The correlation of geomagnetic field to VN-Index return

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ABSTRACT: This study examines the impact of geomagnetic dynamics on the VN-Index return. Using the VN-Index daily and geomagnetic data for the period from 28 July 2000 until 31 December 2014, the author applies a linear regression model and logit regression model. With 90% confidence level, the results show that the average rate of return of the VN-Index in the days of geomagnetic storms is higher than normal days by 0.065% to 0.072%. The Probability for the VN-Index to increase in the days of geomagnetic storms is 1.65 times higher than it is on normal days. The study also recommends investors to some investment criteria based on geomagnetic dynamics for VN-Index.

KEYWORDS: geomagnetic storms, stock market, neuroscience economics, emotion in financial decisions.
JEL CLASSIFICATION: G12 . G14 . G17 . G23 . G41.

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1. Introduction

Vietnam's stock market has been developing for over fourteen years. In the process of development, the market is not only affected by the regulations of government policies, the macroeconomic variables, but also the impact of investors' psychological factors (Le Dat Chi, 2007) when making investment decisions. Regarding investors' behaviors, some studies show the weak form of information efficiency in Vietnam's stock market (Le Trung Thanh, 2009; Truong Dong Loc, Lanjouw & Lensink, 2010), a large number of individual investors with herding behavior in Ho Chi Minh Stock Exchange (Tran Viet Ha, 2007) and thus, the Vietnamese stock market have opened the door to attract behavioral finance research (Tran Thi Hai Ly & Hoang Thi Phuong Thao, 2012). Some studies apply theory of the impact of behavioral psychology on securities (Tran Ngoc Tho & Ho Quoc Tuan, 2007), the effect of different days of week (Truong Dong Loc, 2006; Le Long Hau, 2010), or the effect of different days of month according to Lunar calender on Vietnam's stock market (Lai Cao Mai Phuong, 2012). In addition to these above factors, research in developed countries also shows that the geomagnetic fluctuations also affect investors' decisions, which in turn affect the rate of return (ROR) on securities, while in Vietnam's development so far, no study has been reported. Therefore, this paper aims to assess the impact of geomagnetic storms (GMS) on the VN-Index return. The article will answer two research questions: (1) Does the representative variable of geomagnetic fluctuation really affect the return of VN-Index? (2) If yes, to what extent does the probability of the affected cases is higher than the normal cases?

This first study provides empirical evidence on the impact of geomagnetic storms on VN-Index rate of return. The results of this research contribute to both the theoretical and empirical academic repertoire relating to behavioral finance in general and behavioral finance in the Vietnam's stock market in particular.

After the introduction, the structure of the paper is divided into four sections: Section 1 - Theoretical backgrounds comprising of some grounded theories and empirical studies on the impact of emotions on stock trading and empirical research on the impact of geomagnetic field on economic activities and securities; Section 2 - The methodology and model of the study refer to the process for finding representative variables for geomagnetic dynamics (GMSd) that affect the VN-Index return. Then, the GMSd variable is used as the independent variable in the linear regression model and logit model; Section 3 - Results and discussion of results; Section 4 - Conclusions and directions for further research.

2. Literature review

2.1. Some key concepts

Earth's magnetic field is considered as a magnetic dipole, with one pole near the geographic North Pole and the other pole near the geographic South Pole. Compared to the Earth's axis of rotation, the imaginary line connecting these poles forms an angle of about 11.3 °.

Geomagnetic storm: Magnetic storm (GMS) on Earth is a period when the compass needle vibrates sharply for a short period of time because of the magnetic currents flowing from the sun directly into the Earth's magnetic field. Akashofu & Chapman (1972) classify the geomagnetic levels according to the magnetic activity index Ap, when Ap>29 is the threshold for geomagnetic storms.

The essence of emotion: According to Elster (1998), two of the characteristics of the nature of emotion are biological stimulation and valence. Biological stimulation is due to changes in the hormonal and nervous system associated with emotional responses. Then the human body undergoes a hormonal change when experiencing an emotion. Multi-dimensional expressions of emotion can be defined based on a scale with either positive or negative feeling at both ends and a neutral point in the middle. The author also noted that not all strong emotions are at either end of the scale.

