Stock Market Volatility from a Neurofinance Perspective: New Zealand Experience

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Recently growing numbers of research in finance point to areas that encompass neuroscience and psychology. Consequently, market sentiment has become an important focus in many behavioural finance studies in providing an alternative narrative for the apparent failure of standard finance theories. Tracing the price movements of the 50 shares included in the NZX50 Index around the Brexit referendum dates, this study demonstrates the role of market sentiment in triggering volatility in the New Zealand Stock Market. The results show that market sentiment can better explain the short-term movement in share prices.

INTRODUCTION

The liquidity shortfall from the US subprime lending system that triggered the Global Financial Crisis (GFC) in mid-2007 and Brexit in 2016 have prompted researchers to explain the bearish dynamics of the market in terms of behavioural biases. Recent evidence from prior studies suggests behavioural biases in financial decision-making and considers market sentiment (volatility) an important determinant of euphoria or hysteria in the market (Rocha, 2013). In other words, the emotional state of the financial market (market sentiment) has been identified as a relevant variable that can determine the movement of stock prices, besides the full rationality principle.

The dialogue between neuroscience and finance (Neuro-Finance) better explains the influence of emotion on financial decision making. Neuro-Finance explains the underlying cognitive process of financial decision making in terms of biological (neural and physiological) characteristics. Thus, neuro-finance is a physiologically motivated alternative explanation for the apparent failures of standard finance theories, especially in crisis situations. Although, neuro-finance and behavioural theories have collected a lot of empirical evidence to refute the assumptions of market efficiency (Rogers, Securato and Ribeiro, 2009), the predictive power of these still needs to be improved (Hirshleifer, 2015). This study attempts to explain the impact of the Brexit referendum of 2016 on the New Zealand Stock Market from a neuro-finance perspective.

Brexit created a lot of hysteria in the market and New Zealand was no exception. The immediate impact of Brexit was a sharp fall in the yield on a 10-year New Zealand Government bond declining 22 basis points. This was followed by an appreciation of the New Zealand dollar following the pound's fall, expecting that Brexit might benefit New Zealand. A possible reason for this optimism was that Britain being a major trading partner with New Zealand, imports and travel could become cheaper post Brexit. It was also argued that as Britain unravels itself from its European neighbours, it may increase its interest in New Zealand's agricultural assets and property, especially major commercial, industrial and select infra-structure projects.

News is said to have a major impact on market sentiment (volatility). It is possible that small changes in stock prices may be the result of investor liquidity needs or portfolio rebalancing considerations. However, large price changes are more likely to reflect the expected value of new information released through euphoria (on the positive side) or hysteria (on the negative side). Thus, market sentiment is correlated with investor's behaviour deepening the bearish or bullish dynamics of the market. Investors are generally susceptible to manipulations in their evaluation of prices, and market sentiment influences them in judging prices in relative rather than absolute terms (and they use them as an anchored price) (Seymour and McClure, 2008).

The behaviour of stocks that exhibit large price changes provide an opportunity to examine whether stock prices adjust rapidly and completely to the new information. This paper investigates the reaction in the New Zealand Stock Market of the Brexit referendum from a neuro-finance perspective. The analysis is carried out using an Equity Market Sentiment Index (EMSI) constructed from the daily closing prices of the 50 stocks included in the NZX50 Index.

The reminder of this paper is structured as follows. Section 2 explains the research objectives and the motivations for the study. This is followed by a review of the recent literature on neuro-finance and the formation of a set of testable hypotheses in Section 3. Section 4 discusses the data and research methodology. The results and their implications are analysed in Section 5. Finally, Section 6 concludes the study.

RESEARCH OBJECTIVES AND MOTIVATONS FOR THE STUDY

Under the traditional finance theory, the price of shares contains all the information that investors need in rational decision making. However, this line of thinking has been critiqued, and several studies have shown that it is not applicable in times of bubbles and financial crises. Studies in behavioural finance and neuro- finance have shown that what matters in determining the attractiveness of an investment is not the expected return and financial risk, but the subjective evaluation of the risk and reward (risk and reward perceptions). Following Persaud (1996) and Bandopadhyaya and Jones (2005), the main objective of this study is to show how market sentiment determines the price movements of a group of stocks included in the NZX50 Index around the Brexit referendum date.

This study contributes to the literature in several ways. Although there have been several studies explaining volatility in the New Zealand Stock Market using behavioural approach, this is the first study, as far as I am aware, discussing the reaction of Brexit employing a neuro-finance decision making model. In addition to explaining the overall movement of the NZX 50 Index in terms of the neuro- finance model, this study also analyses the price behaviour of the movers and shakers of the New Zealand stock market (50 stocks included in the NZX 50 Index), based on the reward and risk perceptions under the neuro-finance approach. Such an analysis may help researchers and stock market participants in understanding the cognitive process in investor decision making. Furthermore, empirical studies have revealed that investors demonstrate loss aversion (Rabin, 2000) and do not update their preference in the face of new evidence (Barberis and Thaler, 2005), both of which violate the principle of expected utility. This study provides an alternative explanation of the stock market reaction of a major financial and political event based on the investor goal of "*satisfice*" (good enough) rather than the optimal solution (Cohen, 2005).

