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Risk perception in financial markets: On the flip side☆

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ABSTRACT

We propose an alternative approach to capture the asymmetric risk-return relationship in financial markets using affective cognitive analysis. Implied volatility is employed as a robust gauge of risk perception. Markets exhibit a dramatic increase in fear sentiment when extreme upper-quantile losses hit investors while conditional positive returns fuel exuberance. However, an inverse response is observed in Asian markets due to normative societal phenomena, such as herding. A cognitive paradigm provides with a better interpretation of contagion than classical leverage-feedback theories as risk perception evolves dynamically over time. Overall, the fear of losses is not the flip side of gains' exuberance.

1. Introduction

The recent global financial crisis (GFC) generated a flurry of interest in the financial literature addressing its causes and effects. Several works examine its implications on financial institutions (Maddaloni & Peydró, 2011), corporate investment decisions (Campello, Giambona, Graham, and Harvey (2011), banking lending (De Haas & Van Lelyveld, 2014), and financial contagion (Lee, Tucker, Wang, & Pao, 2014), among others. However, the way financial crisis re-shaped investors' risk perception is less investigated (Hoffmann, Post, & Pennings, 2013; Olsen, 2011).

Risk and uncertainty measurement is of a paramount importance to both academics and practitioners particularly with respect to pricing, hedging and policy making etc. In this context, the contemporary works on "risk perception" incorporate several statistical measures such as return volatility, jumps, negative macroeconomic shocks, the behavioral affective traits of market participants i.e., fear, exuberance overconfidence etc. Among them, fear sentiment is identified as the most relevant stimulus indicator of downward future expectations (Olsen, 2011). Moreover, implied volatility indices e.g., the "VIX" of the Chicago Board Option Exchange (CBOE), are often considered as market fear barometers. Chen (2003) was the first to provide direct evidence that variations in market expectations of implied volatility is a concise risk metric. His conclusions were confirmed by Ang, Hodrick, Xing, and Zhang (2006), who reported that risk perception is better reflected through the shift in market sentiment (ΔVIX). Accordingly, several empirical researches focusing the response of positive and negative stock returns vis-à-vis the change in implied volatility, generally reported a strong inverse and asymmetric relationship between return and implied volatility in the US (e.g., Hibbert, Daigler, & Dupoyet, 2008; Ang et al., 2006; Giot, 2005) as well as in international markets (Badshah, 2013; Bekiros, Jlassi, Naoui, & Uddin, 2017).

None of the studies cited above explicitly inspects the risk-return linkage with respect to perceived risk. For example, Low (2004) found an asymmetric and non-linear relationship between risk (as % of VIX) and return in the US markets. He attributed this type of

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interdependence to loss aversion which is commonly known as the "house money" behavioral bias.[4] Furthermore, Connolly, Stivers, and Licheng (2005) reported a strong inverse relationship between the US market returns and uncertainty and noted that the rise in market uncertainty (risk) influenced cross-market pricing. Giot (2005) highlighted that the high (low) degree of implied volatility in the US equity markets induced negative (positive) returns, implying that eventually a high-level uncertainty led to oversold markets. Christensen and Nielsen (2007) showed that innovations of VIX and returns demonstrated a negative monotonic relationship. In a follow-up study, Gang and Li (2011) showed that the asymmetric risk-return relationship detected by Christensen and Nielsen (2007) was actually non-monotonic but hump-shaped in most of the US markets. The change in investors' risk perception (i.e., shift in implied volatility) in non-US markets has captured limited attention in the modern empirical literature. Gang, Nan, and Zhang (2012) were the only ones investigating the dependence structure of risk (as %VIX) vis-à-vis returns in the Hong Kong market. As inferred by contemporary studies, the prevailing stream of literature continues to be restricted to a single domestic market, capturing only the "local" risk behavior pattern of market agents. In our work, we conduct a survey on risk-return interrelationship across national borders, which we consider to be essential towards its further validation as a global phenomenon.