Neuroscience economics: According to the Oxford dictionary, neuroscience economics is the combination of economic science, neuroscience, and psychology to determine how individuals make economic decisions. In particular, neuroscience uses brain technology to study the behavior of the brain when a person makes financial and economic decisions.

2.2. Fundamental theories and related empirical studies

The theory that explains the origin of emotions is one of the fundamental theories of behavioral science. William's Theory of Emotions (1884) suggests that emotion is a sensation derived from natural reflex. The nervous system automatically controls the unconscious actions of the human body. Cannon (1927), Schachter & Singer (1962, 1979) all agree with William's theory. While Cannon (1927) further explains that the human brain reacts to stimuli before the body takes action, the other two authors argue that emotion is the brain's interpretation of a situation.

2.3. Theoretical and empirical studies of the emotions' impact on stock trading

Damasio (1994) discovers that decision-making and emotion are interrelated. Loewenstein, Weber, Hsee & Welch (2001) proposes new models and theories that combine psychological aspects, including emotion. Loewenstein presents the stages of emotion in the decision-making process. When researching 80 investors in the US stock market from July 7, 2002, to August 9, 2002 (a total of 25 trading days), Steebarger (2003) finds that many investors receive the same information, behave the same, but their understanding of behavior is very different, which is reflected in the description of the information which leads to their decisions. Thus, the author argues that at the time of making decisions they are based on instinct, not on perception, and then they create an appropriate cognitive interpretation of their expectations.

Lo & Repin (2002) study the importance of emotion in the decision-making process of stock market professionals by their psycho-physiological characteristics when they are actively trading in real time. The study is conducted on 10 trading specialists working at large global financial institutions based in Boston, Massachusetts, USA. The results show a strong correlation between market dynamics and psycho-physiological features such as skin transmission, cardiovascular and body temperature. When examining whether emotions are an important factor for the successful decisions of traders in financial markets, Lo, Repin & Steenbarger (2005) finds that traders having strongest responses to profit and loss will have the worst trading performance.

2.4. Empirical studies on the impact of geomagnetic dynamics on economic and securities activities

Carlos & Felix (1934) apply the Jevons (1875) method in the nonagricultural period 1875-1900 and find a high level of correlation between the stages of the sun's activity and the production level of the economy. According to these authors, the high correlation is due to two reasons: (i) human psychology is influenced by optimistic or pessimistic waves due to the change in the number of ultraviolet rays emitted by the sun. These changes are determined by the variation in sunspot and sunlight streaks; (ii) the change in the level of activity of the sun changes the earth's electromagnetic field and affects the electric field of a person. Dewey (1968) points out that 43 different economic and social fields are affected by the solar energy activity. A number of areas have been studied such as stock prices, commodity prices, industrial production and agricultural production, banking and business cycles. By using the AP index as the GMS indicator, Bryan (1993) detects a change in the intensity of GMS induced by the

sun as a major factor regulating a wide range of economic and financial activities such as GDP, consumer price index and stock price. Changes in solar energy produce extremely low and short frequency waves. The very short-wave effects caused by geomagnetic storms can affect chemical reactions in the brain and early body metabolism.

Dimitrova, Stoilova & Cholakov (2002) surveyed 86 volunteers in the fall of 2001 and spring 2002 and indicated that their health status was sensitive to changes in GMS. Research finds that GMS fluctuations can have a direct impact on people's confidence and ability to work. Lednev's (1991) study shows that it is not easy for the frequency and rate of change in GMS intensity to produce observable effects. Research also shows that biological systems can not adapt to rapid changes in frequency and intensity of GMS as easily as human desire. Anna & Cesare (2003) through empirical research finds that GMS has a negative impact on the NASDAQ, S&P 500 and NYSE rate of return on the US stock market. In contrast, research results also show that GMS has a positive impact on rate of return in South Africa and Germany. In Vietnam, until now, there has been no empirical study on the effect of geomagnetic fluctuations on the VN-Index.

