, analyzing and interpreting).

Such perfections in financial markets have been largely debated in the literature with reference to a number of cognitive biases such as overconfidence, information bias, under reactions and various forms of human errors associated with information processing. In particular, Engelberg et al. (2012) show that the short sellers with information processing expertise benefit immensely from the public news arrivals. On the other hand, a number of scholars show that the textual contents of news impact the stock market prices and the currency exchange rates predictions (See e.g. Mittermayer 2004; Zhai et al. 2007; Wuthrich et al. 1998, Butler and Kešelj 2009; Tetlock 2007; Schumaker et al. 2012; Vu et al. 2012; Yu et al. 2013; Hagenau et al. 2013; Chatrath et al. 2014; Nassirtoussi et al. 2015; Sun et al. 2016). Investors spend a substantial amount of time in reading and understanding the content of exchange press releases and the amount of time lag between receiving the news and execution of transactions depends on their skills in reading and understanding the impact of news on stock prices. This process involves a number of steps, for example, analyzing and quantifying the impact etc. Therefore, it is likely that the equilibrium price formation is significantly influenced by the time lag in the process of reading and grasping the essence of the news content. On the other hand, the scholars show that the investors' attention to various sources of information impacts the speed of stock price reaction to information (See e.g. Hirshleifer et al. 2009; Drake et al. 2016 and Li 2018). Engelberg et al (2011) and Fedyk (2017) show that the differences in investors' attention to randomly available information have an impact on the reaction of market prices to new information.

Fama et al. (1969) and many others show that the stock prices quickly adjust to new information (See e.g. Dann et al. 1977; Hillmer and Yu 1979; Brennan et al. 1993; Ederington and Lee 1995; Gosnell et al. 1996; Pan and Poteshman 2006; Reboredo 2013), although it has been critically debated in the subsequent scholarly work. Scholars find evidence for late and early relation of stock prices to new information arrival (See e.g. Abarbanell and Bernard 1992; Poteshman 2001; Kadiyala and Rau 2004; Spyrou et al. 2007). Since the new information arrival is unobservable, numerous studies use proxy variables such as stock volume, number of transactions and various types of other proxies (e.g. internet search volume).

Lamoureux and Lastrapes (1990) first test for heteroscedasticity in stock returns of twenty common stocks using stock volume as a proxy for the number of new information arrival at the market. Scholars such as Ali Ahmed et al. (2005), Ananzeh (2015) and Senarathne and Jayasinghe (2017) revisit the framework of Lamoureux and Lastrapes (1990) using a plain vanilla Generalized Autoregressive Conditional Heteroskedasticity (1, 1) process and show that the Autoregressive Conditional Heteroskedasticity (ARCH) effect vanishes and the total volatility persistence is reduced (or becomes negligible) when the proxy variable (i.e. stock volume) is introduced into the conditional variance equation[1]. The findings suggest that the ARCH is a reflection of time dependence in the rate of new information arrival at the stock market. Along these lines, the recent scholars introduce novel proxy variables for the new information arrival. Proxy variables such as internet search volume (e.g. company name search), margin debt values, patent citations and number of internet news arrivals have been used by a number of scholars (See e.g. Son-Turan 2014; Zhang et al. 2014; Shen et al. 2016; Senarathne 2018; Senarathne and Jianguo 2018; Shen et al. 2018).

Conceptual Framework

Consider the following stock return forecasting specification.

$$r_t = \beta_1 r_{mt} + \varepsilon_t \qquad (1)$$

where,

[1] See Bollerslev (1986).

$$\varepsilon_t = \sigma_1 Z_{1t}\sqrt{F_t} \tag{2}$$

and,

$$V_t = \sigma_2 Z_{2t}\sqrt{F_t} \tag{3}$$

$$F_t = \alpha_0 + \alpha F_{t-1} + \Phi_{t,} \quad F_t \geq 0 \tag{4}$$

In such, r_t is the stock return (ICE) at time t and V_t is the stock volume (ICE) at time t. r_{mt} is the return on NYSE portfolio[2]. The price increments are nonnegative and represent an increasing function of operational time t in the sense of Clark (1973). The mixing variable F_t is subject to two mutually and serially independent stochastic processes, $Z_{1t}$and Z_{2t} with mean zero and unit variance. The white noise $\Phi_{t,}$ is a serially independent random variable with mean zero and unit variance, which is restricted to ensure that F_t is always non-negative. Equation (02) and (03) are related to the mixture of distribution framework of Tauchen and Pitts (1983) adopted from the idea of Lamoureux and Lastrapes, (1994). The heteroscedastic mixture model expects $Z_{1t}$and Z_{2t} to play the same role of a unique directing process within the subordinated stochastic framework of Clark (1973).

