Impact of Investor Sentiments on the Japanese Stock Market[1]

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Abstract

This paper discusses the impact of sentiment indices on the Japanese stock market. Specifically, we employ the consumer confidence index, Put Call Ratio (PCR), Nikkei Volatility Index (VIX), and the stock trading volume as sentiment indices, and analyze their impact on the Nikkei stock average and the Tokyo Stock Exchange Mothers Index (the Mothers Index) using monthly and daily data respectively. We examine spillover effects by VAR model.

Although there are some differences in the results between monthly and daily data because of their different estimation periods, some of the sentiment indices have an impact on the Nikkei stock average and the Mothers Index. Meanwhile, in more cases, the Nikkei stock average and the Mothers Index have a stronger impact on the sentiment indices, which is a significant difference from the conclusions in previous studies that only consider the impact of the sentiment indices on the stock market.

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1. Introduction

Under the assumption that investors behave rationally, the basic framework of finance theory is that prices in various financial markets including stock prices would converge to rational values. Since the mid-1990s, however, empirical studies particularly with the US and European stock markets have reported the possibility that there would not be rational pricing because investors' investment decisions have been influenced by psychological factors. Specifically, such studies conduct analysis in the field of behavioral finance, among which sentiment analysis on investor psychology has attracted much attention in foreign countries.

In the traditional finance theory, investor sentiments are considered to have no cross-sectional effect on stock prices. Otherwise, sentiment analysis has been showing relationships between sentiment and stock prices through two main methods of analysis: one is the approach taken by this study which is econometric analysis based on public statistics including macro data and financial data; the other is a machine learning approach using textual data.

This paper analyzes relationships between sentiment indices and stock indices in Japan using a VAR model. We examine relationships between sentiment indices and stock indices from the impulse response analysis and the Granger causality test. Derivation and analysis of investor sentiment have been conducted mainly for the US and other foreign markets, and few studies have been conducted for the Japanese stock market. In addition, whereas previous studies have mainly analyzed the impact of sentiment indices on stock indices, this paper is unique in that it examines the opposite as well - the possibility that shifts in stock indices affect sentiment indices.

Hereinafter, Section 2 summarizes previous studies; Section 3 describes the estimation methods and data while Section 4 does the estimation results, respectively; and Section 5 summarizes the whole process.

2. Previous Studies

This section first defines the term "sentiment" - the subject of this paper - based on previous studies, which is followed by an overview of previous studies analyzing relationships between sentiment and the stock market.

To be brief, sentiment refers to the mood of people's psychology and economic and business activities in an investment environment that changes from time to time. It influences the country's economy and is reflected in the prices of assets on the market.

Academically, Baker and Wurgler (2007) defines "investor sentiment as investors beliefs about future cash flows and investment risk that are not justified by the facts at hand". The influence of social sentiment on asset prices is more than a hypothesis based on empirical evidence from investors.

To date, the analyses of large databases and academic studies have found that changes in sentiment and thought patterns at the group level affect market prices. For example, the stock prices of countries that have lost in major sporting competitions are directly affected by such loss. Other studies report that changes in the natural environment also affect market prices through their impact on people's emotions. These studies have been reported in the research area of behavioral finance.

The leading study analyzing relationships between investor sentiment and stock prices is Baker and Wurgler (2006). They created a sentiment measure and estimated relationships between sentiment and the returns of stocks by attribution, using US individual company data from 1962 to 2001. The results revealed that valuations of stocks that are rated very subjectively and difficult to arbitrage are significantly affected by investor sentiment.

Bathia and Bredin (2013) used the monthly data for G7 countries from January 1995 to December 2007 to analyze relationships between stock returns and four sentiment indices such as consumer confidence index, equity fund flow, closed-end equity fund, and equity put-call ratio. The results of panel estimation revealed a negative relationship between investor sentiment indices and future returns.

Using monthly data from January 1991 to December 2013, Bathia et al. (2016) analyzed the impact of American investors' sentiment on stock returns of G7 countries' markets by the generalized impulse response function (GIRF) from the VAR model. In specific, this study examined to what extent American sentiment levels affected stock prices in G6 countries and whether global investors were sensitive to changes in American investors' sentiment. The study was unique in that it conducted regression analysis of the University of Michigan Consumer Confidence Index with macro variables and decomposed it into rational and irrational sentiments.

Using daily data from 2 January 2004 to 11 April 2006, Bandopadhyaya and Jones (2008) regressed the residuals of S&P 500 random walk regression with PCR and VIX. Defining PCR (= put trading volume/call trading volume) where put is the expectation of falling stock prices (pessimistic) while call is the expectation of rising stock prices (optimistic), they concluded that pessimism is stronger than optimism if PCR is larger than 1 and pessimism is weaker than optimism if PCR is smaller than 1.

Brown et al. (2003) calculated sentiment from mutual funds in Japan and America, while Zouaoui et al. (2011) used an international panel to look at stock market effects.

