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The Interaction between Market Sentiments in the U.S. Financial Market and Global Equity Market

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Abstract

This paper adopts the volatility index and Baker-Wurgler index as the U.S. financial market sentiment measures. Using monthly data from June 1965 to December 2010, we identify the causal relationships between sentiment and the performance of global equity markets. We include 23 G20 market indices, 28 European indices, 25 Asia-Pacific indices, and 10 Americas indices, and employ Granger causality procedure to explore the linkages. We find that the international equity markets are not greatly affected by the U.S. financial market sentiment. The type of extreme sentiment, whether it is optimistic or pessimistic, is irrelevant to its influential power. The equity markets that are affected by the volatility index do not cluster in any region. In contrast, the majority of global equity markets can Granger cause the U.S. investor sentiments, with optimistic market atmosphere being more affected. The equity markets in the Americas and Europe are highly influential to the U.S. investors, compared to the Asian markets.

Keywords: market sentiment, investor sentiment, financial market, global, equity market, contagion

1. Introduction

This paper employs the market sentiments time series data and global equity market prices and returns to exam the interaction between the U.S. investor sentiments and the international stock performances. We include 23 G20 market indices, 28 European indices, 25 Asia-Pacific indices, and 10 Americas indices, and employ Granger causality tests to explore the linkages. By converting the daily VIX indices into monthly variables, we identify three sentiment types: market panic, extreme market optimism, and market consensus. The pairwise causality tests then identify the mutual impacts of different market sentiments and cross-country equity returns.

While previous studies shed some light on the financial market contagion across countries, these researches mainly focus on the contagion among the homogeneous variables: equity prices, returns, or volatility. For example, Eryigit and Eryigit (2009) study the equity returns contagion and conclude that the market spillovers are geographically based clustering behaviors. Dungey, Fry, and Martin (2003) study the equity prices interactions and suggest that comovements in Asian and Australian stock markets are because of the common systemic interdependent factors. Karunanayake, Valadkhani, and O'Brien (2010) focus on equity volatility contagion and the spillover is unidirectional from the bigger markets to smaller ones.

This paper takes the rare perspective that studies the interaction of heterogeneous financial variables: the spillover between the sentiments and returns. We attempt to address two issues: whether the market sentiment in the United States can spread beyond boundary and affect oversea markets, and whether the global equity market movements can explain the fluctuation of the sentiment in the American market. Exploring the conclusions for these two topics improve the conventional framework of return contagion, which identifies the homogeneous return contagion without revealing the endogenous factor of such contagion. Our study explores the driving force of the integration of oversea equity markets from the sentiment perspective, as sentiment is a measure that is more liquid than the fundamental factors of public listed companies around the world.

Our study does not assume the type of rationality of investors. The debate in terms of the validity of the rational agent assumption leads to the significant distinguishes in the classical theory of finance and the theory of behavior finance. The former is established on the setting of investor maximization of profit and the latter assumes limited rationality. However, this paper attempts to empirically identify the role of investor sentiment,

and the conclusion does not necessarily support either side of the debate. In other words, if investors are prone to the impact of sentiment, it is not equivalent to the assertion that they are irrational, or emotional. Investors might interpret the sentiment delivered from the market rationally and update their investment decisions based on the premise that the sentiment contains information that they are not aware of. Actions on the observation of sentiment are might be rational moves, or irrational herding behaviors.

A few previous literatures emphasize the interaction of sentiment and the security returns (Brown & Cliff, 2004; Joseph, Wintoki, & Zhang, 2011), or the sentiment contagion among geographically different markets (Baker, Wurgler, & Yuan, 2012). The conclusions are inconsistent: Brown and Cliff (2004) do not support that sentiment primarily affects individual investors and small stocks, and sentiment has limited role for near-term future stock returns; on the other side, Baker and Wurgler (2006) suggest the strong role of sentiment in stock returns. Previous findings are dependent to the type of sentiment proxy selected. (Corredor, Ferrer, & Santamaria, 2013). We attempt to categorize and compare the measures of sentiment in the past studies as follows.

Many previous studies use the BW market sentiment index (Baker & Wurgler, 2006, 2007). Examples are Stambaugh, Yu, and Yuan (2012), and Laborda and Olmo (2013). According to Baker and Wurgler's method, the BW index is based on the first principal component of six orthogonal sentiment proxies: value-weighted dividend premium, IPO volume, first day returns on IPO, closed-end fund discount, equity share in new issues, and NYSE turnover.

The stock option based VIX index is also widely adopted as market sentiment variable, for example, Ben-Rephael, Kandel, & Wohl (2012) use the VIX as market sentiment proxy. The Chicago Board Options Exchange (CBOE) VIX indices, which is often referred to as the "investor fear gauge", are the benchmark for stock market volatility. It is based on market portfolio index option prices and incorporates information from the volatility skewness by setting a wide range of exercise prices.

The Index of Consumer Sentiment produced by the University of Michigan Survey Research Center is also utilized as a market sentiment indicator by some articles, for instance, Akhtar, Faff, Oliver, & Subrahmanyam (2012). We however do not involve this series in the current paper as it contains only one series of monthly data and does not separately provide the financial asset investors' extreme or modest emotions.

Other studies employ different methods by assuming the mood of investors as market sentiments from exogenous events. Al-Hajieh, Redhead, & Rodgers (2011) examine whether the mood brought by the holy month of Ramadan affects the Islamic Middle Eastern stock markets. Palomino, Renneboog, & Zhang (2009) uses the outcomes of soccer club games as investor moods to test its relation with the stock returns.

The BW series incorporated in our paper also covers other measures of sentiments used before, such as the trading volume-based BSI (Kumar & Lee, 2006), liquidity (Baker & Stein, 2004), psychological evidence (Barberis, Shleifer, & Vishny, 1998), IPO underpricing (Hrnjić & Sankaraguruswamy, 2011), and the Tobin's Q ratio (Grundy & Li, 2010).

This study uses the BW index and the VIX indices as the proxy of market. The monthly BW data has one series, whereas the daily VIX indices include four series: option volatilities based on Stand and Poor's 100 and 500 indices, the Dow Jones Industrial Average, and the NASDAQ. For each of the daily index, we calculate its monthly maximum, minimum, and median levels as the investor extreme fear, optimistic, and consensus sentiments.

We find that international equity markets are not greatly affected by the U.S. financial market sentiment. Equity indices in different countries and regions are determined by their own fundamental factors of the firms publicly listed, rather than the market sentiment of the United States market. The significant impacts of sentiment do not show any unanimous pattern in term of the sentiment type. The ratio of significant maximum, minimum, and median VIX, which stand for the market panic, optimism, and consensus, are close to even. Hence the directions of market atmosphere are irrelevant to whether it can be contagious among the markets.

We also conclude that the equity markets that are affected by the volatility sentiment index do not fall into any category in terms of region or scale. Markets that can be infected by the U.S. VIX sentiment are from the following countries: Brazil, Canada, Mexico, the United States, Indonesia, Jordan, South Korea, and Austria. These countries vary from small developing economies to large developed countries. On the other hand, countries of which the equity markets are not affected also have various types.