r_{it} could be written as $\varepsilon_t = \sum_{j=1}^{F_t} \delta_{jt}$ when the mean conditional on current information is constrained to zero. Conditional price increments of firm i are collected at every jth trade in the market, directed by the unobservable mixing variable F_t[3]. In a market with k number of equity firms (equity financed), $r_{mt} \approx 1/k(\sum_{i=1}^{k} \sum_{j=1}^{F_t} \delta_{jt})$[4]. Note that the conditional variance $\Omega = E(\varepsilon_t^2 | n_t)$, which is characterized by $\varepsilon_t |\ n_t \sim N(0, \sigma^2 n_t)$, in such, $\Omega = \sigma^2 n_t$. Let the observable proxy V_t be replaced by $Q_t = \sqrt{\log(D_t) * \log(V_t)}$ where D_t is the press reading time at time t summed up over a monthly time horizon. Assume that the time lag between exchange press releases and the execution of transactions is only explained by reading time. That is to say, the investors are fully comprehended with the press releases at the end of reading and prepared to execute the transactions immediately after reading (based on the assessment of the impact of information on stock prices, if any). In each intraday trade at time t, the

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[2] Note that the number of transactions is an inappropriate proxy variable for the specification above, as it does not reflect the value relevance of the information flow (See especially Senarathne and Jayasinghe 2017; Lamoureux and Lastrapes, 1990).

[3] These increments are summed up over a monthly time horizon.

[4] This is proxied by the index return (i.e. NYSE Composite index).

corresponding press reading time and the total number of time lags in the equilibrium price formation of each day (i.e. aggregate of all intraday trades) could then be arrived at by $\sqrt{\log(D_t) * \log(V_t)}$. The volume V_t reflects the value relevance of new information content of each press release and the corresponding trades are executed only upon the receipt of new information.

The Exponential Generalized Autoregressive Conditional Heteroskedasticity (EGARCH) model of Nelson (1991) is used to forecast stock return volatility as,

$$R_t = c + \beta r_{mt} + \ + \varepsilon_t, \tag{5}$$

$$\varepsilon_t \backslash (\varepsilon_{t-1}, \varepsilon_{t-2}, \ldots\ldots) \sim N(0, h_t), \tag{6}$$

$$\ln(\sigma_t^2) = \omega + \eta \ln(\sigma_{t-1}^2) + \gamma \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha \left[\frac{|\varepsilon_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right] \tag{7}$$

Where,

β = The beta coefficient which measures the systematic component of risk attached to ICE.
σ_t^2 = Conditional variance at time t.
ω = Intercept term of the conditional variance equation.
η = Coefficient applicable to previous period's error term or ARCH coefficient.
γ = Asymmetric volatility coefficient.
α = return volatility coefficient applicable to GARCH term or long-term volatility coefficient.

The proxy variable is included in the variance equation (7) as,

$$\ln(\sigma_t^2) = \omega + \eta \ln(\sigma_{t-1}^2) + \gamma \frac{\varepsilon_{t-1}}{\sqrt{\sigma_{t-1}^2}} + \alpha \left[\frac{|\varepsilon_{t-1}|}{\sqrt{\sigma_{t-1}^2}} - \sqrt{\frac{2}{\pi}} \right] + \psi Q_t \tag{8}$$

Under null hypothesis of ARCH reflects the time dependence in the rate of information arrival proxied by Q_t, the coefficient η and α of EGARCH model[5] should be negligible in the sense of Lamoureux and Lastrapes, (1990).