Shakri et al. (2021) analyzed relationships between the COVID 19 crisis and cryptocurrencies using data from 31 December 2019 to 18 August 2020. In doing so, they utilized economic news sentiment indices and financial market sentiment indices. The VAR Granger causality framework and the Weblet analysis showed that the virtual currency market was affected by sentiment in the early part of the period, but this influence disappeared from around June 2020.

For an analysis in Japan, Iwanaga (2019) analyzed the relationship with idiomatic volatility using sentiment derived in America. Ishijima and Kazumi (2017) derived sentiment from natural language processing of Nikkei articles, verifying its predictability to daily indices, stock and J-REIT prices, and property prices. Other machine learning-related studies have also been carried out. In this study, in order to focus more on investors' attitudes, we use published survey data rather than machine learning for sentiment.

3. Estimation Method

3.1 Estimation model

We examine relationships between investor sentiment and stock prices. In practice, the impact of sentiment on stock prices does not always observe the same timing and may involve a lag. Since the causality of stock prices on sentiment cannot be ignored, we use VAR models that also take into account interdependent relationships (spillover).

The following reduced form VAR model is used to estimate:

$$\text{Stock Price}(t) = f(\text{Sentiment}(t-1, t-2, \cdots), \text{Stock Price}(t-1, t-2, \cdots))$$

$$\text{Sentiment}(t) = f(\text{Stock Price}(t-1, t-2, \cdots), \text{Sentiment}(t-1, t-2, \cdots))$$

Sentiment is a sentiment index. In this paper, whether sentiment indices have an impact on stock prices and, if so, to what extent there is a lag are examined. Furthermore, the impact of stock prices on the sentiment indices is also examined.

3.2 Data

The estimation period is from April 2011 to December 2019 for monthly data and from 4 January 2017 to 30 December 2019 for daily data. The end of the period is set to December 2019 because the market structure has changed significantly after the COVID-19 crisis; the estimation period runs before its impact emerged.

The data used in this paper are as follows: (a) and (b) are stock indices and (c) through to (f) are sentiment indices. (g) through to (i) are exogenous variables. Closing prices are used as financial data.

(a) Nikkei Stock Average

(b) The Mothers Index

(c) Consumer confidence index

These are statistics published monthly by the Cabinet Office of Japan and use figures for the households of two or more persons and seasonally adjusted figures. The consumer confidence index is only available on a monthly basis and is not used in the daily analysis. The effect on the Nikkei stock average and the Mothers Index of prior hypothesis are positive.[2]

(d) Nikkei VIX

The Nikkei Volatility Index published by Nikkei Inc. - an index of indicating how investors expect the Nikkei stock average to fluctuate in the future. The higher the index value, the more investors expect the market to fluctuate significantly in the future.[3] The effect on the Nikkei stock average and the Mothers Index of prior hypothesis are negative.

(e) PCR (Put Call Ratio)

PCR is defined as (put options trading volume) / (put options trading volume + call options trading volume). This is made from the Osaka Exchange Daily Report. As mentioned earlier, the higher the volume of puts traded, the more pessimistic it becomes. The effect on the Nikkei stock average and the Mothers Index of prior hypothesis are negative.

(f) Stock trading volume

The total trading value of domestic stocks and foreign stocks traded at the stock exchanges in Japan. The former comprises the First Section, the Second Section, Mothers, TOKYO PRO Market, JASDAQ Standard and JASDAQ Growth. Because the higher trading value is considered to be the increased demand, the effect on the Nikkei stock average and the Mothers Index of prior hypothesis are positive.

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[2] The prior hypothesis in this paper assumes market followers. In the case of contrarians, the prior hypothesis is the opposite.

[3] Calculation started on 19 November 2010 (retroactive calculation possible until 12 June 1989). https://indexes.nikkei.co.jp/nkave/index/profile?idx=nk225vi

(g) Inflation rate

As the inflation rate, the rate of change in the consumer price index published by the Statistics Bureau of the Ministry of Internal Affairs and Communications of Japan is used. It is used solely as monthly data.

(h) Exchange rate (The dollar-yen exchange rate)

(i) Indices of Industrial Production

Monthly data from the "Indices of Industrial Production" published by the Ministry of Economy, Trade and Industry of Japan is used; the year of 2015 = 100.

Descriptive statistics are available in Table 1 and Table 2. Two types of analysis are conducted in this analysis, one using monthly data and the other using daily data. Table 1 is the basic statistics for monthly data, being time-series data from April 2011 to December 2019.[4] Table 2 presents the basic statistics for daily data.

3.3 Estimation Method

In selecting the estimation model, the stationarity of the data is first checked by a unit root test[5]. In case of stationary, the data are estimated as is with the VAR, while in the case of unstationarity, the data are estimated with the VAR model by taking differences[6]. The VAR model is determined by testing the lag order. Then, causality is verified by the Granger causality test. Further, using the impulse response analysis[7], the impact of stock prices and sentiment indices on other variables is discussed respectively.

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[4] LNVOLUME is the logarithm of the stock trading volume, and logarithms are used to mitigate the effect of specific outliers in real numbers.