Another recent stream of literature mainly followed by Slovic (2000), Bouyer and Bagdassaian (2001), highlighted that individuals' risk perceptions can be a function of many social factors. Indeed, individual risk choice is dictated by agents' "own world's view". The term indicates that perceived risk can be only "*sensed*" through brain filtration of the individual perception of "real world". For instance, Chui, Titman, and Wei (2010) showed that investors from different societal cultures tend to interpret information differently. Scherer and Cho (2003) detected a homogenous risk perception degree among individuals with strong social linkages or "group interaction". Bouyer and Bagdassaian (2001) further reported that individuals with an egalitarian/individualistic world view tend to perceive hazard as riskier than those pertaining a fatalistic world perception. Additionally, Hofstede (2001) indicated a strong inverse relationship between perceived risk and collectivistic culture. Most importantly cultural studies showed that perceived risk tends to be low among groups of large size exhibiting a low "*social relatedness*" (Olsen, 2011). Recently, Aussenegg, Goetz, and Ranko Jelic (2013) demonstrated that the magnitude of "fear sentiment" (defined as the return-implied volatility relationship) varied across European countries and attributed this variation to cross-cultural and institutional differences. Subsequently, Low's (2004) findings for the US markets may not be universally applicable but can vary according to variant cultural and social attributes. The controversy is inherent, as Low (2004) insisted that US investors exhibit significant fear (exuberance) following consecutive market losses (gains), yet Gang et al. (2012) traced no fear or exuberance in the behavioral patterns of agents in the Hong Kong stock market.

In addition to cultural factors, risk perception is influenced by "emotional" features, i.e., dread, enthusiasm or illusions in the form of heuristic trading rules. In financial markets, investors tend to respond to fear/risk in several "semi-recognized and subtle ways" (Olsen, 2011).[5] Neuro-finance theory attributes different behaviors to the effect of how individuals mentally and/or physically perceive uncertainty and risk. For instance, Weber and Siebermorgen (2005) found that decision makers' familiarity emotion ("feeling of known") played a significant role in reducing perceived risk. In particular, Moreno and Kida (2003) reported that a positive (negative) "perceived emotion" led to the decrease (increase) of risk-taking behavior.

Overall, it is now widely admitted that emotional attributes tend to be the most significant factors towards complex, highly uncertain and heterogeneous observed behavioral patterns in modern financial markets. In fact, as information is incomplete or many times unreliable, decision makers feel less confident (Ho & Keller, 2002). Relying on heuristic biases to simplify their decision process is a common trait as pointed out in the works of Hibbert et al. (2008) and Bekiros et al. (2017). Motivated by the aforementioned empirical findings, in the present work we take cultural, emotional and behavioral attributes into consideration to examine change in the sign and magnitude of "perceived risk" across international financial markets.

This paper differs from the existing literature in several ways. Firstly, while our empirical work incorporates most of the previously developed methodologies such as by Low (2004), Giot (2005) and Gang et al. (2012), it provides a novel generalization and recalibration framework of those models which were limited mostly to the US markets. Our study investigates 20 international markets from different regions and countries around the globe including Asia, Latin America, US, Europe and South Africa. This is the largest deployed database in the literature so far, towards providing a scrutinized analysis of investor risk-return relationships. Our empirical evidence shows that (i) all international financial markets exhibit an asymmetric and non-linear risk-return dependence structure while (ii) the risk-return relationship is not monotonic but differs significantly across regions.

Secondly, we allow the onset and aftermath of the GFC to distinguish whether significant changes in the risk perception of market agents exist. The results indicate that the dramatic shocks experienced during the GFC have radically modified investors' perceptions and behavioral patterns. We demonstrate that after the onset of the crisis, risk expectations were dominated by "fear sentiment" exhibited by a statistically "abnormal" rise in the percentage change of implied volatility indices. It seems that investors became highly sensitive towards prior market losses immediately after the crisis.

Thirdly, the use of large dataset for different time periods and investment horizons promotes the efficient comparison of the magnitude of changes in risk perception (implied by the innovations in the volatility indices) across global markets. Specifically, we measure the significance of cognitive, emotional and cultural attributes (and the impact of their differences) in shaping investors' risk perception dynamically over time. We find that among the advanced markets, U.S. and Japan participants exhibit the most conservative behavior towards big losses. On the contrary, Asian market agents reveal the most "flexible" attitude towards fear. Our results are consistent with cross-cultural comparative outcomes from the behavioral finance literature. Interestingly, we indicate that risk perception tends to be similar among highly integrated markets (e.g., in Europe or Asia) where "group-interaction" and herding phenomena prevail. Moreover, our findings suggest that the incorporation and thereby extrapolation of behavioral and emotional patterns in asset-pricing modeling, provides with a better rationalization of the observed asymmetric and non-linear risk-return relationship than the utilization of fundamentals.