As we reverse the causality direction and examine the impacts of the global equity market to the volatility sentiment, the results suggest that: Firstly, the majority of global equity markets can Granger cause the U.S. investor sentiments. Most of the countries that cannot lead to market atmosphere turbulence are small and have

limited influence on the regional or global economy. Secondly, the type of sentiment being affected is not even. We detect 22 or 29% of causalities lead to influence of market panic, 32 or 42% lead to influence of market optimism, and the rest 22 or 29% result in the change of consensus market sentiment. Optimistic market atmosphere is more affected by the global equity market, rather than the pessimistic or modest ones. Thirdly, the driving forces of U.S. financial market sentiment are not evenly located in the world. The equity markets in the Americas are highly influential to the U.S. investors. In addition, the American financial market also observes the performances of European markets closely. However, the Asian markets are much less influential. The global equity markets and the U.S. financial markets are mutually less influential, when the U.S. sentiment is measured by the BW index. In addition, the markets that bear the relationship have changed.

2. Data and Methodology

This paper employs data from two categories: the market sentiments time series data and global equity market prices and returns. The Baker and Wurgler (2006, 2007) index (BW) and the VIX indices serve as market sentiments in the United States financial market. The BW index is based on first principal component of six (standardized) sentiment proxies: value-weighted dividend premium, IPO volume, first day returns on IPO, closed-end fund discount, equity share in new issues, and NYSE turnover. Baker and Wurgler first use each of the six proxies as the explained variable and use a set of macroeconomic conditions as the explanatory variables to perform a linear regression. The residuals of the six regressions are orthogonal with respect to a set of macroeconomic conditions. These linear independent regression errors are linearly combined to be the BW index. The specific relationship for the orthogonalized variables is:

$$SENTIMENT_t = -0.198CEFD_t + 0.225TURN_t + 0.234NIPO_t + 0.263RIPO_{t-1} + 0.211S_t - 0.243P_{t-1}^{D-ND} \quad (1)$$

where SENTIMENT is the BW market sentiment index, CEFD is the closed-end fund discount; TURN is the natural log of the raw turnover ratio, detrended by the 5-year moving average; NIPO is number of IPOs; RIPO is the average first-day returns; S is the share of equity issues in total equity and debt issues; $P^{D\text{-}ND}$ is the dividend premium by calculating the log difference of the average market-to-book ratios of payers and nonpayers.

The VIX indices are another measure of market sentiment from the investor side. The Chicago Board Options Exchange (CBOE) publishes the CBOE Volatility Index (VIX) as the scale of stock market volatility. CBOE first creates the weighted average value of options with a constant maturity of 30 days to expiration. The options are based on market portfolio index option prices and incorporate information from the volatility skewness by setting a wide range of exercise prices. Four market portfolio indices are included: the Standard and Poor's 100 and 500 index, the Dow Jones Industrial Index, and the NASDAQ returns. VIX is often cited as an indicator of investor panic, as volatility signifies financial turbulence. During financial stress and periods of significant security price drops, VIX increases, and vice versa. We adopt the S&P 500-based VIX index in this paper.

We convert the daily VIX indices into monthly variables. The daily index is the average of daily high and low. For each of the daily index based on different market portfolios, we calculate its monthly maximum, minimum, and median levels. Monthly VIX maximum is the highest point of market panic; in contrast, the monthly VIX minimum is the extreme market optimism. The monthly median VIX, as the market consensus, is the general investor attitude without extreme gauges.

The series of major equity market indices are organized by the Yahoo! Finance database. We categorize the indices, with some repeating ones, into four categories: the G20 group, markets, the European markets, the Asia-Pacific markets, and the Americas markets. The G20 group includes 23 indices; the European markets include 28 indices; the Asia-Pacific markets include 25 indices, and the Americas markets include 10 indices. Table 1 provides a detailed list of index names and codes. All the series involved includes monthly data from June 1965 to December 2010, with some missing data. The series use the close level of the index and are not adjusted by split and dividend payout. The reason that we do not employed the adjusted close level is the nature of sentiment contagion is not directly related to the fundamentals of the firm in the short term.

Table 1. The equity markets, stock indices and codes in groups

G20 Markets								
Market	Indices	Code	Market	Indices	Code	Market	Indices	Code
Argentina	MERVAL	ARG	India	BSE Sensex	IND1	Spain	IBEX 35	ESP
Australia	All Ordinaries	AUS	India	S&P Nifty	IND2	UK	FTSE 100	GBR
Brazil	Bovespa	BRA	Indonesia	Jakarta Composite	IDN	USA	S&P 500	USA1
Canada	S&P TSX Composite	CAN	Italy	FTSE MIB	ITA	USA	NASDAQ Composite	USA2
China	Shanghai Composite	CHN	Japan	Nikkei 225	JPN	USA	Dow Jones Industrial	USA3
China	Hang Seng (Hong Kong)	HGK	Mexico	Mexbol IPC	MEX	USA	Russell 1000	USA4
France	CAC-40	FRA	Russia	RTSI	RUS	USA	Wilshire 5000	USA5
Germany	DAX	DEU	South Korea	KOSPI Composite	KOR			
European Markets								
Market	Indices	Code	Market	Indices	Code	Market	Indices	Code
Austria	ATX	AUT	Hungary	BUX Blue Chip	HUN	Russia	RTSI	RUS
Belgium	Euronext BEL-20	BEL	Iceland	OMX Iceland All-Share	ISL	Serbia	BELEX 15	SRB
Croatia	CROBEX	HRV	Ireland	ISEQ 20 Price	IRL	Slovenia	SBITOP	SVN
Czech	PS	CZE	Italy	FTSE MIB	ITA	Spain	IBEX 35	ESP
Denmark	OMX Copenhagen 20	DNK	Latvia	OMX Riga	LVA	Sweden	OMX Stockholm 30	SWE
Estonia	OMX Tallinn	EST	Lithuania	OMX Vilnius	LTU	Switzerland	Swiss Market	CHE
Finland	OMX Helsinki 25	FIN	Luxembourg	Lux General	LUX	UK	FTSE 100	GBR
France	CAC-40	FRA	Netherlands	AEX Amsterdam	NLD	Ukraine	UX	UKR
Germany	DAX	DEU	Norway	OMX Oslo 20	NOR			
Greece	Athens Composite	GRC	Romania	BET	ROM			
Asia-Pacific Markets								
Market	Indices	Code	Market	Indices	Code	Market	Indices	Code
Australia	All Ordinaries	AUS	India	S&P Nifty	IND2	Malaysia	Kuala Lumpur Composite	MYS
New Zealand	NZSE 50	NZL	Indonesia	Jakarta Composite	IDN	Singapore	Straits Times	SGP
China	Shanghai Composite	CHN	Israel	Tel Aviv 100	ISR	Korea	KOSPI Composite	KOR
China	Hang Seng (Hong Kong)	HGK	Japan	Nikkei 225	JPN	Sri Lanka	Colombo All Shares	LKA
India	BSE Sensex	IND1	Jordan	Amman General	JOR	Taiwan	Taiwan Weighted	TWN
Americas Markets								
Market	Indices	Code	Market	Indices	Code	Market	Indices	Code
Argentina	MERVAL	ARG	Mexico	Mexbol IPC	MEX	USA	Russell 1000	USA4
Brazil	Bovespa	BRA	USA	S&P 500	USA1	USA	Wilshire 5000	USA5
Canada	S&P TSX Composite	CAN	USA	NASDAQ Composite	USA2			
Ecuador	Bolsa de Quito General	ECU	USA	Dow Jones Industrial Average	USA3			

Note. This table presents the four groups of equity markets in this paper: the G20 group markets, the European markets, The Asia-Pacific markets, and the Americas markets. The codes of the indices involved in the regressions are established by the International Organization for Standardization (ISO) in 2000.

Before we proceed to the Granger causality tests, we first run the standard ADF unit root tests on all the time series variables. The variables that do not reject the hull hypothesis of non-stationary variable cannot be included in the Granger causality regressions because of the autocorrelation violation. These variables are then converted into the first order difference form, which are tested to be covariance stationary. We involve two series for each equity market index: the plain price levels, and the return levels. The results are reported in Table 2.