Data and about ICE

Intercontinental Exchange (ICE) is an American company that operates twelve regulated exchanges and six clearing houses around the world. ICE operates a portfolio of businesses in the services industry[6] and the company receives the listing status in November 16, 2005. It is widely accepted that the market risk profile and operating conditions (e.g. market efficiency) differ from one market to another and these differences can be explained with reference to beheviour of investors (e.g. risk preference, learning, psychological issues, biases in processing of information and decision making etc). The operating risk of an exchange could be ascertained by computing a common index[7] (on exchange traded portfolio of businesses) to reflect the overall return on the business portfolio, which provides the benchmark for the risk of exchange operations. Then, the news arrival on the operation of business portfolio of the exchange should be highly sensitive to index return, given the amount of business and financial (if any) risk involved in the exchange operations. The flow of income on exchange operations and related services depends on the performance of the markets. For example, if the markets are dull or affected by a crisis, the income of the exchange is low during such periods because the incomes of an exchange is usually determined as a percentage of the total exchange's turnover at varies stages[8]. Since there is no such common index computed to reflect the return on ICE business portfolio, let ICE stock return be taken as the proxy for the return on exchanges—which also reflects other business investment risk.

Reading time of each press release is assessed and recorded using the Instant Reading Time extension (version 1.65 updated on 30th June 2017) offered by Umpox which can be added to the Google Chrome browser toolbar[9]. It displays the time taken to read any page across the web. The average time is set by default at 275 words per minute. The nomination of average reading speed in the extension

[5] Especially the ARCH effect in the sense of Lamoureux and Lastrapes (1990).
[6] See https://www.theice.com/about.
[7] I.e., by computing the volatility of such index return.
[8] See e.g. NYSE trading fees https://www.nyse.com/markets/nyse/trading-info#trading-fees.
[9] Extension is available in Google Chrome Web store and can be accessed on https://chrome.google.com/webstore/detail/instant-reading-time/afipdkkndmggnmffcmepioemogfnnibf?hl=en.

does not impact the variations in the reading time as it is just a standardized unit of measure of the reading time.

Monthly stock returns[10] and ICE press release data on all categories (Ags and metals, corporate, credit, currencies and indexes, energy, equities and options and interest rates) are obtained from the ICE webpage[11] Stock return and press reading time data covers a sampling period from March 2006 to September 2018. Some descriptive statistics of these sample data are as follows.

Empirical Findings

Table 1: Statistical Properties of Sample

Variable	Mean	Median	Max.	Min.	JB	ADF	LM	Q (20)
R_{it}	0.0142	0.0190	0.2714	-0.3702	63.42	-12.07	9.04	30.89
R_{mt}	0.0032	0.0089	0.1076	-0.2174	125.28	-10.16	NA	39.87
V	1.2E+08	8.1E+07	7.6E+08	9.1E+06	574.60	-1.78	NA	920.29
RT	39.76	35.00	115.00	9.00	85.31	-3.66	NA	127.01

Source: Author's computation

Notes:

1. JB - Jarque–Bera test statistic for normality. Under null hypothesis for normality, critical value of $\chi 2$ (2) distribution at 5% significance level is 5.99.
2. ADF- Augmented Dickey–Fuller test statistic for stationarity of data for maximum 13 lags. Under null hypothesis for data having unit root, the critical value at 5% significance level is -2.88
3. LM is the ARCH LM test statistic for number of observations multiplied by the R-squared value for 3 lags. Under null hypothesis, critical value of $\chi 2$ (3) distribution at 5% significance level is 7.815 (OLS equation $R_{it} = c + R_{mt} + \varepsilon_t$,).
4. Q (20) is the Ljung-Box Q statistic for serial correlation upto 20 lags, in the reading time series data. Under the null hypothesis for no serial correlation, the critical value of $\chi 2(20)$ distribution at 5% significance level is 31.41.
5. *Statistically significant at 5% and **Statistically significant at 10%

ICE stock returns, NYSE Composite index returns, stock volume and press reading time data are highly nonnormally distributed as Jarque–Bera test statistic substantially exceeds its critical value for all variables. Except for volume data, all other variables are stationary as ADF test statistic exceeds the critical value of -2.87 at 5 percent significance level. When compared with ICE stock returns and NYSE Composite index returns, the press reading time data are nearly stationary

[10] Available at https://finance.yahoo.com.
[11] Available at https://ir.theice.com/press/press-releases/all-categories/all-stories.

as ADF test statistic (-3.66 reported) marginally exceeds the critical value[12]. LM test statistic for ARCH effect in data for ICE stock returns exceeds the critical value of 7.815. As such, the null hypothesis of no ARCH effect in stock return data is rejected. However, the ARCH effect in ICE stock returns exists as the null hypothesis of no ARCH effect is clearly rejected. Ljung-Box Q statistic for ICE stock returns is 30.89 for 20 lags, which is slightly below the critical value of 31.41. Therefore, the null hypothesis of no serial correlation in ICE stock returns is nearly accepted. Stock volume and press reading time data are highly serially correlated.