Fourthly, we explicitly identify the influence of the US market on risk perception of global markets. Our empirical results suggest a significant positive correlation between changes in VIX and the implied volatility indices of other countries. We find that a rise in perceived risk in the US market increases investor risk perception throughout international markets. In addition, a multivariate causality framework confirms a global contagion effect in market sentiment mainly originating from the US. Further analysis indicates that the risk transmission mechanism during the GFC is not confined to emerging markets rather it demonstrates a dynamic bi-directional pattern of leads and lags.

The paper is organized as follows: Section 2 describes the data, performs a preliminary statistical analysis and analyzes the risk-metric properties of implied volatility indices. Section 3 proceeds with a thorough investigation of the heterogeneity of risk perception among

[4] According to the "house money effect", prior realized investor gains enhances risk-taking behavior.

[5] Various response patterns (emotions) towards fear of imminent losses have been identified and reported in the literature such as panic selling, pessimism, prolonged holdings of unprofitable stocks, shifts to fixed returns annuities' purchases etc.

various agent types in financial markets and the variations in the risk-return dependence structure under different market conditions and time periods. Section 4 discusses possible causes and behavioral implications derived by the detected risk-return interrelationships. Section 5 investigates the implied volatility spillovers and contagion mechanisms among the US and global financial markets. Section 6 concludes the paper.

2. Preliminary analysis: the role of implied volatility

Earlier studies on the risk-return relationship were mainly based on historical variance and realized volatility measures (e.g., Das & Sarkar, 2000). However, historical volatility as a statistical estimator may induce sampling and model specification errors as reported by Poon and Granger (2003), Giot (2005) and Siriopoulos and Fassas (2012). As Whaley (2009) showed, during the global financial crisis when investors feared huge losses and risk perception was abnormally high, the VIX increased to reach its highest value exactly on the day of the market crash; contrarily the VIX dramatically declined when the market rallied upwards. It was also Durand, Lim, and Zumwalt (2011) who revealed a significant sensitivity of the market risk premium to changes in VIX in the Fama and French three-factor model and advocated in favor of the predictive power of VIX. Similarly, many scholars investigated the performance of implied volatility indices outside the US and reported their superiority in capturing risk expectations such as in India (Kumar, 2012) as well as in the Greek stock market (Siriopoulos & Fassas, 2012) and in European equity markets (Bekiros et al., 2017). The common approach in implementing the implied volatility metric is the use of its percentage change, which is calculated by dividing daily innovations over previous day's level. This specific estimation measurement allows capturing the variation in market sentiment based on the change in market expectations at the highest (daily) frequency (Bekiros et al., 2017; Gang et al., 2012; Hibbert et al., 2008; Low, 2004).

In our study we follow the aforementioned standard method using the percentage change in implied volatility denoted as (%IV). Our dataset covers daily market price indices and implied volatility indices (IV) from twenty countries around the world. Specifically, the sample comprises eleven advanced markets including Australia (AU), Canada (CN), Euro-zone (EU), France (FR), Germany (GR), Japan (JP), Hong Kong (HK), Germany (GR), the Netherlands (NL), Switzerland (SZ), United Kingdom (UK) and the United States (US). Next, two Latin American markets are included i.e., Brazil (BR) and Mexico (MX), with IBOV (BR) and MEXBOL Index (MX) respectively. Furthermore, four Asian markets are covered namely China (CN), India (IN), South Korea (KR) and Malaysia (ML). Lastly, three emerging markets are incorporated in the empirical investigation i.e., Greece (GC), Russia (RS) and South Africa (SF). The sample period spans January 03, 2000 to May 16, 2014, for most advanced markets while other samples are also used for the rest of the countries investigated based on the launched date of their volatility indices. The daily prices are extracted from DataStream and Bloomberg databases. A detailed summary of all indices utilized in our paper is presented in Table 1.