Table 2. Unit root tests of the prices and returns of global equity series

G20										
Series	t-test	P value	Series	t-test	P value	Series	t-test	P value	Series	t-test	P value
ARG	-0.545	0.878	ESP	-1.773	0.393	IND2	-0.312	0.92	USA1	1.081	0.997
RETARG	-12.59	0	RETESP	-15.18	0	RETIND2	-14.88	0	RETUSA1	-26.37	0
AUS	-1.043	0.739	FRA	-1.52	0.522	ITA	-1.535	0.513	USA2	-0.34	0.916
RETAUS	-18.01	0	RETFRA	-15.19	0	RETITA	-6.016	0	RETUSA2	-19.84	0
BRA	-1.25	0.653	GBR	-1.255	0.651	JPN	-1.395	0.586	USA3	0.999	0.997
RETBRA	-13.53	0	RETGBR	-18.38	0	RETJPN	-26.38	0	RETUSA3	-23.35	0
CAN	-0.996	0.756	HGK	-1.417	0.574	KOR	-0.856	0.8	USA4	-1.073	0.727
RETCAN	-16.23	0	RETHGK	-17.45	0	RETKOR	-12.09	0	RETUSA4	-14.08	0
CHN	-2.605	0.094	IDN	1.144	0.998	MEX	0.725	0.993	USA5	-0.253	0.924
RETCHN	-12.7	0	RETIDN	-12.1	0	RETMEX	-15.7	0	RETUSA5	-6.896	0
DEU	-1.069	0.728	IND1	-0.378	0.909	RUS	-1.55	0.507			
RETDEU	-15.73	0	RETIND1	-13.14	0	RETRUS	-11.97	0			
European										
Series	t-test	P value	Series	t-test	P value	Series	t-test	P value	Series	t-test	P value
AUT	-1.565	0.499	EST	-1.771	0.39	ISL	-0.001	0.956	ROM	-1.48	0.541
RETAUT	-12.95	0	RETEST	-7.796	0	RETISL	-7.793	0	RETROM	-10.86	0
BEL	-2.22	0.2	FIN	-1.693	0.433	ITA	-1.535	0.513	RUS	-1.55	0.507
RETBEL	-13.34	0	RETFIN	-9.867	0	RETITA	-6.016	0	RETRUS	-11.97	0
CHE	-1.751	0.405	FRA	-1.52	0.522	LTU	-2.444	0.135	SRB	-1.397	0.58
RETCHE	-13.91	0	RETFRA	-15.19	0	RETLTU	-5.944	0	RETSRB	-5.868	0
CZE	-1.593	0.485	GBR	-1.255	0.651	LUX	-1.762	0.397	SVN	-2.116	0.24
RETCZE	-11.96	0	RETGBR	-18.38	0	RETLUX	-7.139	0	RETSVN	-6.578	0
DEU	-1.069	0.728	GRC	-1.621	0.471	LVA	-2.563	0.109	SWE	-2.566	0.102
RETDEU	-15.73	0	RETGRC	-15.29	0	RETLVA	-6.798	0	RETSWE	-11.97	0
DNK	-0.762	0.826	HRV	-1.614	0.473	NLD	-2.153	0.225	UKR	-2.148	0.227
RETDNK	-11.1	0	RETHRV	-12.47	0	RETNLD	-15.32	0	RETUKR	-5.983	0
ESP	-1.773	0.393	HUN	-1.321	0.619	NOR	-1.442	0.558			
RETESP	-15.18	0	RETHUN	-11	0	RETNOR	-7.42	0			
Asia-Pacific										
Series	t-test	P value	Series	t-test	P value	Series	t-test	P value	Series	t-test	P value
AUS	-1.043	0.739	IND1	-0.378	0.909	JPN	-1.395	0.586	NZL	-0.824	0.808
RETAUS	-18.01	0	RETIND1	-13.14	0	RETJPN	-26.38	0	RETNZL	-8.945	0
CHN	-2.605	0.094	IND2	-0.312	0.92	KOR	-0.856	0.8	SGP	-1.718	0.421
RETCHN	-12.7	0	RETIND2	-14.88	0	RETKOR	-12.09	0	RETSGP	-15.79	0
HGK	-1.417	0.574	ISR	-1.007	0.751	LKA	0.202	0.972	TWN	-2.85	0.053
RETHGK	-17.45	0	RETISR	-11.61	0	RETLKA	-12.35	0	RETTWN	-8.055	0
IDN	1.144	0.998	JOR	-1.584	0.486	MYS	-0.496	0.888			
RETIDN	-12.1	0	RETJOR	-6.399	0	RETMYS	-13.46	0			
Americas										
Series	t-test	P value	Series	t-test	P value	Series	t-test	P value	Series	t-test	P value
ARG	-0.545	0.878	ECU	-2.816	0.06	USA2	-0.34	0.916	USA5	-0.253	0.924
RETARG	-12.59	0	RETECU	-11.51	0	RETUSA2	-19.84	0	RETUSA5	-6.896	0
BRA	-1.25	0.653	MEX	0.725	0.993	USA3	0.999	0.997			
RETBRA	-13.53	0	RETMEX	-15.7	0	RETUSA3	-23.35	0			
CAN	-0.996	0.756	USA1	1.081	0.997	USA4	-1.073	0.727			
RETCAN	-16.23	0	RETUSA1	-26.37	0	RETUSA4	-14.08	0			

Note. The null hypothesis is unit root does not exist. Significant p values therefore imply the series is non-stationary. The variables with only codes presented in Table 1 are the price levels of the series, and the variables with RET added as the prefix are the return levels of the series.

Table 2 suggests the existence of unit root in all the price level series of the equity market indices. Hence we proceed to replace the original variables with first order difference series and use the stationary variables in the following Granger causality tests. For a bivariate linear autoregressive model with pairwise variables X_1 and X_2, the test regression is:

$$X_1(t) = \sum_{j=1}^{P} A_{11,j} X_1(t-j) + \sum_{j=1}^{P} A_{12,j} X_2(t-j) + E_1(t)$$

$$X_2(t) = \sum_{j=1}^{P} A_{21,j} X_1(t-j) + \sum_{j=1}^{P} A_{22,j} X_2(t-j) + E_2(t)$$

P in the regression equations is the maximum number of lags included, and the matrix A is the plain vanilla VAR coefficients. $E.(t)$ is the regression residual. If the variance of $E.(t)$ is improved by adding X_1 or X_2, it implies that X_1 or X_2 Granger causes X_2 or X_1. The way to detect such improvement is by testing whether, for example, the coefficients carried by A_{12} are jointly different from zero. If the null hypothesis of $A_{12} = 0$ is rejected significantly by the F test, X_2 Granger causes X_1. We use the Bayesian Information Criterion (BIC) to determine the number of lags.

3. Results and Discussion

We present the Granger causality results in this section. Table 3 and Table 4 employ the VIX index as the indicator of market sentiments, whereas Table 5 and 3.4 replace the VIX index with the BW index. All the tests are performed in four groups of markets: the Americas, the Asia-Pacific area, Europe, and G20. The prefixes RET of the equity indices refer to the return level of these indices, and the prefixes DIF of the indices denote the first order difference of the price levels of these indices. For the VIX index, we calculate the monthly maximum (MAX), minimum (MIN), and median (MEDIAN) levels to represent the market panic, optimism, and consensus sentiments, respectively. For both the tables 3 to 4, statistically significant results imply that the variable in the left column can Granger cause the variable in the right column.