[5] For unit root tests, there are Dickey-Fuller test/Augmented Dickey-Fuller test (drift term only, drift term + trend term, neither of them), Phillips-Perron test, etc., but they have low test power.

[6] When all variables are unstable (to be precious, I(1)), a cointegration test is performed, and if there is cointegration, estimation is made with the VEC(Vector Error Correction) model.
However, many researches perform the VAR analysis at the level without confirming stationarity in order to interpret the results easily. See Hamilton (1994) for details.

[7] It traces how an impact given on the error term in an equation will pass on to such variable and other variables.

4. Estimation Results

4.1 Monthly Data

The results of the unit root test find that although not all variables are stationary, all variables which differences are taken are stationary and are estimated with the VAR. The estimation results, the Granger causality test results, and the impulse response function are presented in Table 3, Table 4, Table 5, Figure 1, and Figure 2, respectively. The results of the estimation using the Mothers Index instead of the Nikkei stock average are also shown.

In a model including the Nikkei stock average, the optimal lag is found to be 4 from the lag order test. Table 3 indicates D(PCR(-1)) is negatively significant for D(NIKKEI) and D(CCI(-1)) shows a positive impact on D(Nikkei), while D(Nikkei(-1)) has a positive impact on D(PCR) and D(LNVOLUME), indicating that sentiment indices and stock prices interact with each other. A model including the Mothers Index also have an optimal order of 4. Table 4 says that there are few variables/lags that are significant for D(MOTHERS).

The causality tests in Table 5 demonstrate that D(NIKKEI) and D(PCR) are causally related to each other at a significance level of 10%, and that there is a causal relation from D(NIKKEI) to D(VIX) and D(LNVOLUME). Meanwhile, using the Mothers Index, there is a significant causal relation only from D(VIX) to D(MOTHERS).

The impulse response function in Figure 1[8] shows that D(NIKKEI) reacts negatively to changes in D(PCR) in the first period, positively in the second period and then converges; also reacts negatively to changes in D(VIX) in the first period, positively in the second period and then gradually converges. Conversely, shifts in D(NIKKEI) also affects the shifts of each sentiment measure. In using the Mothers Index, D(MOTHERS) does not react much to changes in D(PCR), but reacts to changes in D(VIX) in the same way as D(NIKKEI).

[8] Cholesky ordering is as follows: D(NIKKEI) or D(MOTHERS), D(PCR), D(CCI) D(VIX), D(LNVOLUME).

4.2 Daily Data

The monthly analysis in the previous section reveals that stock prices are affected by sentiment indices. Here, in order to observe the formation process of these inter-variable relationships, a more detailed daily analysis is carried out: the same analysis as the monthly data is carried out with daily data for the three-year period starting from 1 January 2017.[9] The results of the unit root tests find that all variables are unstationary. Therefore, a cointegration test is performed. Since there are there cointegrations, the estimation is made with the VEC model. The lag order test demonstrates that the optimal lag is 5 for either model containing the Nikkei stock average or the Mothers Index. The estimation results obtained are presented in Table 6 and Table 7.

The results of the analysis differ from those of the monthly analysis. Table 6 and 7 show that Most of the explanatory variables for D(NIKKEI) and D(MOTHERS) do not give significant effects. Therefore, the daily analysis concludes that sentiment indices have little effect on stock prices. Otherwise, it can be seen that D(NIKKEI) and D(MOTHERS) have a significant effect on D(PCR) and D(VIX).

Next, a Granter causality test is conducted to examine the robustness of causal relationships between these stock price and sentiment indices. Its main results are illustrated in Table 8 below.[10]

The results of the Granger causality test do not confirm any effect of each sentiment indicator on stock returns. Conversely, the causality relationship from D(NIKKEI) to D(PCR) and from D(MOTHERS) to D(PCR) and D(VIX) is confirmed. This result backs the results of the VEC estimation, meaning that a decline in stock prices leads to a deterioration in market sentiment.

It can be read from Figure 3[11] that the relevant impulse response analysis shows that the negative impact continues over time. However, it can be seen that the

[9] However, those macro variables used in the monthly analysis as control variables are not included in the analysis because they are not available on a daily basis.
[10] As many results do not confirm any causal relationship, they have been omitted.
[11] Cholesky ordering is as follows: NIKKEI, PCR, VIX, LNVOLUME.

negative impact is weakening gradually.

In summary, the results of the daily analysis confirm that, unlike the monthly analysis, the sentiment effect on stock prices is not observed, while stock prices affect sentiment.

5. Conclusion

This paper considers the impact of sentiment indices on the Japanese stock market. In specific, employing the consumer confidence index, PCR, VIX, and the stock trading volume as sentiment indices, we analyze their impact on the Nikkei stock average and the Mother Index using the monthly and daily data. In doing this, we used a VAR model to assess spillover effects.

Although there are differences in the empirical results between monthly and daily data due to their different estimation periods, some of the sentiment indices have an effect on the Nikkei stock average and the Mothers Index. The indices that show significant effects are the consumer confidence index and the PCR. These results would be a contribution of this paper as they are not observed in the analysis of Japan for the period from 1995 to 2007 by Bathia and Bredin (2013).