Next, Table 2 displays the descriptive statistics of the daily logarithmic returns of the stock indices and their associated daily change of volatility index for all markets over the entire sample period. The statistical analysis in Panels A and C, reveals that emerging markets - especially Asian markets – such as Japan and Hong Kong exhibit high day-to-day return variation as opposed to developed countries. Additionally, the standard deviation of volatility indices in advanced markets presented in Panel B is quite similar across countries, yet quite different among emerging markets. For instance, Hong Kong and Japan show an unusual high volatility compared to the Latin American, European and South African markets. Chinese, Japanese and Indian markets present the highest standard deviation. Out of all the countries examined, the Russian emerging equity market has the lowest positive average return and the highest standard deviation both for the stock and the implied volatility indices, hence the highest risk perception. In general, return and volatility indices for all international markets possess the same basic statistical properties regarding normality and skewness characteristics. Indeed, the Kurtosis coefficient for all countries is positive, different from zero and largely over three, which indicates that all index distributions exhibit fat and asymmetric tails. Obviously, the Jacque-Bera test does not reject non-normality. Moreover, all advanced markets (except the Euro-zone), Asian markets (with the exceptions of HK, IN and KR) and Latin American markets, are negatively skewed. The heavy-tail seems to be more pronounced for Asian markets. Finally, the ADF test at 1% level rejects the null of a unit root, thus both return and volatility series are stationary.

3. Risk perception under different market conditions

3.1. Asymmetries in the contemporaneous risk-return relationship

Low (2004) and Gang and Li (2011) demonstrated the extreme high daily variation in US stock prices while revealed a non-linear asymmetric relationship between returns and volatility. In our work, we investigate whether this holds across international markets utilizing Low's (2004) model both in upward and downward markets. More formally, Low (2004) employed a two-partition asymmetric OLS regression, separately for bull and bear markets:

$$\text{D: } \%IV_{it}^{-} = \alpha_D^{-} + \eta_D R_{it}^{-} \tag{1.a}$$

$$\text{U: } \%IV_{it}^{+} = \alpha_U^{+} + \eta_U R_{it}^{+} \tag{1.b}$$

The index i refers to each market. Specifically, $\%IV_{it}^{-}$ symbolizes the innovations of risk perception as percentage changes in volatility index ($\%IV_{it}$) particularly for downside returns R_{it}^{-}. The latter denotes the daily percentage change in returns for the underlying index downsized by removing the days when $R_t \geq 0$, in accordance with Low (2004). Similarly the $\%IV_{it}^{+}$ denotes the innovations of $\%IV_{it}$ with R_{it}^{+} accounting for the daily percentage change in returns while removing the days when $R_t \leq 0$. To incorporate the inherent non-linearities Low (2004) adjusted the partitioned models in Eqs. (1.a) and (1.b) by adding an extra quadratic term:

$$\text{D: } \%IV_{it}^{-} = \alpha_D^{-} + \eta_D R_{it}^{-} + \eta_D^2 (R_{it}^{-})^2 \tag{1.c}$$

$$\text{U: } \%IV_{it}^{+} = \alpha_U^{+} + \eta_U R_{it}^{+} + \eta_U^2 (R_{it}^{+})^2 \tag{1.d}$$

where, η and η^2 stand for the corresponding coefficients in each $(-)$ and $(+)$ regression. In particular, we estimate the term η_0 as the slope difference $(\eta_U - \eta_D)$ between models U and D. This approach has been exhaustively implemented in the works of Low (2004) and Gang et al. (2012) to describe the convexity in upside and downside markets robustly.

The estimation results over the total sample period (2000–2014) are reported in Table 3. The analysis of both developed and emerging markets indicates a strong negative risk-return relationship, as R_{it} is highly significant at 1% level. This inverse relationship is "steeper" for American ($\eta_{D,\ US} = -1.06$ [−21.99]) and advanced markets (e.g., $\eta_{D,\ UK} = -1.04$ [−16.52]) when compared to Asian (e.g., $\eta_{D,\ CH} = -0.26$ [−7.08]) or Latin American markets (e.g., $\eta_{D,\ MX} = -0.33$ [−4.71]). Therefore, we could infer that advanced markets (especially the US) are more sensitive to volatility changes than emerging ones. We also observe that the US market appears to be very "individualistic" wherein investors exhibit a high desire to avoid potential losses and/or get rapidly wealthy (Hofstede, 2001). This might also explain US investors' tendency to get extremely reluctant towards negative returns, even if the probability of expected losses is very low (Olsen, 2011). In what follows, we check for robustness by employing the two-partition asymmetric regressions separately. We observe that both the magnitude and significance of the R_{it} coefficients are consistently larger for downside markets i.e., confirming the asymmetric risk-return linkage.

Table 1
Index description.