Table 3 describes the causality from the market sentiment in the United States financial market to the global equity market. The results reveal three major facts: firstly, international equity markets are not greatly affected by the U.S. financial market sentiment. Equity indices in different countries and regions are more independent from the impact of the U.S., and are determined by their own fundamental factors of the firms publicly listed.

Secondly, the significant impacts of sentiment do not show any unanimous pattern in term of the sentiment type. The ratio of significant maximum, minimum, and median VIX, which stand for the market panic, optimism, and consensus, are close to even. We thus draw the conclusion that the directions of market atmosphere are irrelevant to whether it can be contagious among the markets. Global investors do not weigh extreme or modest emotions more than one the other.

Thirdly, the equity markets that are affected by the volatility sentiment index do not fall into any category in terms of region or scale. Markets that can be infected by the U.S. VIX sentiment are from the following countries: Brazil, Canada, Mexico, the United States, Indonesia, Jordan, South Korea, and Austria. These countries vary from small developing economies like Indonesia to large developed economies, such as Canada. On the other hand, countries of which the equity markets are not affected also have various types. For instance, Ecuador, Sri Lanka, Japan, and the U.K., are independent from such sentiment.

Table 3. Significant granger causalities from the VIX-based sentiment to the global equity markets

Americas Markets											
MAX	RETARG	MEDIAN	RETBRA	MIN	RETECU	MAX	RETUSA1	MEDIAN	RETUSA2	MIN	RETUSA4
MAX	DIFARG	MEDIAN	DIFBRA †	MIN	DIFECU	MAX	DIFUSA1	MEDIAN	DIFUSA2	MIN	DIFUSA4
MIN	RETARG	MAX	RETCAN	MEDIAN	RETECU	MIN	RETUSA1	MAX	RETUSA3	MEDIAN	RETUSA4
MIN	DIFARG	MAX	DIFCAN	MEDIAN	DIFECU	MIN	DIFUSA1	MAX	DIFUSA3	MEDIAN	DIFUSA4
MEDIAN	RETARG	MIN	RETCAN	MAX	RETMEX	MEDIAN	RETUSA1	MIN	RETUSA3	MAX	RETUSA5 †
MEDIAN	DIFARG	MIN	DIFCAN †	MAX	DIFMEX †	MEDIAN	DIFUSA1	MIN	DIFUSA3	MAX	DIFUSA5
MAX	RETBRA	MEDIAN	RETCAN	MIN	RETMEX	MAX	RETUSA2	MEDIAN	RETUSA3	MIN	RETUSA5
MAX	DIFBRA †	MEDIAN	DIFCAN	MIN	DIFMEX †	MAX	DIFUSA2	MEDIAN	DIFUSA3	MIN	DIFUSA5
MIN	RETBRA †	MAX	RETECU	MEDIAN	RETMEX	MIN	RETUSA2	MAX	RETUSA4	MEDIAN	RETUSA5 †
MIN	DIFBRA †	MAX	DIFECU	MEDIAN	DIFMEX †	MIN	DIFUSA2	MAX	DIFUSA4	MEDIAN	DIFUSA5 †

Asia Pacific Markets											
MAX	RETAUS	MIN	DIFHGK	MAX	RETIND2	MIN	DIFJOR	MAX	RETLKA	MIN	DIFNZL
MAX	DIFAUS	MEDIAN	RETHGK	MAX	DIFIND2	MEDIAN	RETJOR	MAX	DIFLKA	MEDIAN	RETNZL
MIN	RETAUS	MEDIAN	DIFHGK	MIN	RETIND2	MEDIAN	DIFJOR	MIN	RETLKA †	MEDIAN	DIFNZL
MIN	DIFAUS	MAX	RETIDN	MIN	DIFIND2	MAX	RETJPN	MIN	DIFLKA	MAX	RETSGP
MEDIAN	RETAUS	MAX	DIFIDN	MEDIAN	RETIND2	MAX	DIFJPN	MEDIAN	RETLKA	MAX	DIFSGP
MEDIAN	DIFAUS	MIN	RETIDN †	MEDIAN	DIFIND2	MIN	RETJPN	MEDIAN	DIFLKA	MIN	RETSGP
MAX	RETCHN	MIN	DIFIDN	MAX	RETISR	MIN	DIFJPN	MAX	RETMYS	MIN	DIFSGP
MAX	DIFCHN	MEDIAN	RETIDN †	MAX	DIFISR	MEDIAN	RETJPN	MAX	DIFMYS	MEDIAN	RETSGP
MIN	RETCHN	MEDIAN	DIFIDN	MIN	RETISR	MEDIAN	DIFJPN	MIN	RETMYS	MEDIAN	DIFSGP
MIN	DIFCHN	MAX	RETIND1	MIN	DIFISR	MAX	RETKOR	MIN	DIFMYS	MAX	RETTWN
MEDIAN	RETCHN	MAX	DIFIND1	MEDIAN	RETISR	MAX	DIFKOR	MEDIAN	RETMYS	MAX	DIFTWN
MEDIAN	DIFCHN	MIN	RETIND1	MEDIAN	DIFISR	MIN	RETKOR †	MEDIAN	DIFMYS	MIN	RETTWN
MAX	RETHGK	MIN	DIFIND1	MAX	RETJOR †	MIN	DIFKOR †	MAX	RETNZL	MIN	DIFTWN
MAX	DIFHGK	MEDIAN	RETIND1	MAX	DIFJOR	MEDIAN	RETKOR †	MAX	DIFNZL	MEDIAN	RETTWN
MIN	RETHGK	MEDIAN	DIFIND1	MIN	RETJOR	MEDIAN	DIFKOR	MIN	RETNZL	MEDIAN	DIFTWN
European Markets											
MAX	RETAUT †	MIN	DIFCHE	MAX	RETDNK	MIN	DIFEST	MAX	RETGBR	MIN	DIFHRV
MAX	DIFAUT	MEDIAN	RETCHE	MAX	DIFDNK	MEDIAN	RETEST	MAX	DIFGBR	MEDIAN	RETHRV
MIN	RETAUT †	MEDIAN	DIFCHE	MIN	RETDNK	MEDIAN	DIFEST	MIN	RETGBR	MEDIAN	DIFHRV
MIN	DIFAUT	MAX	RETCZE	MIN	DIFDNK	MAX	RETFIN	MIN	DIFGBR	MAX	RETHUN
MEDIAN	RETAUT †	MAX	DIFCZE	MEDIAN	RETDNK	MAX	DIFFIN	MEDIAN	RETGBR	MAX	DIFHUN
MEDIAN	DIFAUT	MIN	RETCZE	MEDIAN	DIFDNK	MIN	RETFIN	MEDIAN	DIFGBR	MIN	RETHUN
MAX	RETBEL	MIN	DIFCZE	MAX	RETESP	MIN	DIFFIN	MAX	RETGRC	MIN	DIFHUN
MAX	DIFBEL	MEDIAN	RETCZE	MAX	DIFESP	MEDIAN	RETFIN	MAX	DIFGRC	MEDIAN	RETHUN
MIN	RETBEL	MEDIAN	DIFCZE	MIN	RETESP	MEDIAN	DIFFIN	MIN	RETGRC	MEDIAN	DIFHUN
MIN	DIFBEL	MAX	RETDEU	MIN	DIFESP	MAX	RETFRA	MIN	DIFGRC	MAX	RETISL
MEDIAN	RETBEL	MAX	DIFDEU	MEDIAN	RETESP	MAX	DIFFRA	MEDIAN	RETGRC	MAX	DIFISL
MEDIAN	DIFBEL	MIN	RETDEU	MEDIAN	DIFESP	MIN	RETFRA	MEDIAN	DIFGRC	MIN	RETISL
MAX	RETCHE	MIN	DIFDEU	MAX	RETEST	MIN	DIFFRA	MAX	RETHRV	MIN	DIFISL
MAX	DIFCHE	MEDIAN	RETDEU	MAX	DIFEST	MEDIAN	RETFRA	MAX	DIFHRV	MEDIAN	RETISL
MIN	RETCHE	MEDIAN	DIFDEU	MIN	RETEST	MEDIAN	DIFFRA	MIN	RETHRV	MEDIAN	DIFISL
G20 Markets											
MAX	RETARG	MEDIAN	DIFCAN	MEDIAN	RETFRA	MIN	DIFIND1	MIN	RETKOR †	MAX	DIFUSA2
MAX	DIFARG	MAX	RETCHN	MEDIAN	DIFFRA	MEDIAN	RETIND1	MIN	DIFKOR †	MIN	RETUSA2
MIN	RETARG	MAX	DIFCHN	MAX	RETGBR	MEDIAN	DIFIND1	MEDIAN	RETKOR †	MIN	DIFUSA2
MIN	DIFARG	MIN	RETCHN	MAX	DIFGBR	MAX	RETIND2	MEDIAN	DIFKOR	MEDIAN	RETUSA2
MEDIAN	RETARG	MIN	DIFCHN	MIN	RETGBR	MAX	DIFIND2	MAX	RETMEX	MEDIAN	DIFUSA2
MEDIAN	DIFARG	MEDIAN	RETCHN	MIN	DIFGBR	MIN	RETIND2	MAX	DIFMEX †	MAX	RETUSA3
MAX	RETAUS	MEDIAN	DIFCHN	MEDIAN	RETGBR	MIN	DIFIND2	MIN	RETMEX	MAX	DIFUSA3
MAX	DIFAUS	MAX	RETDEU	MEDIAN	DIFGBR	MEDIAN	RETIND2	MIN	DIFMEX †	MIN	RETUSA3
MIN	RETAUS	MAX	DIFDEU	MAX	RETHGK	MEDIAN	DIFIND2	MEDIAN	RETMEX	MIN	DIFUSA3
MIN	DIFAUS	MIN	RETDEU	MAX	DIFHGK	MAX	RETITA	MEDIAN	DIFMEX †	MEDIAN	RETUSA3
MEDIAN	RETAUS	MIN	DIFDEU	MIN	RETHGK	MAX	DIFITA	MAX	RETRUS	MEDIAN	DIFUSA3
MEDIAN	DIFAUS	MEDIAN	RETDEU	MIN	DIFHGK	MIN	RETITA	MAX	DIFRUS	MAX	RETUSA4
MAX	RETBRA	MEDIAN	DIFDEU	MEDIAN	RETHGK	MIN	DIFITA	MIN	RETRUS	MAX	DIFUSA4
MAX	DIFBRA †	MAX	RETESP	MEDIAN	DIFHGK	MEDIAN	RETITA	MIN	DIFRUS	MIN	RETUSA4
MIN	RETBRA †	MAX	DIFESP	MAX	RETIDN	MEDIAN	DIFITA	MEDIAN	RETRUS	MIN	DIFUSA4