Table 2: Maximum Likelihood Estimation of EGARCH Model

EGARCH	β	η	γ	α	ψ	Sum of Volatility Coeff.
σ_t^2 without Q_t	0.758* (5.444)	0.088** (1.812)	-0.080 (-1.156)	0.965* (243.26)	NA	0.974
σ_t^2 with Q_t	0.770* (5.093)	0.070 (0.428)	0.255* (2.087)	0.120 (0.672)	1.271* (6.921)	0.446

Source: Author's estimation

Notes:

1. Asymptotic t-statistics appear in parentheses.
2. *Statistically significant at 5% assuming returns are conditionally normally distributed. **Statistically significant at 10%.
3. The coefficients are estimated using the methods described by Bollerslev and Wooldridge (1992) for obtaining quasi-maximum likelihood (QML) covariance and robust standard errors.

Beta coefficient (β) is statistically significant at 5 percent significance level as in equation (5). The coefficient η which represents the ARCH term in the conditional variance equation is statistically significant at 10 percent significance level. This is quite obvious given the amount of serial correlation observed in the ICE return data (See descriptive statistics). The coefficient that captures the asymmetric effect of innovations on volatility is negative but highly insignificant. As such, there is no possibility of observing any negative correlation between lagged returns and contemporaneous volatility. The coefficient of past periods' volatility is very highly statistically significant at 5 percent significance level[13]. The residual diagnostic tests on specifications (5) and (7) produce satisfactory results. Jarque–Bera test: 0.3102; Wald coefficient restriction test statistics for null hypotheses,

[12] Approaching the test critical value at 1%.

[13] Note that the intercept term (not reported) has become insignificant, which observation can be attributed tp high persistence of GARCH (See Francq and Zakoïan 2009).

$\eta = 0$ and $\alpha + \eta = 0$ are 3.28 (F-stat)** and 311.09 (F-stat)*; ARCH-LM (obs* R-squared) : 3.69)).

When Q_t is included in the conditional variance equation of EGARCH model, the ARCH (η) and GARCH (α) terms become highly statistically insignificant. The total volatility persistence as measured by the sum of the EGARCH coefficients becomes highly negligible. The coefficient of leverage effect (γ) remains insignificant even after inclusion of Q_t in the conditional variance equation (8). The coefficient ψ is however positive and statistically significant at 5 percent significance level. This implies that the content of information flow—as measured by (i.e. proxied by) the press reading time—is positively associated with the conditional volatility. This relationship can be clearly observed in the business operations with high business and financial risk because the investors are more concerned about their wealth when the funds are invested in firms with high business risk. The information arrival is reflected in the conditional volatility by the time lag required to read and comprehend the relevant information, which impacts the determination of equilibrium market prices. As conceptualized, the impact of new information arrival on volatility (i.e. variance of increments) is clearly an increasing function of press reading time (i.e. textual contents).

The residual diagnostic tests for specifications (5) and (8) are also satisfactory. Jarque–Bera test : 0.092; Wald coefficient restriction test statistics for null hypotheses, $\eta = 0$ and $\alpha + \eta = 0$ are 0.6689 (F-stat) and 0.8513 (F-stat); ARCH-LM (obs* R-squared) : 1.22)).

These findings suggest that the information processing time (i.e. press reading time) reflects the type of residual heteroscedasticity accounted for by the ARCH in the EGARCH specification used to test the time dependence in the information arrival process. As such, the underlying new information arrivals impact the equilibrium price determination of common stocks (in this case, ICE returns). The economic importance of these findings is twofold. Firstly, it is a responsibility of the government to make available the necessary market infrastructure for an efficient and effective information processing platform, which will directly impact the stock market efficiency and welfare of capital markets. Secondly, effective and efficient (e.g. timely) news consumption benefits the society at large—by efficient allocation of financial resources in capital markets—given the asymmetric interconnection between certain macroeconomic variables (See e.g. Evgenidis et al. 2017).