Category	Country	Underlying index	Volatility ticker	Starting date	Index provider	Option pricing method	Forecasting horizon (trading days)
Advanced markets							
	Australia	S&P/ASX-200	SPAVIX	Jan-02-2008	Australian Securities Exchange (AEX)	Model-free implied-volatility	22
	Canada	S&P/TSX 60	VIXC	Oct-01-2009	TMX group Canada	Model-free implied-volatility	22
	Euro-Zone	EURO STOXX 50	VSTOXX	Jun-01-1999	Eurex	Model-free implied-volatility	22
	France	CAC40	VCAC40	Jan-02-2000	NYSE Euronext Paris	Model-free implied-volatility	22
	Germany	DAX	VDAX-new	Jan-02-2000	Deutsche Börse	Model-free implied-volatility	22
	Hong Kong	HIS	VHSI	Jan-02-2001	Hang Seng Index Co. Ltd. (HSIL)	Model-free implied-volatility	22
	Japan	Nikkei 225	VXJ	Jan-02-2000	Osaka Stock Exchange (OSE)	Model-free implied-volatility	22
	Netherlands	AEX	VAEX	Jan-02-2000	NYSE Euronext Amsterdam	Model-free implied-volatility	22
	Switzerland	SMI	VSMI	Jan-02-1999	SWX Swiss Exchange	Model-free implied-volatility	22
	United Kingdom	FTSE 100	VFTSE	Jan-02-2000	NYSE Euronext	Model-free implied-volatility	22
	United Nations	S&P500	VIX	Jan-02-1986	CBOE	Model-free implied-volatility	22
Emerging markets							
Asia	China	FTSE/Xinhua 25–Hang Seng	ASCNCHIX	Jan-03-1999	Alpha Shares LLC	Black-Scholes-Merton (1973)	22
	India	Nifty 50	INVIXN	Nov-01-2007	NSE India	Model-free implied-volatility	22
	South Korea	KOSPI 200	VKOSPI	Jan-02-2003	Korea Exchange (KSE)	Model-free implied-volatility	22
	Malaysia	FBMKLCI	VFBMKLCI	Nov-08-2011	Unofficial	Model-free implied-volatility	22
Latin America	Brazil	IBOV	VBOV	Jan-02-2000	Unofficial	Black-Scholes-Merton (1973)	22
	Mexico	MEXBOL	VIMEX	Mar-26-2004	Mexican Derivative Exchange	Black (1976)	66
Europe & South Africa	Greece	FTSE/ATHEX 20	GRIV	Jan-02-2004	Unofficial	Model-free implied-volatility	22
	Russia	RTS	RTSVX	Jan-10-2006	Moscow Exchange	Black-Scholes-Merton (1973)	22
	South Africa	FTSE/JSE 40	SAVI	Feb-02-2007	Johannesburg Stock Exchange (JSE)	Black-Scholes-Merton (1973)	66

Notes: The Bloomberg tickers for the developed markets are: Australia (SPAVIX), Canada (VIXC), Euro-zone (VSTOXX), France (VCAC), Germany (VDAX), Japan (VXJ), Hong Kong (VHSI), Netherlands (VAEX), Switzerland (VSMI), United States (VIX), United Kingdom (VFTSE). For the Asian markets: China (ASCNCHIX), India (INVIXN), Korea (VKOSPI), Malaysia (VFBMKLCI). For Latin American markets: Brazil (VXEWZ) and Mexico (VIMEX) and for other European and South African markets: South Africa (SAVIT 40), Russia (RTSVX) and Greece (GRIV).

Table 2
Descriptive statistics.