Additionally, in more cases, changes in the Nikkei stock average and the Mothers Index have a stronger impact on the sentiment indices, which turn out to be a significant difference from the conclusions in the previous studies that only considers the impact of sentiment indices on the stock market. Price indicators such as PCR are affected, which is our important finding in terms of put and call pricing.

We conduct the analysis of the Japanese market in this paper, but the Japanese stock market is also heavily influenced by foreign markets, and therefore its association with foreign markets is a subject for our future work.

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Table1: Descriptive Statistics of Monthly Data (2011/4-2019/12)

	Mean	Median	Maximum	Minimum	Std Dev	Obs
NIKKEI (Yen)	16690	17425	24120	8435	4728	105
MOTHERS	831	897	1313	309	258	105
CCI	41.115	41.300	45.600	33.200	2.525	105
PCR	0.544	0.548	0.643	0.404	0.056	105
VIX	21.702	21.200	36.600	13.880	5.252	105
LNVOLUME	17.717	17.837	18.274	16.826	0.357	105
CPI (%)	0.630	0.400	3.700	-0.900	1.016	105
EXRATE(Yen/Dollar)	103.434	108.560	124.220	76.300	13.781	105
IP	100.895	100.900	105.800	89.200	2.685	105

Note: The followings are definitions of each variable: NIKKEI: Closing Price of the Nikkei Average; MOTHERS: Tokyo Stock Exchange Mothers Index; CCI: Consumer Confidence Index, households of two or more persons, seasonally adjusted; PCR: Put Option Trading Value/(Call Option Trading Value + Put Option Trading Value); VIX: Nikkei Volatility Index Average Published by Nikkei Inc.; LNVOLIUME: Logarithmic Value of Stock Trading Value; CPI: Consumer Price Index Growth Rate; EXRATE: Dollar-Yen Exchange Rate and; IP: Indices of Industrial Production, the year of 2015 = 100.

Table2: Descriptive Statistics of Daily Data (4/1/2017 - 30/12/2019)

	Mean	Median	Maximum	Minimum	Std Dev	Obs
NIKKEI (Yen)	21401	21547	24271	18336	1378	733
MOTHERS	1024	1025	1356	757	122	733
PCR	0.597	0.608	0.854	0.137	0.105	733
VIX	17.638	16.740	36.050	12.190	3.541	733
LNVOLUME	14.883	14.879	15.737	14.216	0.203	733

Note: The followings are definitions of each variable: NIKKEI: Closing Price of the Nikkei Average; MOTHERS: Tokyo Stock Exchange Mothers Index; PCR: Put Option Trading Value/(Call Option Trading Value + Put Option Trading Value); VIX: Nikkei Volatility Index Average Published by Nikkei Inc.; and LNVOLIUME: Logarithmic Value of Stock Trading Value

Table 3: VAR Estimates for NIKKEI Based on Monthly Data (103 Obs)

	D(NIKKEI)	D(PCR)	D(CCI)	D(VIX)	D(LNVOLUME)
D(NIKKEI(-1))	-0.334 **	0.000 *	0.000	0.001	0.000 ***
D(NIKKEI(-2))	0.108	0.000	0.000	0.000	0.000
D(NIKKEI(-3))	0.074	0.000	0.000	0.001	0.000
D(NIKKEI(-4))	0.001	0.000	0.000	0.000	0.000 *
D(PCR(-1))	-4809.136 **	-0.346 ***	-0.492	9.303	-0.162
D(PCR(-2))	-1156.149	-0.001	-1.211	5.221	-0.629
D(PCR(-3))	4142.582 *	-0.261 **	-1.540	-10.075	-1.169 ***
D(PCR(-4))	2864.484	-0.228 **	3.199	-5.590	-0.353
D(CCI(-1))	129.596 *	-0.001	-0.031	-0.604	0.004
D(CCI(-2))	-26.013	-0.001	0.117	0.157	0.012
D(CCI(-3))	-63.814	0.002	-0.096	-0.212	0.009
D(CCI(-4))	-7.258	-0.004	-0.115	0.186	-0.011
D(VIX(-1))	-30.055	0.000	-0.029	-0.392 **	0.002
D(VIX(-2))	14.870	-0.002	-0.001	-0.424 **	-0.006
D(VIX(-3))	14.169	-0.002 *	0.031	-0.149	-0.015 ***
D(VIX(-4))	19.673	0.000	0.040	-0.215 *	-0.009 **
D(LNVOLUME(-1))	275.655	-0.012	0.964	9.667 **	-0.289 **
D(LNVOLUME(-2))	368.018	0.037	0.531	3.141	-0.171
D(LNVOLUME(-3))	-420.447	0.063 *	-0.191	4.200	0.062
D(LNVOLUME(-4))	463.753	0.046	0.785	2.258	0.134
D(CPI)	48.714	-0.008	-0.158	-0.884	-0.008
D(EXRATE)	228.635 ***	-0.002 *	-0.010	-0.543 ***	0.013 ***
D(IP)	-109.423 **	0.000	-0.011	0.268	0.006
C	88.493	-0.001	0.031	-0.376	-0.004
R-squared	0.575	0.355	0.181	0.429	0.486
Adj. R-squared	0.451	0.168	-0.057	0.262	0.336
Sum sq. resids	28240438	0	80	1124	1