Conclusion

The standard assumptions of EMH suggest that the information relevant to stock price changes is freely and widely available to investors at any given point in time. Levišauskait (2010) argues that the '*investors are more willing to trade if prompt and complete information about trades and prices in the market is available*'. If the traders are induced by the availability of timely information, there should be a close association between time required to comprehend the content of information and the reaction of stock prices to new information, because the investors have different skill levels in processing information (See Engelberg et al. 2012; Fedyk, 2016b). Before executing transactions, investors should spend a sufficient amount of time to read and understand the content of information—which will ultimately impact the subsequent equilibrium price formation of equities. As such, the press reading time may be of some interest to arbitrageurs who search for mispriced securities.

An article on Harvard Business Review (See Fedyk 2016a)[14] discusses about how investors' reading habit impacts stock prices and concludes that news releases are vitally important for stock market efficiency and stability. Fedyk (2016b) compares the news consumption patterns of different finance professionals and finds that the hedge funds and private investors are faster in news consumption than their peers. Imperfections in processing information have been studied by Fedyk and Hodson (2015) where they show that the market prices react to the same information multiple times when financial news releases occur at the same time.

When the aggregate ICE press reading time is included in the conditional variance equation of EGARCH model, the ARCH and GARCH terms become highly insignificant at 5% significance level and the total volatility persistence becomes highly negligible. The estimation results of EGARCH suggest that the residual heteroscedasticity of ICE returns reflects the time lag between press reading and the equilibrium price determination (ultimately the textual content). The textual contents of news arrival are therefore significant in explaining the price change variance. The aggregate press reading time is positively and significantly related to the conditional volatility of ICE stock return. As such, the higher the amount of relevant textual contents (i.e. amount or content of information), the higher the volatility of stock return and *vice versa*. This observation is in line with the findings of Lamoureux and Lastrapes (1990) that the conditional volatility is positively associated with the mixing variable. This study opens up many avenues

[14] See also Fedyk (2016b).

for future research on the use of big data for exploring the relationship between news consumption and stock return volatility.

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References

Abarbanell, J. S. and Bernard, V. L., 1992, Tests of analysts' overreaction/underreaction to earnings information as an explanation for anomalous stock price behavior, *The Journal of Finance* 47 (3): 1181-1207.

Ahern, K. R. and Sosyura, D., 2014, Who writes the news? Corporate press releases during merger negotiations, *The Journal of Finance* 69 (1): 241-291.

Ali Ahmed, H. J., Hassan, T. and Nasir, A., 2005, The relationship between trading volume, volatility and stock market returns: a test of mixed distribution hypothesis for a pre-and post crisis on Kuala Lumpur Stock Exchange, *Investment Management and Financial Innovations* 2 (3): 146-158.

Ananzeh, I. E. N., 2015, Factors effecting trading volume: A test of mixed distribution hypothesis, *International Journal of Financial Research* 6 (4): 207.

Bollerslev, T., 1986, Generalized autoregressive conditional heteroskedasticity, *Journal of Econometrics* 31 (3): 307-327.

Bollerslev, T. and Wooldridge, J. M., 1992, Quasi-maximum likelihood estimation and inference in dynamic models with time-varying covariances, *Econometric Reviews* 11 (2): 143-172.

Brennan, M. J., Jegadeesh, N. and Swaminathan, B., 1993, Investment analysis and the adjustment of stock prices to common information, *The Review of Financial Studies* 6 (4): 799-824.

Butler, M. and Kešelj, V., 2009, Financial forecasting using character n-gram analysis and readability scores of annual reports. In: *Canadian Conference on Artificial Intelligence*, Berlin, Heidelberg: Springer, pp. 39-51.

Chatrath, A., Miao, H., Ramchander, S. and Villupuram, S., 2014, Currency jumps, cojumps and the role of macro news, *Journal of International Money and Finance* 40: 42-62.

Clark, P.K., 1973, A subordinated stochastic process model with finite variance for speculative prices, *Econometrica* 41 (1): 135-55.

Cohen-Charash, Y., Scherbaum, C. A., Kammeyer-Mueller, J. D. and Staw, B. M. 2013, Mood and the market: can press reports of investors' mood predict stock prices?, *PloS one*, 8(8), e72031. Available at https://doi.org/10.1371/journal.pone.0072031.

Dann, L. Y., Mayers, D. and Raab Jr, R. J., 1977, Trading rules, large blocks and the speed of price adjustment, *Journal of Financial Economics* 4 (1), 3-22.