3. Data and methodology

3.1. Data

The author's VN-Index was collected from the Ho Chi Minh Stock Exchange (HSX) with data from 28 July 2000 until 31 December 2014. The AP Index, calculated and compiled by the National Geographic Data Center at The US National Oceanic and Atmospheric Administration (NOAA) from 13 different observatories around the world to measure the level of geomagnetic activity.

There are two advantages when using Hirshleifer's & Sunway's (2003) geomagnetic representation variable compared to using sunlight variable (2003), or seasonal affective disorder (SAD) variable used by Kamstra, Kramer & Levi (2003). Firstly, compared to the two sunlight variables and the SAD variable, the geomagnetic representation variable is not highly seasonal. Secondly, the influence of sunlight and SAD variables can vary widely between regions in a country, while the geomagnetic field in the planet variable results in a difference which is lower. In other words, investors from different regions of the world (having different weather or seasons) can easily trade online for stocks listed on the Ho Chi Minh City Stock Exchange Market, those investors' decision is not

affected by the weather in Ho Chi Minh City, where the VN Index is calculated and compiled.

3.2. Methodology

Select the appropriate lag for DGMSi dummy variable (variable representing geomagnetic fluctuations)

According to Akashofu et al. (1972), Ap > 29 is the threshold for geomagnetic storms and this threshold is used to analyze the effect of GMS on rate of return in stock market in the studies of Dimitrova et al. (2002) Anna et al. (2003).

Table 1: Classification of geomagnetic activity indicators (GMS)

Ap indicator	State of geomagnetic field
0-29	Normal to unstable
30-49	Small scale geomagnetic storms
50-99	Large scale geomagnetic storms
≥100[1]	Catastrophic geomagnetic storms

[1]Akashofu et al. (1972) pointed out that extreme geomagnetic storms can affect satellite broadcasting, transmission, durability of pipelines, etc. Such events are rare and occupy a negligible percentage in the sample
Source: Akashofu et al. (1972).

Although the number of geomagnetic storms is high in March, April, September, and October each year, studies by Akashofu et al. (1972), Kamstra et al. (2003), Anna et al. (2003) do not analyze the effects of geomagnetic changes on a monthly basis for human decisions. To explain this, the authors argue that the days of geomagnetic storms do not immediately influence the human decision that day, but the impact is lagged. Based on the research results of these authors, the appropriate maximum lag for the stock indexes they studied in the world is 12 days. Therefore, this study will examine for the next 12 days after the day of geomagnetic storm (the day with Ap> 29) of the GMS_i dummy variable to find which lags are statistically significant with the VN Index's rate of return, with:

$$GMS_i = \begin{cases} 1 \text{ khi Ap>29} \\ 0 \text{ khi Ap≤29} \end{cases} \qquad (1)$$

To determine the days affected by the geomagnetic field (abbreviated as the days of magnetic field), research data are classified as "normal days" if Ap ≤ 29

and "days with magnetic fields" if Ap > 29. For example, the study determines the appropriate lag for the VN-Index is 5. If the day has Ap > 29 is day t, the days t+1, t+2 ... to t+5 are "days with magnetic fields" . Assuming that on day t+1 also has the value Ap > 29, the days with the magnetic field will be from day t+1 to day t+6.

The results of 13 lag analysis (0 to 12) showed that the 5th, 6th, and 7th lags have a 1% significance level; 4th and 8th lags have a 5% significance level; 9th and 10th lags have 10% significance level, the remaining lags are not statistically significant. Therefore, the lags between 4th and 10th will be included in the factor analysis.

Determine the representative variable for geomagnetic fluctuations, denoted as GMSd, for inclusion in the research model

By using the main component analysis, i.e a series of geomagnetic representative data GMSd synthesized information from the lag finds to be included in the regression model. The condition for implementing this method is that the lagged variables must be correlated with each other and the Kaiser-Meyer-Olkin criterion (KMO) must be higher than 0.7 (Kaiser, 1974). The analysis results show that the 4th to 10th lags of independent variables are highly correlated (over 0.7), so it is appropriate to use factor analysis.