Note: NIKKEI: Closing Price of the Nikkei Average; CCI: Consumer Confidence Index, households of two or more persons, seasonally adjusted; PCR: Put Option Trading Value/(Call Option Trading Value + Put Option Trading Value); VIX: Nikkei Volatility Index Average Published by Nikkei Inc.; LNVOLIUME: Logarithmic Value of Stock Trading Value; CPI: Consumer Price Index Growth Rate; EXRATE: Exchange Rate; and IP: Indices of Industrial Production. D at the beginning of each variable indicates the difference from one period earlier. *,** and *** indicate that coefficient = 0 can be rejected at significance levels of 10%, 5% and 1% respectively.

Table 4: VAR Estimates for MOTHERS Based on Monthly Data (103 Obs)

	D(MOTHERS)	D(PCR)	D(CCI)	D(VIX)	D(LNVOLUME)
D(MOTHERS(-1))	-0.131	0.000	-0.003 *	0.011	0.000
D(MOTHERS(-2))	0.140	0.000	0.001	-0.003	0.000
D(MOTHERS(-3))	-0.329	0.000	-0.004 **	0.005	0.000
D(MOTHERS(-4))	-0.057 **	0.000	0.002	0.014 *	0.000
D(PCR(-1))	-264.882	-0.402 ***	-2.429	1.633	-0.810 *
D(PCR(-2))	-439.836 *	-0.062	0.058	4.235	-0.917 **
D(PCR(-3))	-21.066	-0.106	-2.119	-11.735	-0.496
D(PCR(-4))	410.897 *	-0.222 **	3.238	-13.080	-0.432
D(CCI(-1))	9.724	-0.003	0.074	-0.495	0.013
D(CCI(-2))	-1.225	0.000	0.066	0.086	0.004
D(CCI(-3))	2.242	0.002	-0.023	-0.125	0.010
D(CCI(-4))	-2.090	-0.002	-0.152	-0.095	-0.012
D(VIX(-1))	-1.387	-0.001	-0.073 **	-0.486 ***	-0.006
D(VIX(-2))	1.567	-0.003 **	0.008	-0.467 ***	-0.005
D(VIX(-3))	-1.472	-0.002	-0.014	-0.325 **	-0.012 ***
D(VIX(-4))	0.027	-0.001	0.049 *	-0.189	-0.010 ***
D(LNVOLUME(-1))	11.815	0.009	1.850 *	7.299 *	-0.251 **
D(LNVOLUME(-2))	5.664	0.056 *	0.601 *	6.657 *	-0.166
D(LNVOLUME(-3))	93.270	0.069 **	0.845	5.141	0.007
D(LNVOLUME(-4))	69.007	0.057 *	1.081	2.819	0.130
D(CPI)	-19.796	-0.007	-0.164	-0.854	-0.014
D(EXRATE)	7.238 **	-0.003 **	-0.010	-0.405 **	0.016 ***
D(IP)	-2.091	0.000	-0.031	0.251	0.000
C	3.226	0.000	0.033	-0.299	-0.002
R-squared	0.257	0.325	0.275	0.425	0.364
Adj. R-squared	0.041	0.129	0.064	0.257	0.178
Sum sq. resids	396802	0	71	1132	1

Note: The following are definitions for each variable: MOTHER: Tokyo Stock Exchange Mothers Index; CCI: Consumer Confidence Index, households of two or more persons, seasonally adjusted; PCR: Put Option Trading Value/(Call Option Trading Value + Put Option Trading Value); VIX: Nikkei Volatility Index Average Published by Nikkei Inc.; LNVOLIUME: Logarithmic Value of Stock Trading Value; CPI: Consumer Price Index Growth Rate; EXRATE: Exchange Rate; and IP: Indices of Industrial Production. D at the beginning of each variable indicates the difference from one period earlier. *, ** and *** indicate that coefficient = 0 can be rejected at significance levels of 10%, 5% and 1% respectively.