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Prior Studies

Recent research on behavioural finance and neuro finance has accumulated evidence to show that investors disregard the assumptions of market efficiency (Fellner and Maciejvsky, 2007). Neuro-Finance strives to explain investor decision making based on insights from psychology, neuroscience and finance.

It evaluates information about risky investment choices and provides neural and psychological signals relating to individual differences in investment decision making. To this end, the proponents of neuro finance argue that investment decisions are influenced by emotions and individual investor differences such as gender, genes, neuroanatomy and personality.

Laying out the biological perspective, Knutson, Fong, Bennett, Adams and Hommer (2003) contend that evolutionary pressure has given humans the two basic motivational tendencies of approach and avoidance. The approach and avoidance systems include brain regions associated with financial concepts such as reward and risk on the one hand, and with emotions on the other (Alcaro and Panksepp, 2011). The primary rewards (food and sex) will contribute to our survival, however, the secondary rewards such as wealth are unlikely to have contributed to the evolution of the approach and avoidance system (Odum, 2011). The neural "hardware" in the brain, being somewhat ignorant of the properties of the secondary rewards, tries to maximize the secondary rewards in the same manner as primary rewards. In other words, our neural system aims at maximizing our biological fitness/chances of survival rather than maximizing utility. Consequently, our brains are not adept at generating advantageous financial decisions and their biologically adapted nature is likely the cause of several behavioural biases in investment decision making (Platt and Huettel, 2008). In short, the observed deviations from financially optimal investment choices may be biologically optimal since cognitive limitations prevent investors from maximizing utility and opt for "satisfice (Cohen, 2005), that is, to aim for a "good enough result". This provides a neuro-finance explanation of the "irrational exuberance" of Shiller (2003) in financial markets.

Financial decisions are different from the decisions that drove the evolution of the human brain, and this difference is seen in "cognitive illusions" that occur when the assumptions of the world are violated. Since financial markets are different from nature, our assumptions are violated frequently leading to sub-optimal investment decisions. This is akin to visual illusions, where the brain creates false perceptions due to assumptions that are inaccurate. Examining financial decisions using neurobiological perspectives may help reveal such underlying possibly wrong assumptions and explain why some investors take risks and others don't, and why our preferences may change over time.

Barber, Lee, Liu and Odean (2014) argue that the behaviour biases of investors evidenced in financial markets leading to sub-optimal decisions may be related to our biological nature. In stock markets high past returns need not be associated with future returns because stock prices can show mean-reverting behaviour. Therefore, buying stocks that had previously been sold for gains (a behaviour associated with reinforcement learning) does not necessarily increase financial investor performance. Since market crashes are infrequent, investors have little experience with them, and, thus, learning from past outcomes leads to underweighting of low-probability events until they occur, and overweighting when they occur (Weber, and Blais, 2006). Moreover, investor behaviour shows the tendency to quickly collect sufficient rewards (intertemporal discounting) to prevent potential losses, rather than to maximize long-term reward accumulation. This may again explain the investor's tendency to opt for "*satisfice*", rather than optimum solution by maximizing the utility.

Another area where the neuro-finance model can give better explanations than the traditional and behavioural models is the realm of risk and ambiguity. Ambiguity refers to situations of uncertainty in which the probabilities of outcome are incompletely known (Ellsberg, 1961) (e.g. weather forecasts, betting in games with unknown rules). However, in the case of risk the probabilities of outcome may be estimated from relative frequencies (Hsu, Bhatt, Adolphs, Tranel, and Camerer, 2005) such as gambling on a roulette wheel. In investment decision making, both risk and ambiguity (uncertainty) exist, and while some uncertainty can be estimated and reduced, a part will remain irreducible (Lo and Repin, 2002). In finance, risk and ambiguity are treated as distinct forms of uncertainty. The behavioural models of choice under risk are well established, however, but both for risk and ambiguity individual choice remains difficult to predict.

The neuro-finance model may provide new insights on this risk-ambiguity dichotomy. Several studies have dealt with this problem and they reported insular activation in response to ambiguity (Huettel, Stowe, Gordon, Warner, and Platt, 2006). Huettel, et.al. (2006) found that risk and ambiguity share similar neural substrates overall, including the insula of the brain. They found that regions of the prefrontal cortex were highly correlated with individual ambiguity preferences, whereas regions of the posterior parietal cortex and intraparietal sulcus were correlated with individual risk preferences.

HYPOTHESIS DEVELOPMENT

I will now lay out the basis for my argument that emotions play an important role in the investment decision making process. Financial market emotions are determined by several factors such as market data, expert opinion, government decisions and domestic and international events (Rocha, 2013). In this context, the market sentiment is relevant since it defines the emotional status of the financial market which in turn facilitates the movement of stock prices. When the magnitude of factors influencing investment decision grows, it can trigger investors to behave in a herding way (Hwang and Salman, 2004). The subprime crisis of 2008, when investors did not behave as predicted by the CAPM (Capital Asset Pricing Model) and the Markowitz's portfolio selection, is an example of this herding tendency. Here, the analysis of benefit and risks based on neural mechanisms provides convincing financial reasoning behind the behavioural biases such as herding in the market.