KMO compliance check: In this method, KMO accepts values between 0 and 1, with small values meaning that in overall, variables have too little in common to warrant a factor analysis. The GMS4 to GMS10 variables have KMO > 0.8 and KMO values are generally at 0.89, so according to Kaiser (1974), the variables are well suited for inclusion in the factor analysis.

Table 2: KMO values of variables in the factor analysis

Variable	KMO
4th lag (GMS_4)	0.9014
5th lag (GMS_5)	0.8729
6th lag (GMS_6)	0.9065
7th lag (GMS_7)	0.9021
8th lag (GMS_8)	0.9059
9th lag (GMS_9)	0.8605
10th lag (GMS_{10})	0.8951
Overall	0.8918

Figure 1: Factor discovery chart
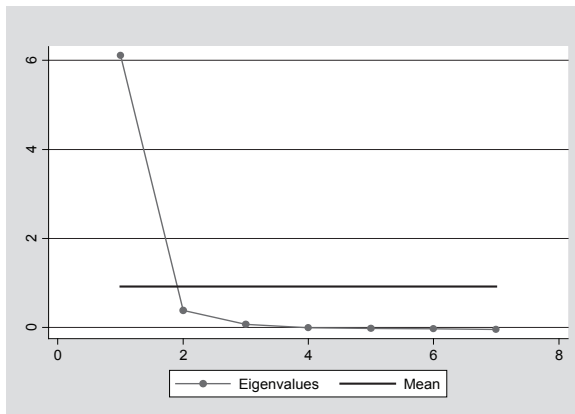
*Note: The horizontal axis represents the number of factors and the vertical axis
represents the characteristic number
Source: Analysis results from Stata 11 software.*

A common tool for determining the number of retained factors is based on the chart. According to Cattell (1966), the chart is a graph of the eigenvalue showing the descending order. Slope indicates major factors. When the slope is over, other factors are normally less than 1. Figure 1 shows that the first factor should be retained because of the type of chart and Kaiser's famous standard which states that factors with an eigenvalue higher than 1 should be retained. Therefore, only the first factor should be included in the analysis.

Table 3: Factor loading of the first factor

Variable	Firsr factor
4th lag (GMS$_4$)	0.8620
5th lag (GMS$_5$)	0.9246
6th lag (GMS$_6$)	0.9579
7th lag (GMS$_7$)	0.9673
8th lag (GMS$_8$)	0.9633
9th lag (GMS$_9$)	0.9461
10th lag (GMS$_{10}$)	0.9133

Source: Analysis results from Stata 11 software.

Factor loading is also called factor weighting. According to Hair, Anderson, Tatham & Black (1998), factor loading is the criteria to ensure a level of practical significance in factor analysis. The factor loading greater than or equal to 0.5 is considered to be practically meaningful, showing that the observed variables converge on the first factor. Thus, the author uses the GMSd variable derived from this model to measure the effect of the geomagnetic field variables on the VN-Index return. This variable is extracted from the first factor in the primary factor analysis method.

3.3. Models

In this study, the author uses the linear regression model and the logit regression model to study the effect of geomagnetic dynamics on the VN-Index return. These models is used by Anna et al. (2003) to study the major stock indexes on the US stock market.

Linear model has the form: $r_t = \alpha + \beta_{GMS}GMS_d + \varepsilon$ (2)

Logit model has the form: $\log(odd) = \beta_0 + \beta_i GMS_d + \varepsilon$ (3)

Or $Pr(VNI) = \beta_0 + \beta_j GMS_d + \varepsilon$ (4)

Table 4: Variable definition, calculation method and expected sign of regression coefficients

Variable code	Variable name	Calculation method	Expected sign of regression coefficients
The dependent variable of the linear regression model is rt	VN-Index rate of return	$r_t = 100[\ln(\text{VN-Index}_t) - \ln(\text{VN-Index}_{t-1})]$	
The dependent variable of the logit regression model is Pr(VNI)	Probability of VN-Index increase	Variable identifier Pr (VNI) has a value of 1 if $r_t \geq 0$; Has a value of 0 if $r_t < 0$;	
Independent variable GMSd	Geomagnetic representation variable	Main component analysis, aggregating information from appropriate lags which was identified in the preliminary study	+/-

4. Results

4.1. Results

Linear regression

Table 5: Summary of stationary test results

Variables	ADF	Critical values			Conclusion
		1%	5%	10%	
R	-47.6010	-2.3270	-1.6450	-1.2820	Stationary at 1% significance level
GMS_d	-14.3440	-2.3270	-1.6450	-1.2820	Stationary at 1% significance level

The data series are stationary, so that they are suitable to be included for analysis in the next steps.