Drake, M. S., Gee, K. H. and Thornock, J. R., 2016, March Market Madness: The Impact of Value-Irrelevant Events on the Market Pricing of Earnings News, *Contemporary Accounting Research* 33 (1): 172-203.

Ederington, L. H. and Lee, J. H. 1995, The short-run dynamics of the price adjustment to new information, *Journal of Financial and Quantitative Analysis* 30 (1): 117-134.

Engelberg, J. E. and Parsons, C. A., 2011, The causal impact of media in financial markets, *The Journal of Finance* 66 (1): 67-97.

Engelberg, J. E., Reed, A. V. and Ringgenberg, M. C., 2012, How are shorts informed?: Short sellers, news, and information processing, *Journal of Financial Economics* 105 (2): 260-278.

Evgenidis, A., Tsagkanos, A. and Siriopoulos, C., 2017, Towards an asymmetric long run equilibrium between stock market uncertainty and the yield spread. A threshold vector error correction approach, *Research in International Business and Finance* 39: 267-279.

Fama, E. F., 1965, The behavior of stock-market prices, *The Journal of Business* 38 (1): 34-105.

Fama, E. F., Fisher, L., Jensen, M. C. and Roll, R., 1969, The adjustment of stock prices to new information, *International Economic Review* 10 (1): 1-21.

Fedyk, A., 2016a, Research: How investors' reading habits influence stock prices, *Harvard Business Review*. Retrieved from https://hbr.org/2016/09/research-how-investors-reading-habits-influence-stock-prices

Fedyk, A., 2016b, News consumption: From information to returns. Available at https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2817095

Fedyk, A., 2017, *Front page news: The effect of news positioning on financial markets*, Working paper, Harvard University. Available at https://scholar.harvard.edu/files/fedyk/files/afedyk_frontpagenews.pdf

Fedyk, A. and Hodson, J., 2017, When can the market identify old news?. Available at https://scholar.harvard.edu/files/fedyk/files/oldnews_reprintsrecombination.pdf

Francq, C. and Zakoïan, J. M., 2009, Testing the nullity of GARCH coefficients: correction of the standard tests and relative efficiency comparisons, *Journal of the American Statistical Association* 104 (485): 313-324.

Gosnell, T. F., Keown, A. J. and Pinkerton, J. M., 1996, The intraday speed of stock price adjustment to major dividend changes: Bid– ask bounce and order flow imbalances, *Journal of Banking & Finance* 20 (2): 247-266.

Hagenau, M., Liebmann, M. and Neumann, D., 2013, Automated news reading: Stock price prediction based on financial news using context-capturing features, *Decision Support Systems* 55 (3): 685-697.

Hillmer, S. C. and Yu, P. L., 1979, The market speed of adjustment to new information, *Journal of Financial Economics* 7 (4): 321-345.

Hirshleifer, D., Lim, S. S. and Teoh, S. H., 2009, Driven to distraction: Extraneous events and underreaction to earnings news, *The Journal of Finance* 64 (5): 2289-2325.

Kadiyala, P. and Rau, P. R., 2004, Investor reaction to corporate event announcements: underreaction or overreaction?, *The Journal of Business* 77 (2): 357-386.

Lamoureux, C. G. and Lastrapes, W. D., 1994, Endogenous trading volume and momentum in stock-return volatility, *Journal of Business & Economic Statistics* 12 (2), 253-260.

Lamoureux, C. G. and Lastrapes, W. D., 1990, Heteroskedasticity in stock return data: Volume versus GARCH effects, *The Journal of Finance* 45 (1): 221-229.

Levišauskait, K., 2010, Investment analysis and portfolio management. Leonardo da Vinci programme project. Available at https://www.bcci.bg/projects/latvia/pdf/8_IAPM_final.pdf

Li, J., 2018, Endogenous Investor Inattention and Price Underreaction to Information, Working paper, Stanford Graduate School of Business. Available at https://www.jiacui-li.com/uploads/1/0/5/7/10578946/20180801_noappendix.pdf

Mittermayer, M. A., 2004, Forecasting intraday stock price trends with text mining techniques, In *System Sciences, Proceedings of the 37th Annual Hawaii International Conference*, (pp. 10). IEEE.

Nassirtoussi, A. K., Aghabozorgi, S., Wah, T. Y. and Ngo, D. C. L., 2015, Text mining of news-headlines for FOREX market prediction: A Multi-layer dimension reduction algorithm with semantics and sentiment, *Expert Systems with Applications* 42 (1): 306-324.