The finance theory assumes expected benefits from investment as a projection of complex future earnings. However, from the neuroscience point of view, benefit assessment is a prior estimate of the possible reward to be obtained by implementing a given action, and it is a function of dopaminergic circuits (Schultz, 2002). In the neuro-finance context, what matters is not the expected return of a given share, but the subjective reward evaluation or feelings. Conversely, what matters is not the loss or financial cost associated with share investment, but the risk perception (Rocha, Massad, and Burattini, 2010). The neural mechanisms estimate risks usually in circumstances where information about the probability of occurrence of the events is scarce, and the opportunity for analytical complexity is virtually non-existent and the neural circuits for risk assessment involve primary serotonergic circuits.

Several prior studies investigated the link between brain activity and risk-taking behaviour. Rudorf, Preuschoff and Weber (2012) found that risk-seeking subjects were shown to have lower activation within the ventral striatum and anterior insula compared to risk-averse subjects. The risk averse subjects appear to differ from risk-seeking subjects in their brain activation while processing the outcome of risky choices. Thus, insular-induced overestimation of risk might modulate the approach behaviour (Khuhen and Knutson, 2005) and reinforcement learning (Schultz, 2002) in investors. Similarly, loss aversion is also identified by the specific pattern of neuronal activation. Increased activation of the insula, the amygdala and the putamen was seen in loss-averse subjects compared to more loss-tolerant subjects (Canessa, et al. 2013). These findings indicate that brain functional activation data can provide valuable information for the understanding and prediction of individual financial decisions related to risk and reward perceptions in investment.

Thus, the attractiveness of making an investment in a stock is determined by the risk and reward perceptions, which in turn influence the investor's decision-making process. Neurosciences have shown that decision-making depends on a large network of neurons distributed in several areas of the brain (Botvinick, Cohen and Carter, 2004). Some of these areas oversee the estimation of benefits and risks while some others calculate the conflict generated by divergent perceptions of benefit and risk, as well as estimate the cognitive effort for deciding. Following the model developed by Rocha (2013) for financial decision making where trading in a stock is dependent on the expected benefit and risk perceptions formed due to the brain activity, it is possible to assume that the positive and negative price variations in the bull and bear markets are determined by market sentiment or emotions triggering volatility in the market. Here, we see how brain activity plays an important part in the decision-making process of investors culminating in market sentiment (volatility) through euphoria (on the positive side) or hysteria (on the negative side). Considering that risk and reward (benefits) are analytical variables from the finance point of view, while a subjective evaluation is from the neuro-finance perspective, I predict, therefore, that the volatility in the New Zealand Stock Market around the Brexit referendum date in 2016 is triggered by market sentiments. My first and second hypotheses in alternative form are

H_1: The NZX50 Index exhibits extreme volatility around the Brexit referendum date in 2016, and the impact of Brexit on the New Zealand Stock Market is adverse due to negative market sentiment.

H_2: The volatile price behaviour of the 50 stocks included in the NZX50 Index around the Brexit referendum date in 2016 is the result of negative market sentiment.

DATA AND RESEARCH METHODOLOGY

The data for the study is secondary in nature which includes the NZX 50 Index and the closing prices of the 50 largest, eligible stocks listed on the Main Board (NZSX) of the NZX by float-adjusted market capitalization. The rationale of selecting 50 stocks is that the NZX 50 Index measures the performance of these 50 largest stocks listed on the Main Board (NZX), and it is considered that New Zealand's preeminent benchmark index, covers approximately 90% of the New Zealand equity market capitalization. The sources of data include Morning Star, Yahoo Finance, Google Finance and the annual reports of the sampled firms. The sample period is 2015-2017 which spans the period of Brexit in 2016.

In this study I apply the Equity Market Sentiment Index (EMSI) developed by Bandopadhyaya and Jones (2005) to capture the market sentiment. Using data over the period from 2015 to 2017, I compute daily returns of NZX50 and for each of the 50 securities in the NZX50 Index, and then compute average standard deviation of the daily returns over the previous five days (the "historic volatility") for each day of the sample period. I then rank the daily rate of return and rank the historic volatility and compute the Spearman rank correlation coefficient between the rank of the daily returns for each firm and the rank of the historic volatility of the returns for each firm and multiply the result by 100. The EMSI is therefore computed as follows:

$$\text{EMSI} = \frac{\sum(Rir-Rer)(Riv-Rev)}{\left[\sum(Rir-Rer)\,^\wedge\, 2\sum(Riv-Rev)^\wedge 2\right]^\wedge 1/2} \qquad 100 \leq \text{EMSI} \leq 100 \qquad (1)$$

where Rir and Riv are the rank of the daily return and the historical volatility for security i, respectively, and Rer and Rev are the mean return and historical volatility rankings, respectively.