MIN	DIFBRA †	MIN	RETESP	MAX	DIFIDN	MAX	RETJPN	MEDIAN	DIFRUS	MEDIAN	RETUSA4
MEDIAN	RETBRA	MIN	DIFESP	MIN	RETIDN †	MAX	DIFJPN	MAX	RETUSA1	MEDIAN	DIFUSA4
MEDIAN	DIFBRA †	MEDIAN	RETESP	MIN	DIFIDN	MIN	RETJPN	MAX	DIFUSA1	MAX	RETUSA5 †
MAX	RETCAN	MEDIAN	DIFESP	MEDIAN	RETIDN †	MIN	DIFJPN	MIN	RETUSA1	MAX	DIFUSA5
MAX	DIFCAN	MAX	RETFRA	MEDIAN	DIFIDN	MEDIAN	RETJPN	MIN	DIFUSA1	MIN	RETUSA5
MIN	RETCAN	MAX	DIFFRA	MAX	RETIND1	MEDIAN	DIFJPN	MEDIAN	RETUSA1	MIN	DIFUSA5
MIN	DIFCAN †	MIN	RETFRA	MAX	DIFIND1	MAX	RETKOR	MEDIAN	DIFUSA1	MEDIAN	RETUSA5 †
MEDIAN	RETCAN	MIN	DIFFRA	MIN	RETIND1	MAX	DIFKOR	MAX	RETUSA2	MEDIAN	DIFUSA5 †

Note. Series with † rejects the null hypothesis that the series on the left fails to Granger cause the series on the right at 5% level of significance.

In the next step, we reverse the causality direction and examine the impacts of the global equity market to the volatility sentiment. Such tests are intuitively correct, because investors do not generate their judgments and attitudes based on pure emotion. The VIX index is an indicator of investors' belief based on their observations in the international markets. Table 4 reports the regression results. The causal relationships from the equity markets to the VIX sentiment index are much more significant, compared to Table 3. We summarize the conclusions below:

Firstly, the majority of global equity markets can Granger cause the U.S. investor sentiments. Only a few countries cannot lead to market atmosphere turbulence, which are: Ecuador, Indonesia, Jordan, South Korea, Sri Lanka, Malaysia, Estonia, Italy, and Iceland. Most of these economies are small and have limited influence in the regional or global economy, other than South Korea and Italy. Somewhat surprising is the fact that South Korea, Italy, and Indonesia are the G20 countries. Therefore it seems that the U.S. investors form their sentiments not from a fully reasonable source, but are slightly biased. Such biasness is not significant to affect their rationality, especially given the fact that the entire G8 group is considering expel Italy.

Secondly, the type of sentiment being affected is not even. We detect 76 existing significant causal relationships in the non-overlapping markets from the following four groups. We identify an existing causal relationship as long as either of the price level or the return level of the index can Granger cause the investor attitude. In the 76 significant causalities, 22 or 29% of them lead to influence of market panic, 32 or 42% of them lead to influence of market optimism, and the rest 22 or 29% result in the change of consensus market sentiment. Optimistic market atmosphere is more affected by the global equity market, rather than the pessimistic or modest ones.

Thirdly, the driving forces of U.S. financial market sentiment are not evenly located in the world. The equity markets in the Americas are highly influential to the U.S. investors, with Ecuador being the only exception. In addition, the American financial market also observes the performances of European markets closely, except Estonia and Iceland. However, the Asian markets are much less influential. The number of causality and the robustness of such relationship are lower. Some countries merely present weak impact on the U.S. market attitude by exhibiting only one causal link. For example, only the price level of the Shanghai Composite Index in China affects the optimistic end of the U.S. sentiment, while its return level has no role in the U.S. market in terms of all types of sentiment.

In order to compare the effectiveness of the sentiment measures, we proceed to perform the pairwise Granger causality tests between the BW sentiment index and the international equity market. Table 5 reports the causality from the BW sentiment index to the global equity market, whereas Table 6 reports the causality in the opposite direction. This further step generates non-collinear conclusions, because of the fundamentally different natures of the VIX index and the BW index. The former is based on the volatility of option prices of the S&P 500 index, yet the latter is a linear combination of fundamental market variables.