Nelson, D. B., (1991), Conditional heteroskedasticity in asset returns: A new approach, *Econometrica* 59 (2): 347-370.

Pan, J. and Poteshman, A. M., 2006. The information in option volume for future stock prices, *The Review of Financial Studies* 19 (3): 871-908.

Poteshman, A. M., 2001, Underreaction, overreaction, and increasing misreaction to information in the options market, *The Journal of Finance* 56(3): 851-876.

Reboredo, J. C., Rivera-Castro, M. A., Miranda, J. G. and García-Rubio, R., 2013, How fast do stock prices adjust to market efficiency? Evidence from a detrended fluctuation analysis, *Physica A: Statistical Mechanics and its Applications* 392 (7): 1631-1637.

Schumaker, R. P., Zhang, Y., Huang, C. N. and Chen, H., 2012, Evaluating sentiment in financial news articles, *Decision Support Systems* 53(3): 458-464.

Senarathne, C. W., 2018, *The information flow interpretation of margin debt value data: Evidence from New York Stock Exchange*, Working paper, Wuhan University of Technology.

Senarathne, C. W. and Jayasinghe, P., 2017, Information flow interpretation of heteroskedasticity for capital asset pricing: An expectation-based view of risk, *Economic Issues* 22 (1): 1-24.

Senarathne, C. W. and Jianguo, W., 2018, *The impact of patent citation information flow regarding economic innovation on common stock returns: Volume vs. patent citations*, Working paper, Wuhan University of Technology.

Shen, D., Li, X. and Zhang, W., 2018, Baidu news information flow and return volatility: Evidence for the sequential information arrival hypothesis, *Economic Modelling* 69: 127-133.

Shen, D., Zhang, W., Xiong, X., Li, X. and Zhang, Y., 2016, Trading and non-trading period Internet information flow and intraday return volatility, *Physica A: Statistical Mechanics and its Applications* 451: 519-524.

Son-Turan, S., 2014, Internet search volume and stock return volatility: The case of turkish companies, *Information Management and Business Review* 6 (6): 317-328.

Spyrou, S., Kassimatis, K. and Galariotis, E., 2007, Short-term overreaction, underreaction and efficient reaction: evidence from the London Stock Exchange, *Applied Financial Economics* 17 (3): 221-235.

Sun, A., L, M. and Fabozzi, F. J., 2016, Trade the tweet: Social media text mining and sparse matrix factorization for stock market prediction, *International Review of Financial Analysis* 48: 272-281.

Tauchen, G. E. and Pitts, M., 1983, The price variability-volume relationship on speculative markets, *Econometrica* 51 (2): 485-505.

Tetlock, P. C., 2007, Giving content to investor sentiment: The role of media in the stock market, *The Journal of Finance* 62 (3): 1139-1168.

Vlastakis, N. and Markellos, R. N., 2012, Information demand and stock market volatility, *Journal of Banking & Finance* 36 (6): 1808-1821.

Vu, T. T., Chang, S., Ha, Q. T. and Collier, N., (2012, December), *An experiment in integrating sentiment features for tech stock prediction in twitter*, In 24th International Conference on Computational Linguistics (p. 23-38), Mumbai, India: The COLING 2012 Organizing Committee.

Wuthrich, B., Cho, V., Leung, S., Permunetilleke, D., Sankaran, K., Zhang, J. and Lain, W., 1998, October, *Daily stock market forecast from textual web data*, In IEEE International Conference on Systems Man and Cybernetics (Vol. 3, pp. 2720-2725), Institute of Electrical Engineers Inc (IEEE).

Yu, Y., Duan, W. and Cao, Q., 2013, The impact of social and conventional media on firm equity value: A sentiment analysis approach, *Decision Support Systems* 55(4): 919-926.

Zhai, Y., Hsu, A. and Halgamuge, S. K., 2007, June, *Combining news and technical indicators in daily stock price trends prediction*, In International Symposium on Neural Networks (pp. 1087-1096). Springer, Berlin, Heidelberg.

Zhang, Y., Feng, L., Jin, X., Shen, D., Xiong, X. and Zhang, W., 2014, Internet information arrival and volatility of SME PRICE INDEX, *Physica A: Statistical Mechanics and its Applications* 399: 70-74.