To examine the explanatory power of the EMSI, I posit the following equation:

$$NXZ50\ Index\ Volatility\ t = \beta 0 + \beta 1 NZX50\ Index\ Volatility\ t-1 + \beta 2\ EMSI\ t + \varepsilon_t \qquad (2)$$

I estimate the following equation, which includes additional lagged values of the EMSI and the NZX50 Index.

$$NXZ50\ Index\ Volatility\ t = \beta 0 + \beta 1\ NZX50\ Index\ Volatility\ t-1 + \beta 2\ EMSI\ t + \beta 3 EMSI\ t - 1 + \beta 4 EMSI\ t-2 + \beta 5 EMSI\ t-3 + \varepsilon\, t \qquad (3)$$

Standard specification tests were employed to decide the appropriate number of lags included for both the variables. Volatility is calculated as the average standard deviation of the daily returns over the previous five days (the "historic volatility") for each day of the sample period.

To control for potential endogeneity between market sentiment and market volatility, I employ the propensity score matching method (Lee and Masulis, 2011). The statistical significance of a relationship between market sentiment and market volatility due to Brexit in the New Zealand stock market may be explained by the potential endogeneity between these two variables. This is because the market sentiment caused by Brexit could trigger investors to behave in a 'herding' way (Hwang and Salmon, 2004), which in turn might generate hysteria in the market. This simultaneity between market sentiment and market volatility may not give us unbiased estimates of the causal effects between these two variables.

Employing the propensity score matching method, I follow a two-step process. I first estimate a logit model with B-Dummy (Brexit Dummy variable)) as the dependent variable with the endogenous choice variables being SD $_{t-1}$, EMSI and its lagged values. The variable B-Dummy is a dichotomous variable equal to 1 for the post-Brexit observations and 0 otherwise. I posit a negative relationship between the B-Dummy variable and the EMSI variable as investors could experience a negative market sentiment due to Brexit. The logistic equation takes the following form.

$$Brexit\ Dummy = \beta 0 + \beta 1\ NZX50\ Index\ Volatility\ t-1 + \beta 2\ EMSI\ t + \beta 3 EMSI\ t-1 + \beta 4 EMSI\ t-2 + \beta 5 EMSI\ t-3 + \varepsilon\ \boldsymbol{t} \quad (4)$$

RESULTS AND DISCUSSION

Figures 1 to 4 present the Equity Market Sentiment Index (EMSI), the NZX50 Index return ranks and the market volatility respectively. The figures clearly show that there was a sharp dip in the overall movement of the New Zealand stock market around the dates of the Brexit referendum caused by severe negative market sentiment. Both the EMSI and NZX50 Index return ranks registered a sharp fall around the Brexit referendum dates supporting my predictions in (H_1) and (H_2) that the New Zealand stock market experienced extreme volatility (see Figure 4) due to negative market sentiment around the Brexit referendum dates.

FIGURE 1
EQUITY MARKET SENTIMENT INDEX (EMSI)
SAMPLE PERIOD (1/04/2015-28/09/2017)

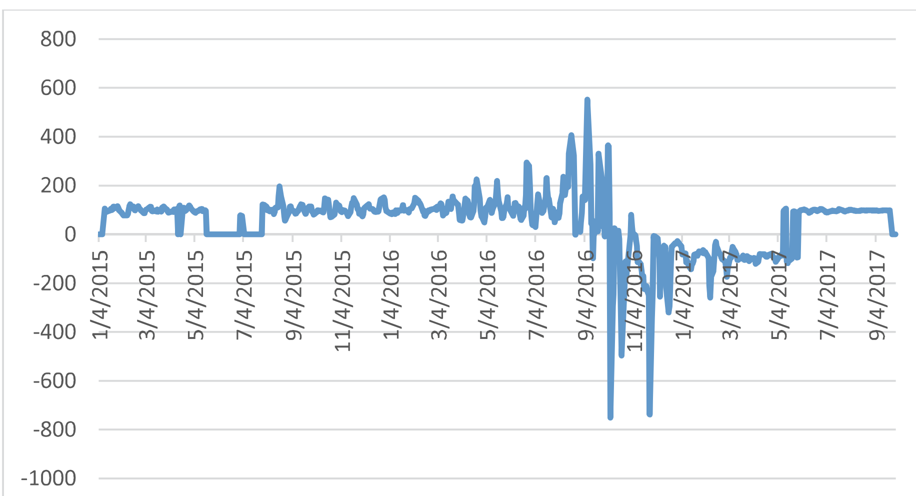


FIGURE 2
EQUITY MARKET SENTIMENT INDEX (EMSI)
SAMPLE PERIOD (24/5/2016-20/7/2016)