The global equity markets and the U.S. financial markets are mutually less influential, when the U.S. sentiment is measured by the BW index. In addition, the markets that bear the relationship have changed. The previously closely-linked Americas markets show independence. A plausible explanation is that the components of the BW index focus on the U.S. firms. As part of the BW index, the number of IPOs, the average IPO first-day returns, the share of equity issues in total equity and debt issues, and the dividend premium are strongly affected by the profitability of the individual firms publicly listed in the U.S. These factors, however, do not respond to the global equity market turbulences in the short run. We also conclude that the VIX index is a better measure of sentiment contagion in the global context.

Table 4. Granger causality from the global equity markets to the VIX-based sentiment

Americas Markets																							
RETARG	MAX		RETBRA	MEDIAN	†	RETECU	MIN		RETUSA1	MAX		†	RETUSA2	MEDIAN	†	RETUSA4	MIN	†					
DIFARG	MAX		DIFBRA	MEDIAN	†	DIFECU	MIN		DIFUSA1	MAX		†	DIFUSA2	MEDIAN	†	DIFUSA4	MIN	†					
RETARG	MIN	†	RETCAN	MAX		†	RETECU	MEDIAN		RETUSA1	MIN		†	RETUSA3	MAX		†	RETUSA4	MEDIAN	†			
DIFARG	MIN	†	DIFCAN	MAX		†	DIFECU	MEDIAN		DIFUSA1	MIN		†	DIFUSA3	MAX		†	DIFUSA4	MEDIAN	†			
RETARG	MEDIAN		RETCAN	MIN		†	RETMEX	MAX		RETUSA1	MEDIAN		†	RETUSA3	MIN		†	RETUSA5	MAX				
DIFARG	MEDIAN		DIFCAN	MIN		†	DIFMEX	MAX		†	DIFUSA1	MEDIAN		†	DIFUSA3	MIN		†	DIFUSA5	MAX			
RETBRA	MAX	†	RETCAN	MEDIAN	†	RETMEX	MIN		†	RETUSA2	MAX		†	RETUSA3	MEDIAN	†	RETUSA5	MIN					
DIFBRA	MAX	†	DIFCAN	MEDIAN	†	DIFMEX	MIN		†	DIFUSA2	MAX		†	DIFUSA3	MEDIAN	†	DIFUSA5	MIN					
RETBRA	MIN	†	RETECU	MAX			RETMEX	MEDIAN	†	RETUSA2	MIN		†	RETUSA4	MAX		†	RETUSA5	MEDIAN				
DIFBRA	MIN	†	DIFECU	MAX			DIFMEX	MEDIAN	†	DIFUSA2	MIN		†	DIFUSA4	MAX		†	DIFUSA5	MEDIAN				
Asia Pacific Markets																							
RETAUS	MAX	†	DIFHGK	MIN		†	RETIND2	MAX		DIFJOR	MIN		RETLKA	MAX		DIFNZL	MIN	†					
DIFAUS	MAX	†	RETHGK	MEDIAN	†	DIFIND2	MAX		†	RETJOR	MEDIAN		DIFLKA	MAX		RETNZL	MEDIAN						
RETAUS	MIN	†	DIFHGK	MEDIAN	†	RETIND2	MIN			DIFJOR	MEDIAN		RETLKA	MIN		DIFNZL	MEDIAN						
DIFAUS	MIN	†	RETIDN	MAX			DIFIND2	MIN		†	RETJPN	MAX		DIFLKA	MIN		RETSGP	MAX					
RETAUS	MEDIAN	†	DIFIDN	MAX			RETIND2	MEDIAN		DIFJPN	MAX		RETLKA	MEDIAN		DIFSGP	MAX						
DIFAUS	MEDIAN	†	RETIDN	MIN			DIFIND2	MEDIAN		†	RETJPN	MIN		†	DIFLKA	MEDIAN		RETSGP	MIN	†			
RETCHN	MAX		DIFIDN	MIN			RETISR	MAX		DIFJPN	MIN		†	RETMYS	MAX		DIFSGP	MIN	†				
DIFCHN	MAX		RETIDN	MEDIAN			DIFISR	MAX		RETJPN	MEDIAN		DIFMYS	MAX		RETSGP	MEDIAN	†					
RETCHN	MIN		DIFIDN	MEDIAN			RETISR	MIN		†	DIFJPN	MEDIAN		RETMYS	MIN		DIFSGP	MEDIAN	†				
DIFCHN	MIN	†	RETIND1	MAX			DIFISR	MIN		†	RETKOR	MAX		DIFMYS	MIN		RETTWN	MAX					
RETCHN	MEDIAN		DIFIND1	MAX		†	RETISR	MEDIAN		DIFKOR	MAX		RETMYS	MEDIAN		DIFTWN	MAX						
DIFCHN	MEDIAN		RETIND1	MIN			DIFISR	MEDIAN		RETKOR	MIN		DIFMYS	MEDIAN		RETTWN	MIN	†					
RETHGK	MAX	†	DIFIND1	MIN		†	RETJOR	MAX		DIFKOR	MIN		RETNZL	MAX		DIFTWN	MIN	†					
DIFHGK	MAX	†	RETIND1	MEDIAN			DIFJOR	MAX		RETKOR	MEDIAN		DIFNZL	MAX		RETTWN	MEDIAN						
RETHGK	MIN	†	DIFIND1	MEDIAN	†	RETJOR	MIN			DIFKOR	MEDIAN		RETNZL	MIN		†	DIFTWN	MEDIAN					
European Markets																							
RETAUT	MAX	†	DIFCHE	MIN		†	RETDNK	MAX		†	DIFEST	MIN		RETGBR	MAX		†	DIFHRV	MIN	†			
DIFAUT	MAX	†	RETCHE	MEDIAN	†	DIFDNK	MAX		†	RETEST	MEDIAN		DIFGBR	MAX		†	RETHRV	MEDIAN					
RETAUT	MIN	†	DIFCHE	MEDIAN	†	RETDNK	MIN		†	DIFEST	MEDIAN		RETGBR	MIN		†	DIFHRV	MEDIAN					
DIFAUT	MIN	†	RETCZE	MAX		†	DIFDNK	MIN		†	RETFIN	MAX		†	DIFGBR	MIN		†	RETHUN	MAX	†		
RETAUT	MEDIAN	†	DIFCZE	MAX		†	RETDNK	MEDIAN		†	DIFFIN	MAX		†	RETGBR	MEDIAN	†	DIFHUN	MAX				
DIFAUT	MEDIAN	†	RETCZE	MIN		†	DIFDNK	MEDIAN		†	RETFIN	MIN		†	DIFGBR	MEDIAN	†	RETHUN	MIN	†			
RETBEL	MAX	†	DIFCZE	MIN		†	RETESP	MAX		DIFFIN	MIN		†	RETGRC	MAX		DIFHUN	MIN					
DIFBEL	MAX	†	RETCZE	MEDIAN		DIFESP	MAX			RETFIN	MEDIAN		†	DIFGRC	MAX		RETHUN	MEDIAN					
RETBEL	MIN	†	DIFCZE	MEDIAN	†	RETESP	MIN		†	DIFFIN	MEDIAN		†	RETGRC	MIN		DIFHUN	MEDIAN					
DIFBEL	MIN	†	RETDEU	MAX		†	DIFESP	MIN		†	RETFRA	MAX		†	DIFGRC	MIN		†	RETISL	MAX			
RETBEL	MEDIAN	†	DIFDEU	MAX		†	RETESP	MEDIAN		DIFFRA	MAX		†	RETGRC	MEDIAN		DIFISL	MAX					
DIFBEL	MEDIAN	†	RETDEU	MIN		†	DIFESP	MEDIAN		RETFRA	MIN		†	DIFGRC	MEDIAN		RETISL	MIN					
RETCHE	MAX	†	DIFDEU	MIN		†	RETEST	MAX		DIFFRA	MIN		†	RETHRV	MAX		DIFISL	MIN					
DIFCHE	MAX	†	RETDEU	MEDIAN	†	DIFEST	MAX			RETFRA	MEDIAN		†	DIFHRV	MAX		RETISL	MEDIAN					
RETCHE	MIN	†	DIFDEU	MEDIAN	†	RETEST	MIN			DIFFRA	MEDIAN		†	RETHRV	MIN		DIFISL	MEDIAN					