Table 6: Auto-correlation correction results by Prais–Winsten and Cochrane-Orcutt Iterative method

	Regression coefficient (Coef)	Standard error (Std. Err.)	t-value	Significance level (P>|t|)
Constant	0.0492	0.0386	1.2800	0.2010
GMS_d	0.0719	0.0345	1.9200	0.0550
Rho	0.2024			
Durbin-Watson statistics (original) = 1.5949				
Durbin-Watson statistics (adjusted) = 1.9733				

Source: Analysis results from Stata 11 software.

Mis-specification test results of the model are as follows

The author will use Ramsey's RESET (1969) to test for model's mis-specification. Hypothesis H_0: The proposed model is specified correctly.

With a significance level of alpha = 5%, P-value = 0.1268>0.05 so the H_0 hypothesis should be accepted and it could be concluded that the proposed model is correct and it does not omit any important explanatory variables. Therefore, the model here is perfectly suitable for further analysis and forecast in the following sections.

In summary, through partial test results and corrective measures, if the tests are violated, the research model has no heteroskedasticity, no autocorrelation, and the model is specified correctly. Therefore, it is possible to use regression results for analytical and predictive purposes.

Linear regression model has the form:
$$r_t = 0.0492 + 0.0719\ GMS_d \tag{5}$$

The significance level of GMS_d is 5%.
Logit regression model:

Table 7: Results of the logit regression equation

Pr(VNI)	Regression coefficient	Standard error	Z	P>|z|	90% confidence level	
GMS_d	0.06295	0.0344	1.8300	0.0670**	0.0064	0.1195
Constant	0.0181	0.0342	0.5300	0.5960	-0.0381	0.0743
Number of observations: 3.429 LR chi2(1): 3.3500 Prob > chi2: 0.0671 Pseudo R²: 0.0007			Number of iterations 2: log likelihood = -2374.9847			
Pr(VNI)	Odd ratio	Standard error	Z	P>|z|	90% confidence level	
GMSd	1.0650	0.0366	1.8300	0.0670	1.0064	1.1270

*Note: ** is significant at 10%.*

Logit regression model has the form:
$$Pr(VNI) = 0.0181 + 0.0629 GMS_d \tag{6}$$

Table 8: Summary of the probability of VN–Index increase by eight boundary values of geomagnetic

Boundary values (GMS_d values)	Probability of VN-Index increase	Standard error by Delta method	Z	P>|z|	95% Confidence level	
1 (GMS_d = -5)	0.4264	0.04288	9.9400	0.0000	0.3423	0.5104
2 (GMS_d = -4)	0.4418	0.0349	12.6400	0.0000	0.3733	0.5103
3 (GMS_d = -3)	0.4574	0.0270	16.9600	0.0000	0.4045	0.5103
4 (GMS_d = -2)	0.4731	0.0191	24.7200	0.0000	0.4356	0.5106
5 (GMS_d = -1)	0.4888	0.0121	40.3800	0.0000	0.4651	0.5125
6 (GMS_d = 0)	0.5045	0.0085	59.0600	0.0000	0.4878	0.5213
7 (GMS_d = 1)	0.5202	0.0121	42.9400	0.0000	0.4965	0.5440
8 (GMS_d = 2)	0.5359	0.0191	28.0300	0.0000	0.4985	0.5734

Source: Analysis results from Stata 11 software.