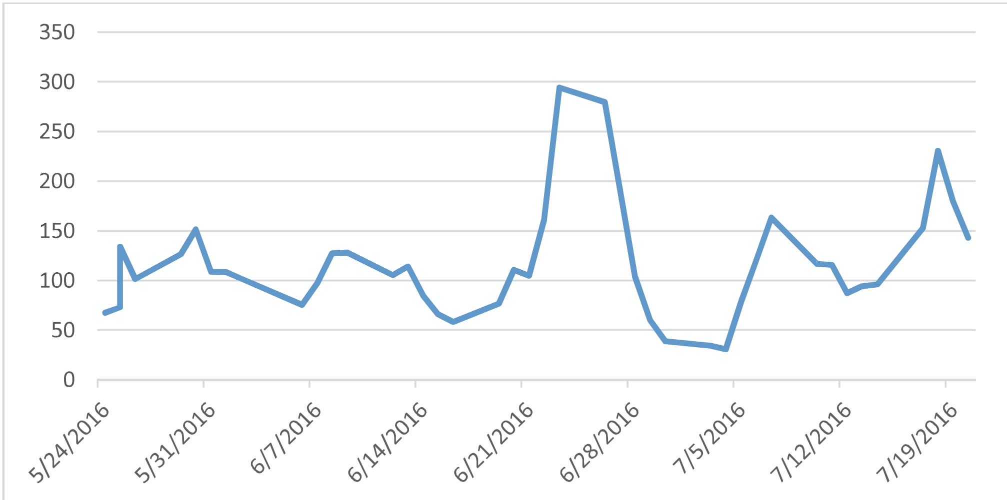


FIGURE 3
NZX50 INDEX DAILY RETRUN RANK:
SAMPLE PERIOD (1/04/2015-28/09/2017)

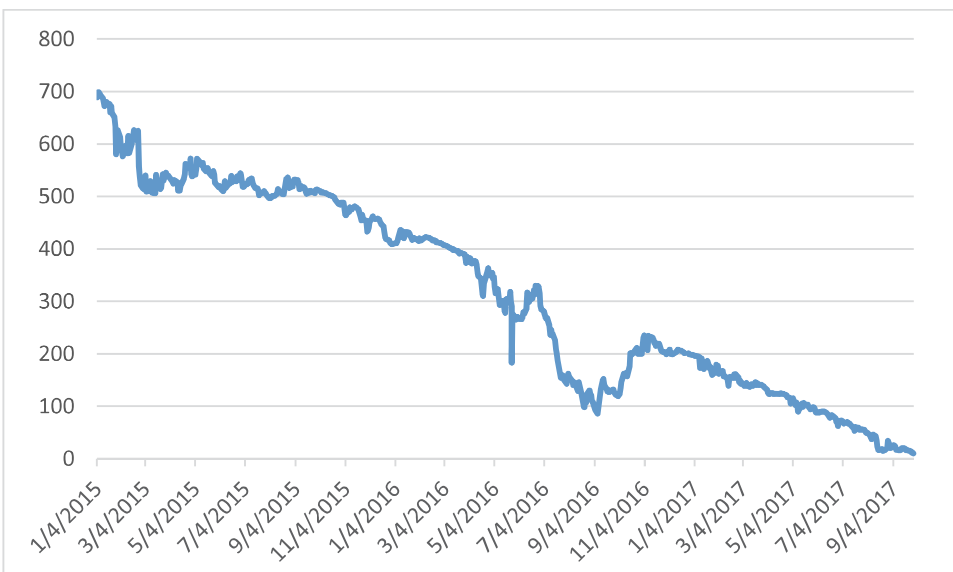
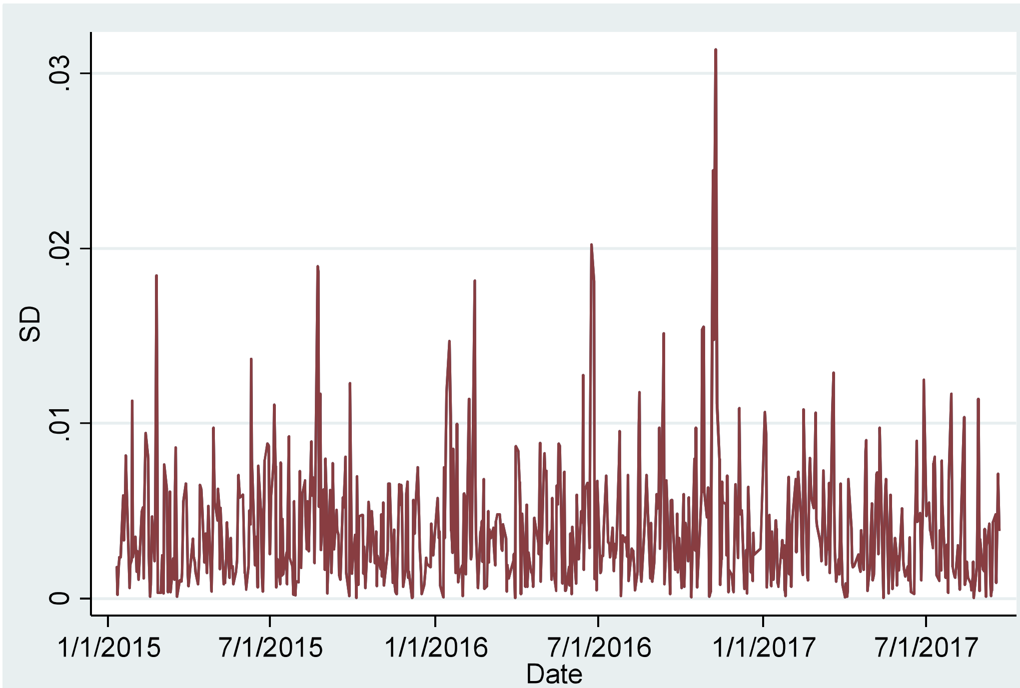


FIGURE 4
VOLATILITY IN THE NEW ZEALAND STOCK MARKET



Note: SD = Volatility (Standard Deviation of the returns of NZX50 Index).