G20 Markets																				
RETARG	MAX		DIFCAN	MEDIAN	†	RETFRA	MEDIAN	†	DIFIND1	MIN	†	RETKOR	MIN		DIFUSA2	MAX	†			
DIFARG	MAX		RETCHN	MAX		DIFFRA	MEDIAN	†	RETIND1	MEDIAN		DIFKOR	MIN		RETUSA2	MIN	†			
RETARG	MIN	†	DIFCHN	MAX		RETGBR	MAX	†	DIFIND1	MEDIAN	†	RETKOR	MEDIAN		DIFUSA2	MIN	†			
DIFARG	MIN	†	RETCHN	MIN		DIFGBR	MAX	†	RETIND2	MAX		DIFKOR	MEDIAN		RETUSA2	MEDIAN	†			
RETARG	MEDIAN		DIFCHN	MIN	†	RETGBR	MIN	†	DIFIND2	MAX	†	RETMEX	MAX		DIFUSA2	MEDIAN	†			
DIFARG	MEDIAN		RETCHN	MEDIAN		DIFGBR	MIN	†	RETIND2	MIN		DIFMEX	MAX	†	RETUSA3	MAX	†			
RETAUS	MAX	†	DIFCHN	MEDIAN		RETGBR	MEDIAN	†	DIFIND2	MIN	†	RETMEX	MIN	†	DIFUSA3	MAX	†			
DIFAUS	MAX	†	RETDEU	MAX	†	DIFGBR	MEDIAN	†	RETIND2	MEDIAN		DIFMEX	MIN	†	RETUSA3	MIN	†			
RETAUS	MIN	†	DIFDEU	MAX	†	RETHGK	MAX	†	DIFIND2	MEDIAN	†	RETMEX	MEDIAN	†	DIFUSA3	MIN	†			
DIFAUS	MIN	†	RETDEU	MIN	†	DIFHGK	MAX	†	RETITA	MAX		DIFMEX	MEDIAN	†	RETUSA3	MEDIAN	†			
RETAUS	MEDIAN	†	DIFDEU	MIN	†	RETHGK	MIN	†	DIFITA	MAX		RETRUS	MAX		DIFUSA3	MEDIAN	†			
DIFAUS	MEDIAN	†	RETDEU	MEDIAN	†	DIFHGK	MIN	†	RETITA	MIN		DIFRUS	MAX	†	RETUSA4	MAX	†			
RETBRA	MAX	†	DIFDEU	MEDIAN	†	RETHGK	MEDIAN	†	DIFITA	MIN		RETRUS	MIN	†	DIFUSA4	MAX	†			
DIFBRA	MAX	†	RETESP	MAX		DIFHGK	MEDIAN	†	RETITA	MEDIAN		DIFRUS	MIN	†	RETUSA4	MIN	†			
RETBRA	MIN	†	DIFESP	MAX		RETIDN	MAX		DIFITA	MEDIAN		RETRUS	MEDIAN		DIFUSA4	MIN	†			
DIFBRA	MIN	†	RETESP	MIN	†	DIFIDN	MAX		RETJPN	MAX		DIFRUS	MEDIAN	†	RETUSA4	MEDIAN	†			
RETBRA	MEDIAN	†	DIFESP	MIN	†	RETIDN	MIN		DIFJPN	MAX		RETUSA1	MAX	†	DIFUSA4	MEDIAN	†			
DIFBRA	MEDIAN	†	RETESP	MEDIAN		DIFIDN	MIN		RETJPN	MIN	†	DIFUSA1	MAX	†	RETUSA5	MAX				
RETCAN	MAX	†	DIFESP	MEDIAN		RETIDN	MEDIAN		DIFJPN	MIN	†	RETUSA1	MIN	†	DIFUSA5	MAX				
DIFCAN	MAX	†	RETFRA	MAX	†	DIFIDN	MEDIAN		RETJPN	MEDIAN		DIFUSA1	MIN	†	RETUSA5	MIN				
RETCAN	MIN	†	DIFFRA	MAX	†	RETIND1	MAX		DIFJPN	MEDIAN		RETUSA1	MEDIAN	†	DIFUSA5	MIN				
DIFCAN	MIN	†	RETFRA	MIN	†	DIFIND1	MAX	†	RETKOR	MAX		DIFUSA1	MEDIAN	†	RETUSA5	MEDIAN				
RETCAN	MEDIAN	†	DIFFRA	MIN	†	RETIND1	MIN		DIFKOR	MAX		RETUSA2	MAX	†	DIFUSA5	MEDIAN				

Note. Series with † rejects the null hypothesis that the series on the left fails to Granger cause the series on the right at 5% level of significance.

Table 5. Granger causality from BW-based sentiment to the global equity markets

Americas Markets																				
BW	RETARG	†	BW	RETCAN		BW	RETMEX		BW	RETUSA2		BW	RETUSA4							
BW	DIFARG		BW	DIFCAN		BW	DIFMEX		BW	DIFUSA2		BW	DIFUSA4							
BW	RETBRA		BW	RETECU		BW	RETUSA1		BW	RETUSA3		BW	RETUSA5							
BW	DIFBRA		BW	DIFECU		BW	DIFUSA1		BW	DIFUSA3		BW	DIFUSA5							
Asia Pacific Markets																				
BW	RETAUS		BW	DIFHGK	†	BW	RETIND2		BW	DIFJOR		BW	RETLKA		BW	DIFNZL				
BW	DIFAUS		BW	RETIDN	†	BW	DIFIND2		BW	RETJPN		BW	DIFLKA		BW	RETSGP				
BW	RETCHN		BW	DIFIDN		BW	RETISR		BW	DIFJPN		BW	RETMYS		BW	DIFSGP				
BW	DIFCHN		BW	RETIND1		BW	DIFISR		BW	RETKOR		BW	DIFMYS		BW	RETTWN	†			
BW	RETHGK	†	BW	DIFIND1		BW	RETJOR		BW	DIFKOR		BW	RETNZL	†	BW	DIFTWN				
European Markets																				
BW	RETAUT		BW	DIFDEU		BW	RETFRA		BW	DIFHUN		BW	RETLVA		BW	DIFRUS				
BW	DIFAUT		BW	RETDNK		BW	DIFFRA		BW	RETISL		BW	DIFLVA		BW	RETSRB				
BW	RETBEL		BW	DIFDNK		BW	RETGBR		BW	DIFISL		BW	RETNLD		BW	DIFSRB				
BW	DIFBEL		BW	RETESP		BW	DIFGBR		BW	RETITA	†	BW	DIFNLD		BW	RETSVN				
BW	RETCHE		BW	DIFESP		BW	RETGRC		BW	DIFITA	†	BW	RETNOR		BW	DIFSVN				
BW	DIFCHE		BW	RETEST		BW	DIFGRC		BW	RETLTU	†	BW	DIFNOR		BW	RETSWE				
BW	RETCZE		BW	DIFEST		BW	RETHRV		BW	DIFLTU		BW	RETROM		BW	DIFSWE				
BW	DIFCZE		BW	RETFIN		BW	DIFHRV		BW	RETLUX		BW	DIFROM		BW	RETUKR	†			
BW	RETDEU		BW	DIFFIN		BW	RETHUN		BW	DIFLUX		BW	RETRUS		BW	DIFUKR	†			