Table 9: Summary of test results of difference between VN-Index increase compared with VN-Index decrease

Group	Number of observation	Mean	Standard error	Standard deviation	95% confidence level	
0	1.699	-0.0314	0.0235	0.9689	-0.0775	0.0147
1	1.730	0.0308	0.0245	1.0187	-0.0172	0.0788
Combination	3.429	-9.29e-09	0.0170	0.9947	-0.0333	0.0333
Difference (diff) = mean (0) - mean (1) Ho: diff = 0			t = -1.8310 Degree of freedom = 3427			
Ha: diff < 0 Pr(T < t) = 0.0336		Ha: diff != 0 Pr(|T| > |t|) = 0.0672			Ha: diff > 0 Pr(T > t) = 0.9664	

Source: Analysis results from Stata 11 software.

4.2. Discussion

Results from a linear regression model

In days without geomagnetic storms, the average daily rate of return of VN-Index is 0.049%. However, the regression coefficient of the constant is not statistically significant. When the geomagnetic indices increase by one unit during days of geomagnetic storms, the average daily VN-Index rate of return will increase by 0.066% compared to normal days (equivalent to 18%/year). With a 95% confidence level, when the geomagnetic indice increase by one unit in days of geomagnetic storms, the average daily VN-Index return may increase from 0.014 to 0.13%.

As a result of the linear regression model, in the days of geomagnetic storms, geomagnetic fluctuations have affected the average daily VN-Index rate of return with 95% confidence level. If a portfolio is created with the exact proportion of the VN-Index, investors who buy this index in stormy days and hold for one year will have a rate of return that is 20.1%/year higher than investors who buy and hold the same portfolio on normal days. This result is statistically significant at 5%, however, it should be noted that the level of explanation of geomagnetic dynamics in the volatility of the VN-Index is only 0.15% and investors have to include both the fees that they have to pay while trading.

Research results from logit model

To demonstrate the suitability of the model, we need to consider the log-likelihood value, if this value is less than zero then the model is more appropriate. The model shows that the result is converged after two iterations at the log likelihood value of -2374.9847 < 0 which represents the suitability of

the research model. LR chi2 (1) indicates a statistical chi-squared value of 3.35 with P-value of 0.0671, indicating that the model is statistically significant at 10% level. The coefficient β_2 is a positive number, indicating that the relationship between the VN-Index rate of return and the geomagnetic fluctuation is a positive relationship. Geomagnetic fluctuations increase during the days of geomagnetic storms, the average VN-Index rate of return increases at 90% confidence level.

Given other factors holding constant, when the geomagnetic representation variable increases by one unit during days of geomagnetic storms, Pr (VNI) increases by 0.0629, corresponding to an increase of average VN-Index return during those days by 0.065% (= e0.0181 + 0.0629 / e0.0181-1). The probability of VN-Index increases in the days of the geomagnetic storms is 1.0650 times higher than normal days.

Geomagnetic fluctuations range from 0.0064 to 0.1195, all of which are higher than 1 with a 90% confidence level, indicating that there is evidence to suggest that the relationship between geomagnetic dynamics and VN-Index rate of return in the logit regression model is statistically significant.

The result of testing the difference between VN-Index rate of return increase compared with VN-Index decrease is as follows:

Hypothesis H_0: There is no difference in geomagnetic representative value in the case of VN-Index return decrease compared with VN-Index return increase (diff = 0).

Geomagnetic difference between the case of VN-Index decrease compared to VN-Index increase

= Geomagnetic representative value when VN-Index decreases (denoted as mean (0)) - Geomagnetic representative value when the VN-Index increases (mean (1)).

Table 9 shows the geomagnetic representative value in case of VN-Index increase is 0.0308 units, in case of VN-Index decrease is -0.0314 units.

With P-value = 0.0336 <0.05 => Reject hypothesis H_0, accept hypothesis Ha: diff <0.

• Difference in geomagnetic representative value in case of VN-Index decrease compared VN-Index increase is lower than zero.

• Statistically significant at 5% level.

• With P-value = 0.0672 <0.1, we reject the hypothesis H_0, accepting the hypothesis Ha: diff = 0.

There is a difference in terms of geomagnetic representative value in case of VN-Index decrease compared to VN-Index increase:

- The value of this difference is -0.0622 unit.
- Statistically significant at 10%.