Table 1 displays the risk categorization of the daily EMSI figures, which were computed based on the method in Persaud (1996) and its application in Bandopadhyaya and Jones (2005). For EMSI values between -10 to +10, the market is said to be risk neutral, and for values between -10 and -30, the market is considered moderately risk-averse. If EMSI figures fall below -30, then the market is considered highly risk averse. Similarly, if EMSI figures fall between +10 and+30 the market is labelled moderately risk seeking, and for values exceeding +30, the market is considered highly risk seeking. The values of daily EMSI in Table 1 clearly show that the risk seeking behaviour (471) is more predominant than the risk-averse behaviour over the sample period. A possible reason could be the opportunities that had risen due to the extreme volatility caused by the overall uncertainty in the stock market.

TABLE1
RISK CATEGORIZATION OF DAILY EQUITY MARKET SENTIMENT INDEX (EMSI) FIGURES

RANGE OF EMSI	CATEGORY	NUMBER OF DAYS
-30 and below	Highly Risk Averse	140
-10 to -30	Moderately Risk Averse	04
-10 to + 10	Risk Neutral	69
+10 to +30	Moderately Risk Seeking	08
+30 and above	Highly Risk Seeking	471

The estimation results of Equation (3) in Panel A of Table 2, indicate that the majority of the variation in the NZX50 Index volatility is explained by the two independent variables NZX50 Index volatility $_{\mathbf{t-1}}$ and EMSI $_{\mathbf{t-2}}$. The coefficients on these two variables are highly significant at the 1% level. However, while the one day lagged value of the NZX50 Index volatility shows a positive effect, the coefficients on

EMSI and its lagged values exhibit a negative impact on the NZX50 return volatility. This implies that the return volatility in the NZX50 Index for any given day is primarily driven by the return volatility on the previous day, and the two day lagged values of the EMSI. The one- day and three- day lagged values appear to not significantly affect the NZX50 Index return volatility of any given day, and the coefficients on these variables are not statistically significant. However, although the coefficient on the three- day value of EMSI is not significant like the EMSI and its other lagged vales, it is negative indicating a negative impact. The coefficient on the given day EMSI is negative and significant at the 5% level. A possible reason for the negative market sentiment might be due to the continuous release of investor unfriendly information in the financial markets both before and after Brexit. The results presented in Panel B of Table 2 are estimated using Equation (3) with a Brexit Dummy variable. The results are on similar lines reported in Panel A. The coefficient on the Brexit Dummy variable is negative and highly significant at the 1% level implying that Brexit had a negative impact on the New Zealand stock market in the short-run.

TABLE 2
PANEL A: REGRESSION TEST RESULTS

The estimated linear model is: $\text{NXZ50 Index Volatility t} = \beta 0 + \beta 1 \text{ NZX50 Index Return Rank t} - 1 + \beta 2 \text{ EMSI t} + \beta 3\text{EMSI t} - 1 + \beta 4\text{EMSI t} - 2 + \beta 5\text{EMSI t} - 3 + \varepsilon \text{ t}$

Variable	Coefficient	Standard Error	t-Statistic	P-value
Constant	0.9382	0.1589	2.3122	0.0000***
NZX50 Index $_{t-1}$	0.3427	0.0362	9.4721	0.0000***
EMSI	-0.0768	0.0374	-2.0531	0.0410**
EMSI $_{t-1}$	-0.1410	0.0935	-1.5142	0.1322
EMSI $_{t-2}$	-0.3396	0. 1005	-3.3842	0.0012***
EMSI $_{t-3}$	-0.1227	0.0987	-1.2434	0.2141
Adjusted R^2	0. 56			

***, **&* indicate statistical significance at the 1%, 5% and 10% levels respectively.

TABLE 2
PANEL B: REGRESSION TEST RESULTS WITH A BREXIT DUMMY VARIABLE

The estimated linear model is: $\text{NXZ50 Index Volatility t} = \beta 0 + \beta 1 \text{ NZX50 Index Return Rank t} - 1 + \beta 2 \text{ EMSI t} + \beta 3\text{EMSI t} - 1 + \beta 4\text{EMSI t} - 2 + \beta 5\text{EMSI t} - 3 + \beta 6\text{Brexit Dummy} + \varepsilon \text{ t}$