Table 5: Granger Causality Test on Monthly Data

Null Hypothesis:	Obs	F-Statistic	Prob.
D(PCR) does not Granger Cause D(NIKKEI)	103	2.09338	0.0878
D(NIKKEI) does not Granger Cause D(PCR)		2.22872	0.0717
D(CCI) does not Granger Cause D(NIKKEI)	103	0.41957	0.7942
D(NIKKEI) does not Granger Cause D(CCI)		1.08838	0.3669
D(VIX) does not Granger Cause D(NIKKEI)	103	0.38871	0.8162
D(NIKKEI) does not Granger Cause D(VIX)		3.81586	0.0064
D(LNVOLUME) does not Granger Cause D(NIKKEI)	103	1	0.4116
D(NIKKEI) does not Granger Cause D(LNVOLUME)		7.6127	0.00002
D(PCR) does not Granger Cause D(MOTHERS)	103	1.81193	0.133
D(MOTHERS) does not Granger Cause D(PCR)		1.06762	0.377
D(CCI) does not Granger Cause D(MOTHERS)	103	0.55796	0.6937
D(MOTHERS) does not Granger Cause D(CCI)		1.87666	0.121
D(VIX) does not Granger Cause D(MOTHERS)	103	0.36935	0.8299
D(MOTHERS) does not Granger Cause D(VIX)		5.63588	0.0004
D(LNVOLUME) does not Granger Cause D(MOTHERS)	103	0.70955	0.5874
D(MOTHERS) does not Granger Cause D(LNVOLUME)		1.73764	0.1482

Table 6: Vector Error Correction Estimates for NIKKEI Based on Daily Data (727 Obs)

	D(NIKKEI)	D(PCR)	D(NVIX)	D(LNVOLUME)
D(NIKKEI(-1))	0.0220	-0.0001 ***	0.0002	0.0000
D(NIKKEI(-2))	-0.0221	-0.0001 ***	-0.0005	0.0000
D(NIKKEI(-3))	-0.0068	-0.0001 ***	-0.0004	0.0000
D(NIKKEI(-4))	0.0783	-0.0001 ***	-0.0009 **	0.0000
D(NIKKEI(-5))	0.0437	0.0000	-0.0007 *	-0.0001 *
D(PCR(-1))	-44.0998	-0.4947 ***	0.5977	0.3575 ***
D(PCR(-2))	-32.4526	-0.4299 ***	0.4814	0.2743 ***
D(PCR(-3))	-128.7016	-0.3335 ***	0.7718	0.1554
D(PCR(-4))	5.1461	-0.1952 ***	-0.3541	0.0598
D(PCR(-5))	19.1647	-0.0930 **	-0.3490	0.0455
D(VIX(-1))	0.8223	-0.0051	-0.0043	0.0037
D(VIX(-2))	-4.5327	-0.0027	-0.0276	-0.0026
D(VIX(-3))	-3.7269	-0.0050	-0.0325	0.0007
D(VIX(-4))	3.2936	-0.0058	-0.1232 **	0.0011
D(VIX(-5))	12.7635	-0.0053	-0.1444 **	-0.0134 **
D(LNVOLUME(-1))	122.4863 *	-0.0048	-0.6083	-0.2360 ***
D(LNVOLUME(-2))	76.8409	-0.0049	-0.1882	-0.1472 ***
D(LNVOLUME(-3))	126.3338 *	0.0029	-0.2454	-0.0693
D(LNVOLUME(-4))	0.6916	0.0113	0.2726	-0.0856 *
D(LNVOLUME(-5))	-12.8931	0.0372	-0.0536	0.0740 *
C	5.8720	0.0022	0.0029	-0.0003
R-squared	0.0226	0.4555	0.0731	0.2707
Adj. R-squared	-0.0094	0.4377	0.0427	0.2468
Sum sq. resids	30375418	5	1128	16

Note: NIKKEI: Closing Price of the Nikkei Average; PCR: Put Option Trading Value/(Call Option Trading Value + Put Option Trading Value); VIX: Nikkei Volatility Index Average Published by Nikkei Inc.; LNVOLIUME: Logarithmic Value of Stock Trading Value. D at the beginning of each variable indicates the difference from one period earlier. *, ** and *** indicate that coefficient = 0 can be rejected at significance levels of 10%, 5% and 1% respectively.

Table 7: Vector Error Correction Estimates for MOTHERS Based on Daily Data (727 Obs)

	D(MOTHERS)	D(PCR)	D(VIX)	D(LNVOLUME)
D(MOTHERS(-1))	0.0017	-0.0007 **	0.0081 **	-0.0006
D(MOTHERS(-2))	0.0211	-0.0003	-0.0005	-0.0003
D(MOTHERS(-3))	-0.0368	-0.0004	-0.0059	-0.0003
D(MOTHERS(-4))	-0.0297	0.0001	-0.0028	0.0000
D(MOTHERS(-5))	0.0319	-0.0003	-0.0042	0.0004
D(PCR(-1))	8.0969	-0.4999 ***	0.1227	0.2514 **
D(PCR(-2))	3.1007	-0.3937 ***	0.3137	0.2000 **
D(PCR(-3))	-2.8765	-0.2805 ***	0.8465	0.1035
D(PCR(-4))	8.3037	-0.1400 ***	-0.0660	0.0342
D(PCR(-5))	4.6755	-0.0623	-0.1450	0.0575
D(VIX(-1))	-0.9467	0.0050	0.0216	0.0010
D(VIX(-2))	-0.1871	0.0048	0.0242	-0.0009
D(VIX(-3))	-0.5054	0.0004	-0.0284	-0.0009
D(VIX(-4))	-0.3780	0.0026	-0.0507	0.0011
D(VIX(-5))	0.1977	-0.0045	-0.1013 **	-0.0017
D(LNVOLUME(-1))	-0.3437	-0.0498	-0.5835	-0.2037 ***
D(LNVOLUME(-2))	-6.0001	-0.0493	-0.2519	-0.1251 **
D(LNVOLUME(-3))	-6.2884	-0.0400	-0.2751	-0.0488
D(LNVOLUME(-4))	-12.2171 ***	-0.0353	0.1840	-0.0664
D(LNVOLUME(-5))	-5.6249	0.0043	-0.1355	0.0701
C	-0.1366	-0.0003	-0.0099	-0.0011
R-squared	0.0308	0.4255	0.0705	0.2800
Adj. R-squared	-0.0009	0.4067	0.0401	0.2564
Sum sq. resids	172664	5.7388	1131	15.720