Thus, the geomagnetic representative value in case of VN Index decrease is -0.0314; in terms of statistical significance, it is actually smaller than the geomagnetic representative value in the case of VN-Index increase (which is 0.0308).

Statistical results of the probability of VN-Index increase by eight boundary value of the geomagnetic field, according to results are presented in Table 8 which shows:

- The probability for VN-Index to increase at the marginal values of the geomagnetic representative variable of 6, 7 and 8 corresponds to the GMSd level of 0, 1 and 2. Of which, the probability of VN-Index increase reaches the highest of 53.59% when the GMSd value is at 2 (the 8th marginal value).

- At the marginal value of the geomagnetic representative variable from 1 to 5 (corresponding to the GMSd level of -5, -4, -3, -2 and -1), the probability for VN-Index to decrease prevails. Of these values, the probability of VN-Index decrease is the highest at 57.36% at the first marginal value (corresponding to GMSd = -5). The downside probability of VN-Index in the next level are 55.81%; 54.25%; 52.69%; 51.12%.

5. Conclusion

With the VN-Index and geomagnetic data from 28 July 2000 until 31 December 2014, the results from the linear regression model and the logit model show that with a 90% confidence level, the average VN-Index rate of return during the days of geomagnetic storms compared to normal days will increase from 0.065-0.072%. The probability for the VN-Index return to increase in the days of geomagnetic storms is 1.064978 times higher compared to normal days. The results also show that the probability of VN-Index to increase at the eighth marginal value is the highest, reaching 53.59%. In contrast, the probability of VN-Index to decrease is the strongest at 57.36% at the first marginal value.

The analysis results of both the linear regression model and the logit model show that the VN-Index rate of return in the days of geomagnetic storms are significantly higher than the normal days. Regarding this empirical finding, one question is whether we can use the information from this analysis to develop a securities trading strategy for investors. In fact, when trading in the stock market in the long term, all investors must pay the costs involved, so if they implement stock trading strategies based on geomagnetic effects, they need to quantify these fees. This paper will propose some suggestions for investors to

develop investment criteria based on geomagnetic dynamics for VN-Index.

A simple trading strategy is to invest on the 4th day after the day of geomagnetic storms and sell on the 10th day after the day of geomagnetic storms. The result of this strategy shows that the average rate of return per transaction is 8.47% and it is higher than the average rate of return when following the strategy of buying stocks on the 11th day and selling on the 3rd day after the day with geomagnetic storms (which is 7.67%). On average, there are around 5.5 rounds of geomagnetic investment (except in the year of 2009 when there was no geomagnetic storm) and about 6 investment rounds in the other way. If the brokerage fee per transaction is 0.4%, rate of return according to the investment strategy above for each round of trading reached 3.72% during the days of geomagnetic storms compared to normal days (which is 2.54%). In case of expansion for this trading strategy, investors may consider delaying the sale of securities which fluctuate in the same direction as the VN-Index in the days of the geographic storm and/or consider buying in these days to take advantage of the positive impact on the VN-Index rate of return on the following days.

The average daily return of the VN-Index during the days of geomagnetic storms is 0.15%, much higher than the average daily rate of return in normal days of 0.04% and in the whole data of 0.07%. In addition, the probability for VN-Index to increase reaches the highest when the geomagnetic representation value is greater than or equal to 2 and the probability of decrease is the strongest when the geomagnetic representation value is less than or equal to minus 5. Therefore, in addition to trading strategies in this way, each investor can actively set up his/her own investment strategies based on the effect of the geomagnetic field on the VN-Index return. An investor can set up their strategies by changing the trading time and/or coupling with the probability of increase/decrease for each of these periods to come up with strategies that are appropriate for himself/herself.

Although the study provides evidence of the effects of geomagnetic storms on the VN-Index rate of return, it has not specifically shown the impact of each storm level on the VN-Index, more research is needed to fill up this gap. In addition, this study only evaluates the impact of geomagnetic on the VN-Index without considering the impact of geomagnetic on the HNX-Index rate of return and the securities on the two exchanges.

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