Variable	Coefficient	Standard Error	t-Statistic	p-value
Constant	0.1649	0.9058	3.8800	0.0000***
NZX50 Index $_{t-1}$	0.9600	0.0079	1.1310	0.0000***
EMSI	-0.0010	0.0008	-1.2401	0.2143
EMSI $_{t-1}$	-0.0013	0.0005	-1.5804	0.1144
EMSI $_{t-2}$	-0.0001	0.0002	-0.1300	0.8942
EMSI $_{t-3}$	-0.0003	0.0008	-0.3700	0.7120
Brexit Dummy	-1.3933	0.0121	-2.4512	0.0000***
Adjusted R^2	0.59			

***, **&* indicate statistical significance at the 1%, 5% and 10% levels respectively.

Table 3 presents the results of the logistic regression and propensity score analysis. In panel A, I present the results of the logistic regression. The coefficient on the variable SD $_{t-1}$ is negative indicating that Brexit had a negative impact on the New Zealand stock market. However, the coefficient is not statistically significant implying that the negative impact of Brexit was not very acute. The coefficients on EMSI and its lagged values have a positive sign and none of the coefficients except the coefficient on EMSI is statistically significant at the 10% level. The possible reason for the positive market sentiment might be due to the investors' perception of new opportunities opening up for New Zealand business in the near future. Overall, the results show that Brexit created a negative market sentiment triggering hysteria in the New Zealand stock market in the post-Brexit period.

Table 3, Panel B presents the results for each of the three propensity score methods. The results for the propensity score and nearest matching methods indicate that Brexit had a considerable impact on the movement of the New Zealand stock market Index (NZX50) with the coefficients at the 1% level. In the case of the inverse probability weight method, the coefficient is at the 5% level. Overall, the results in Table 3, Panel B, after controlling for potential endogeneity, support my contention that Brexit affected the movement of the New Zealand Stock Market in the short- run.

TABLE 3
PANEL A: ESTIMATION OF THE AVERAGE TREATMENT EFFECT (ATE) BASED ON PROPENSITY SCORE MATCHING

The logistic model is: $\mathrm{Brexit\ Dummy} = \beta0 + \beta1\ \mathrm{NZX50\ Index\ Return\ Rank}\ t-1 + \beta2\ \mathrm{EMSI}\ t + \beta3\mathrm{EMSI}\ t-1 + \beta4\mathrm{EMSI}\ t-2 + \beta5\mathrm{EMSI}\ t-3 + \varepsilon\ t$

Variable	Coefficients	Standard Error	Z	P-value
Constant	-0.7473	0.2093	-3.57	0.0000***
SD $_{t-1}$	-6.0403	0.9212	-0.28	0.783
EMSI $_t$	0.235	0.1234	1.9	0.0570*
EMSI $_{t-1}$	0.0684	0.0849	0.81	0.421
EMSI $_{t-2}$	0.0643	0.0684	0.94	0.348
EMSI $_{t-3}$	0.1446	0.1167	1.24	0.215
Log Likelihood	449.4229			
Chi Square	38.6000			0.0000***

***, **&* indicate statistical significance at the 1%, 5% and 10% levels respectively.

Brexit DUMMY is a dichotomous variable taking a value of 1 for the post-Brexit observations and 0 otherwise.

TABLE 3
PANEL B: THE AVERAGE TREATMENT EFFECT BASED ON PROPENSITY SCORE MATCHING

	Propensity sore matching			
ATE	Coefficient	Standard Error	Z	p-value
BREXITDUMMY	1.7261	0.6809	2.5300	0.0110***
	Inverse-probability weights			
	Coefficient	Standard Error	Z	p-value
	1.4511	0.6125	2.3700	0.0180**
	Nearest-neighbour matching			
	Coefficient	Standard Error	Z	p-value
	1.7261	0.6722	2.5700	0.0100***

*** indicates statistical significance at the 1% level.

CONCLUSION

There has been growing interest in investor psychology as a potential explanation for stock price movements. In this study, using a technique developed in Persaud (1996), I constructed a measure called the *Equity Market Sentiment Index* (*EMSI*) which utilizes publicly available data to measure the market's willingness to accept the risks inherent to an equity market at a given point in time. This measure relates the rank of a stock's riskiness to the rank of its return and therefore directly measures the market's pricing of the risk-return trade-off.

Results indicate that the one- day lagged values of the NZX50 Index return volatility and the two- day lagged values of EMSI better explain changes in the market index value than the three-day lagged values of the EMSI. This has important implications since it appears that the short-run changes in the market index value are driven primarily by both the index's own price momentum and investor sentiment. Due to the uncertainty created by Brexit, the EMSI shows a negative impact on the New Zealand Stock Market. This warrants the attention of researchers and practitioners to pay close attention to investor sentiment as a determinant of changes in financial markets.

REFERENCES

Alcaro, A., & Panksepp, J. (2011). *The seeking mind: Primal neuro-affective substrates for appetitive incentive states and their pathological dynamics in addictions and depression*. Retrieved from http://doi.org/10.1016/j.neubiorev.2011.03.002

Bandopadhyaya,A., & Jones.A.(2005). *Measuring investor sentiment in equity markets*. Retrieved from file:///E:/Neuroscience%20finance/Measuring%20Investor%20Sentiment%20in%20Equity%20Markets.pdf

Barberis, N., & Thaler, R. (2003). A survey of behavioural finance. *Handbook of the Economics of Finance*, 1, 1053-1128.