G20 Markets												
BW	RETARG †	BW	RETCHN	BW	RETGBR	BW	RETIND2	BW	RETMEX	BW	RETUSA3	
BW	DIFARG	BW	DIFCHN	BW	DIFGBR	BW	DIFIND2	BW	DIFMEX	BW	DIFUSA3	
BW	RETAUS	BW	RETDEU	BW	RETHGK †	BW	RETITA †	BW	RETRUS	BW	RETUSA4	
BW	DIFAUS	BW	DIFDEU	BW	DIFHGK †	BW	DIFITA †	BW	DIFRUS	BW	DIFUSA4	
BW	RETBRA	BW	RETESP	BW	RETIDN †	BW	RETJPN	BW	RETUSA1	BW	RETUSA5	
BW	DIFBRA	BW	DIFESP	BW	DIFIDN	BW	DIFJPN	BW	DIFUSA1	BW	DIFUSA5	
BW	RETCAN	BW	RETFRA	BW	RETIND1	BW	RETKOR	BW	RETUSA2			
BW	DIFCAN	BW	DIFFRA	BW	DIFIND1	BW	DIFKOR	BW	DIFUSA2			

Note. Series with † rejects the null hypothesis that the series on the left fails to Granger cause the series on the right at 5% level of significance.

Table 6. Granger causality from the global equity markets to the BW-based sentiment

Americas Markets												
RETARG	BW	RETCAN	BW	RETMEX	BW	RETUSA2	BW	RETUSA4	BW			
DIFARG	BW	DIFCAN	BW †	DIFMEX	BW	DIFUSA2	BW	DIFUSA4	BW			
RETBRA	BW	RETECU	BW	RETUSA1	BW	RETUSA3	BW	RETUSA5	BW			
DIFBRA	BW	DIFECU	BW	DIFUSA1	BW	DIFUSA3	BW	DIFUSA5	BW			
Asia Pacific Markets												
RETAUS	BW	DIFHGK	BW	RETIND2	BW	DIFJOR	BW †	RETLKA	BW	DIFNZL	BW	
DIFAUS	BW	RETIDN	BW	DIFIND2	BW	RETJPN	BW	DIFLKA	BW	RETSGP	BW	
RETCHN	BW	DIFIDN	BW	RETISR	BW	DIFJPN	BW	RETMYS	BW	DIFSGP	BW	
DIFCHN	BW	RETIND1	BW	DIFISR	BW	RETKOR	BW	DIFMYS	BW	RETTWN	BW	
RETHGK	BW	DIFIND1	BW	RETJOR	BW †	DIFKOR	BW	RETNZL	BW	DIFTWN	BW	
European Markets												
RETAUT	BW	DIFDEU	BW †	RETFRA	BW	DIFHUN	BW	RETLVA	BW	DIFRUS	BW	
DIFAUT	BW	RETDNK	BW †	DIFFRA	BW †	RETISL	BW	DIFLVA	BW	RETSRB	BW †	
RETBEL	BW	DIFDNK	BW †	RETGBR	BW	DIFISL	BW	RETNLD	BW	DIFSRB	BW	
DIFBEL	BW	RETESP	BW	DIFGBR	BW	RETITA	BW	DIFNLD	BW	RETSVN	BW	
RETCHE	BW	DIFESP	BW	RETGRC	BW	DIFITA	BW	RETNOR	BW †	DIFSVN	BW	
DIFCHE	BW	RETEST	BW	DIFGRC	BW	RETLTU	BW	DIFNOR	BW †	RETSWE	BW	
RETCZE	BW	DIFEST	BW	RETHRV	BW	DIFLTU	BW	RETROM	BW	DIFSWE	BW	
DIFCZE	BW	RETFIN	BW	DIFHRV	BW	RETLUX	BW †	DIFROM	BW	RETUKR	BW	
RETDEU	BW	DIFFIN	BW	RETHUN	BW	DIFLUX	BW †	RETRUS	BW	DIFUKR	BW	
G20 Markets												
RETARG	BW	RETCHN	BW	RETGBR	BW	RETIND2	BW	RETMEX	BW	RETUSA3	BW	
DIFARG	BW	DIFCHN	BW	DIFGBR	BW	DIFIND2	BW	DIFMEX	BW	DIFUSA3	BW	
RETAUS	BW	RETDEU	BW	RETHGK	BW	RETITA	BW	RETRUS	BW	RETUSA4	BW	
DIFAUS	BW	DIFDEU	BW †	DIFHGK	BW	DIFITA	BW	DIFRUS	BW	DIFUSA4	BW	
RETBRA	BW	RETESP	BW	RETIDN	BW	RETJPN	BW	RETUSA1	BW	RETUSA5	BW	
DIFBRA	BW	DIFESP	BW	DIFIDN	BW	DIFJPN	BW	DIFUSA1	BW	DIFUSA5	BW	
RETCAN	BW	RETFRA	BW	RETIND1	BW	RETKOR	BW	RETUSA2	BW			
DIFCAN	BW †	DIFFRA	BW †	DIFIND1	BW	DIFKOR	BW	DIFUSA2	BW			

Note. Series with † rejects the null hypothesis that the series on the left fails to Granger cause the series on the right at 5% level of significance.

4. Concluding Remarks

This paper employs the VIX and BW market sentiments time series data and global equity market prices and returns to exam the interaction between the U.S. investor sentiments and the international stock performances. The monthly data are from June 1965 to December 2010. We first convert the daily VIX indices into monthly variables and identify three sentiment measures: market panic, extreme market optimism, and market consensus. Then we categorize the global equity indices into the G20, European, Asia-Pacific, and the Americas markets, and employ Granger causality tests to explore the linkages.

Before we proceed to the Granger causality tests, we first run the standard ADF unit root tests on all the time series variables. The variables that are not covariance stationary variable are then converted into the first order difference form. In the next step we perform the causality tests between the price and return of equity indices and the maximum, minimum, and median level VIX, as well as the BW index. We find that:

International equity markets are not greatly affected by the U.S. financial market sentiment. The significant impacts of sentiment do not show any unanimous pattern in term of the sentiment type. The directions of market atmosphere are irrelevant to whether it can be contagious among the markets. In addition, the equity markets that are affected by the volatility sentiment index do not fall into any category in terms of region or scale.

Contrary to investors' intuitions, the majority of global equity markets can Granger cause the U.S. investor sentiments. Only a few countries cannot lead to market atmosphere turbulence. However, the type of sentiment being affected is not even. Optimistic market atmosphere is more affected by the global equity market, rather than the pessimistic or modest ones. Furthermore, the driving forces of U.S. financial market sentiment are not evenly located in the world. The equity markets in the Americas and Europe are highly influential to the U.S. investors, compared to the Asian markets. This conclusion suggests a question for future study, as the Asian market included both developed and emerging markets, and both closer and independent international trade partners.

When market sentiment is measured by the BW index, we find that the global equity markets and the U.S. financial markets are mutually less influential. As the BW index reflects more of the earnings performance of the individual firms publicly listed in the U.S., we conclude that the VIX index is a better measure of sentiment contagion in the global context. The meaning of this study can be extended into further studies that explore the component of sentiment contagion. Such component analysis and contagion channel identification will serve as the economic foundation for the econometric linkages that this study explores.

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