Note: The following are definitions of each variable: MOTHER: Tokyo Stock Exchange Mothers Index; PCR: Put Option Trading Value/(Call Option Trading Value + Put Option Trading Value); VIX: Nikkei Volatility Index Average Published by Nikkei Inc.; LNVOLIUME: Logarithmic Value of Stock Trading Value. D at the beginning of each variable indicates the difference from one period earlier. *, ** and *** indicate that coefficient = 0 can be rejected at significance levels of 10%, 5% and 1% respectively.

Table 8 VEC Granger Causality Test on Daily Data

Null Hypothesis:	Obs	Chi-sq	Prob.
D(NIKKEI) does not Granger Cause D(PCR)	727	50.8918	0.0000
D(NIKKEI) does not Granger Cause D(VIX)	727	11.0536	0.0503
D(MOTHERS) does not Granger Cause D(PCR)	727	11.6126	0.0405
D(MOTHERS) does not Granger Cause D(VIX)	727	10.2352	0.0688

Figure 1: Results of Impulse Response for NIKKEI (monthly)
Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 Analytic Asymptotic S.E.s Based on Monthly DATA

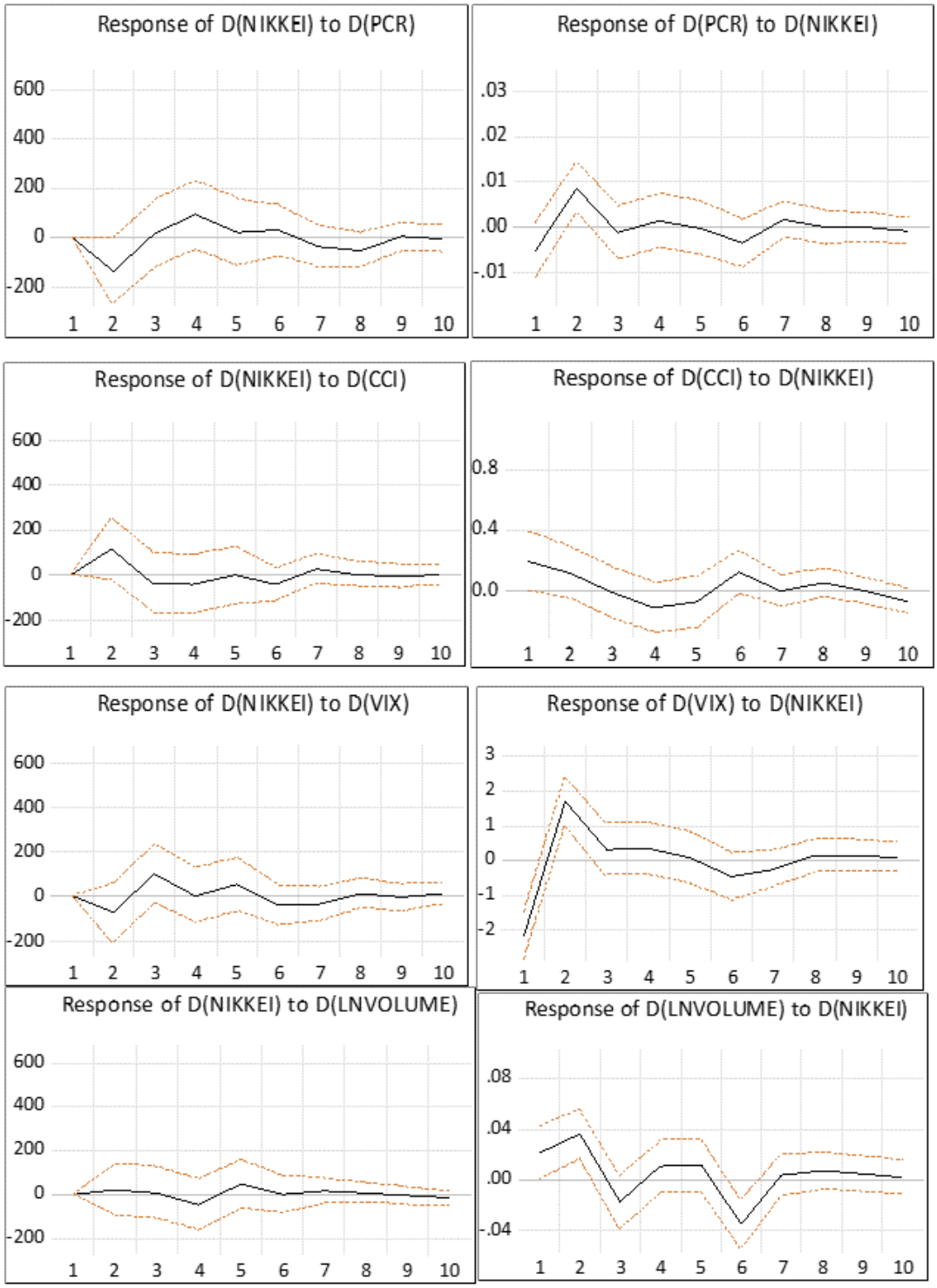

Figure 2: Results of Impulse Response for MOTHERS (monthly)
Response to Cholesky One S.D. (d.f. adjusted) Innovations ± 2 Analytic Asymptotic S.E.s Based on Monthly DATA

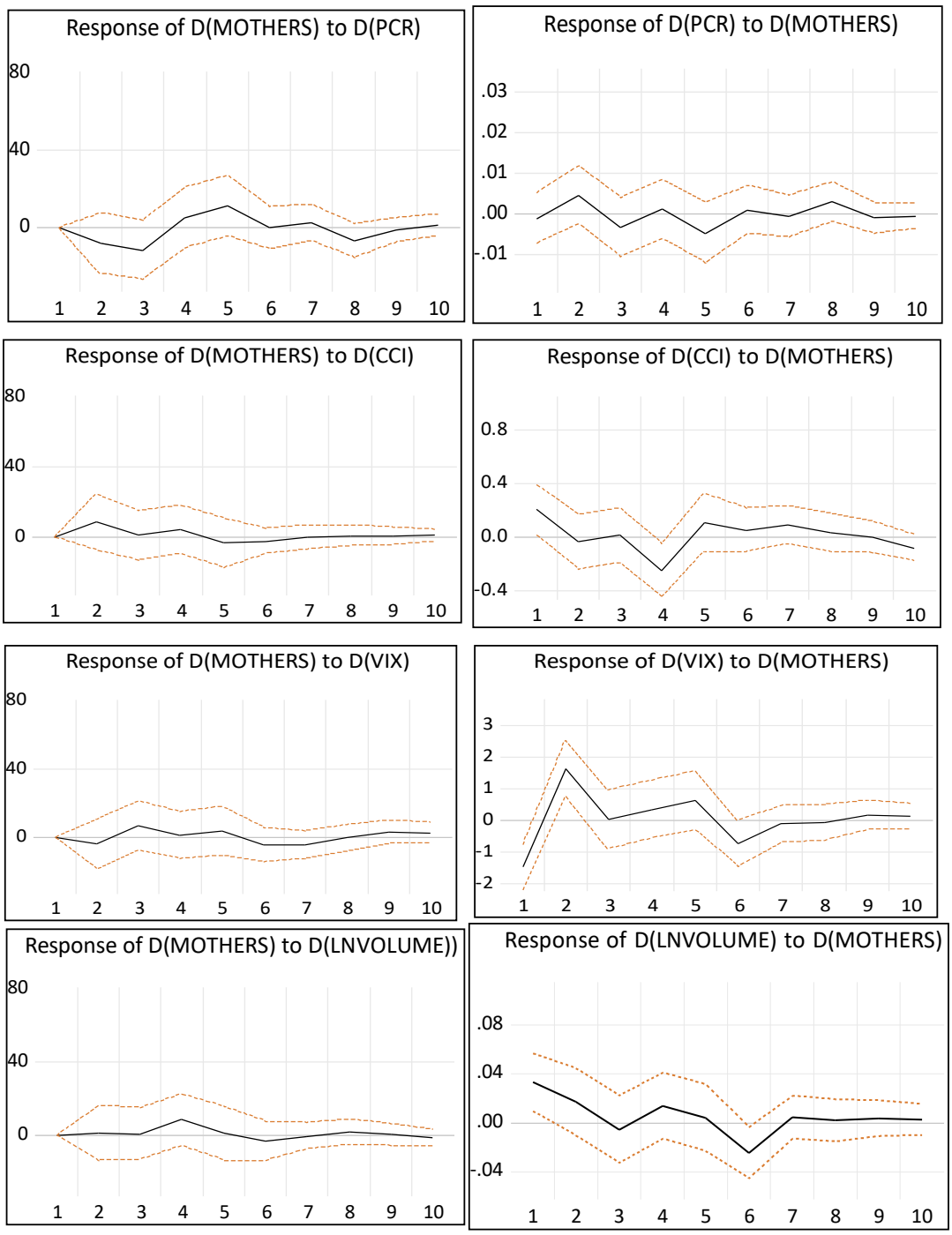

Figure 3: Results of Major Impulse Response (Daily)
Response to Cholesky One S.D. (d.f. adjusted) Innovations Based on Daily DATA