Barber, M., Lee, T., Liu, J., & Odean, T. (2014). The cross-section of speculator skill: Evidence from day trading. *Journal of Financial Markets*, 18(1), 1-24

Botvinick, M.M., Cohen, J.D., & Carter, C.S. (2004). Conflict monitoring and anterior cingulate cortex: And update. *Trends in Cognitive Sciences*, 2044, 529–546.
Canessa, N., Crespi, C., Motterlini, M., Baud-Bovy, G., Chierchia, G., Pantaleo, G., &. Cappa, F. (2013). *The functional and structural neural basis of individual differences in loss aversion*. Retrieved from http://doi.org/10.1523/JNEUROSCI.0497-13.2013.
Cohen, J. D. (2005). The vulcanization of the human brain: A neural perspective on interactions between cognition and emotion. *Journal of Economic Perspectives*, 19(4), 3-24.
Ellsberg, D. (1961). Risk, ambiguity, and the savage axioms. *Quarterly Journal of Economics*, 75(4), 643-669.
Fellner, G., & Maciejvsky, B. (2007). Risk attitude and market behaviour: Evidence from experimental asset markets. *Journal of Economic Psychology*, 28, 351–364.
Hirshleifer, D. (2015). Behavioural finance. *Annual Review of Financial Economics*, 7(1), 133-159.
Hsu, M., Bhatt, M., Adolphs, R., Tranel, D., & Camerer, C. F. (2005). Neural systems responding to degrees of uncertainty in human decision-making. *Science*, 310(5754), 1680-1683.
Huettel, S.A., Stowe, C. J., Gordon, E.M.., Warner, B. T., & Platt, M.L. (2006). Neural signatures of economic preferences for risk and ambiguity. *Neuron*, 49, 766–775.
Hwang, S., & Salmon, M. (2004). Market stress and herding. *Journal of Empirical Finance*, 11, 585–616.
Knutson, B., Fong, G.W., Bennett, S.M., Adams, C.M., & Hommer, D. (2003). *A region of mesial prefrontal cortex tracks monetarily rewarding outcomes: Characterization with rapid event-related fMRI*. Retried from. https://doi.org/10.1016/S1053-8119(02)00057-5
Kuhnen, C.M., & Knutson, B. (2005). The neural basis of financial risk taking. *Neuron*, 47, 763–770.
Kuhnen, C.M., & Knutson,B. (2011). The influence of affect on beliefs, preferences, and financial decisions. *Journal of Financial Quantitative Analysis*, 46, (2011), pp. 605–626.
Lee, G., & Masulis, R. W. (2011). Do more reputable financial institutions reduce earnings management by IPO issuers? *Journal of Corporate Finance,* 17(4), 982-1000.
Lo, A. W., & Repin, D. V. (2002). The psychophysiology of real-time financial risk processing. *Journal of Cognitive Neuroscience*, 14(3), 323-339.
Odum, A.L. (2011). Delay discounting: I'm ok, you're ok. *Journal of the Experimental Analysis of Behaviou*r, 96(3), 427-439.
Platt, M.L., & Huettel, S.A. (2008). Risky business: The neuroeconomics of decision making under uncertainty. *Nature Neuroscience*, 11(4), 398-403.
Persaud, A. (1996). Investors' Changing Appetite for Risk, J.P. Morgan Securities Ltd., *Global FX Research.*
Rocha, A.F., Rocha, F.R., Massad, E., & Burattini, M.N. (2010) Neurodynamic of an election. *Brain Research*, 198-211.
Rocha, A.F. (2013). *What we learn about global systemic risk with neurosciences*. Retrieved from http://papers.ssrn.com/abstract=2316765
Rogers, P., & Securato, J.R. (2009). *Capital asset pricing model (CAPM)*. Retrieved from http://www.anpad.org.br/periodicos/arq_pdf/a_819.pdf
Rabin, M. (2000). Risk aversion and expected-utility theory: A calibration theorem. *Econometrica*, 68(5), 1281-1292.
Rudorf, S., Preuschoff, K., & Weber, B. (2012). Neural correlates of anticipation risk reflect risk aversion. *Journal of Neuroscience*, 32(47), 16683-16692.
Seymour, B., & McClure.S.M. (2008) Anchors, Scales and the Relative Coding of Value in the Brain. *Current Opinion in Neurobiology,* 18, pp. 173–178.
Shiller, R. J. (2003). From efficient markets theory to behavioural finance. *The Journal of Economic Perspectives*, 17(1), 83-104.
Schultz, W. (2002). Getting formal with dopamine and reward. *Neuron*, 36(2), 241-263.
Weber, E.U., & Blais, A.R. (2006). *A domain-specific risk-taking (DOSPERT) scale for adult populations*. Retrieved from. http://doi.org/10.1037/t13084-000