	USA	Australia	Canada	Euro-Zone	France	Germany	Hong Kong	Japan	Netherlands	Switzerland	UK
Sample start	Jan 3, 2000	Jan 2, 2008	Oct18, 2010	Jan 3, 2000	Jan 3, 2000	May 20, 2008	Jan 2, 2001	Jan 3, 2000	Jan 3, 2000	Jan 3, 2000	Jan 3, 2000
Sample end	May 16, 2014	May 16, 2014	May 16, 2014	May 16, 2014	May 16, 2014	May 16, 2014	May 16, 2014	May 16, 2014	May 16, 2014	May 16, 2014	May 16, 2014
Panel A: return series											
Mean	3.762	−2.119	6.318	−2.169	1.550	2.554	3.085	−2.009	0.041	3.075	3.496
Minimum	−6.80	−8.70	−3.70	−8.20	−5.60	−6.00	−69.30	−12.10	−4.60	−7.30	−4.70
Maximum	4.60	5.60	4.20	10.40	6.08	5.20	73.70	9.50	6.20	6.40	3.90
Std. dev (%)	20.295	19.671	13.303	24.154	23.891	2.461	58.367	23.661	23.648	18.989	19.569
Skewness	−0.573	−0.404	−0.197	0.007	−0.162	−0.264	0.631	−0.876	−0.029	−0.505	−0.246
Kurtosis	8.654	7.605	4.759	7.434	5.594	5.928	8.605	10.506	5.984	20.087	5.449
Jarque-Bera	1343.142	162.5767	303.5512	241.1112	279.201	337.0886	1357.109	2082.217	364.5566	636.1046	260.9697
ADF (*p*-value)	−45.129***	−41.524***	−27.199***	−29.945***	−30.253***	−61.454***	−31.365***	−61.493***	−29.350***	−59.118***	−29.185***
Panel B: implied volatility series											
Mean	−1.786	−2.446	−0.822	−1.504	−1.722	−0.137	−1.493	−0.502	−1.557	−0.209	−1.513
Minimum	−17.360	−9.439	−4.670	−13.987	−20.630	−15.050	−15.060	−19.760	−10.740	−7.928	−14.140
Maximum	16.540	10.449	12.830	22.642	28.320	21.920	17.100	31.820	14.012	11.225	23.300
Std. dev (%)	26.863	25.661	20.396	28.428	28.445	24.988	24.473	30.191	25.579	23.411	25.925
Skewness	0.576	0.297	1.263	1.652	0.962	1.361	2.005	3.096	0.936	0.562	1.111
Kurtosis	21.877	9.608	14.875	26.472	33.689	23.293	29.083	53.849	13.225	29.162	24.940
Jarque-Bera	16,237.13	3959.574	5718.238	1552.117	767.2784	2219.654	30,450.48	338,316.5	4967.013	2745.106	869.4651
ADF (*p*-value)	−28.705***	−42.904***	−25.367***	−31.427***	−35.888***	−24.302	−26.759***	40.799***	−39.112***	−15.493***	−28.667***

	China	India	Korea	Malaysia	Brazil	Mexico	Greece	Russia	South Africa
Sample start	Jan 3, 2000	Nov 1, 2007	Jan 2, 2003	Nov 8, 2011	Jan 3, 2000	Mar 26, 2004	Jan 2, 2004	Jan 10, 2006	Feb 2, 2007
Sample end	May 16, 2014	May 16, 2014	May 16, 2014	May 16, 2014	May 16, 2014	May 16, 2014	Dec 12, 2013	May 16, 2014	May 16, 2014
Panel C: return series									
Mean	3.167	1.439	3.029	5.229	6.124	1.825	7.801	0.676	8.453
Minimum	−36.581	−16.962	16.334	11.284	4.259	13.678	10.441	16.374	20.204
Maximum	23.484	21.268	−13.014	−11.172	−9.979	−12.096	−7.266	−9.796	−21.199
Std. dev (%)	33.843	25.795	25.298	23.401	12.944	29.200	21.971	39.084	36.823
Skewness	−0.764	1.562	0.112	−0.569	−1.317	−0.025	0.121	0.206	−0.324
Kurtosis	47.844	31.205	14.047	10.837	18.793	10.012	9.567	5.777	15.587
ADF (*p*-value)	−22.669	−38.387	−53.256	−31.488	−60.316	−47.464	−48.470	−41.439	−42.524
Panel D: implied volatility series									
Mean	−5.348	−3.252	−3.050	−0.726	−1.545	−1.007	−2.793	−1.276	−1.057
Minimum	21.268	22.000	23.000	15.760	12.802	10.560	14.714	41.766	7.840
Maximum	−16.962	−20.470	−13.920	−17.135	−9.381	−14.160	−16.771	−33.196	−3.980
Std. dev (%)	33.142	34.067	30.556	12.458	19.380	19.054	39.782	63.762	12.622
Skewness	1.288	0.286	2.558	−1.340	0.630	−0.036	0.110	0.928	0.990
Kurtosis	24.221	26.607	34.700	244.389	22.232	27.007	8.380	27.283	12.743
ADF (*p*-value)	−28.989	−35.619	−24.221	−16.574	−13.914	−47.464	−42.202	−11.403	−42.596

Notes: We report summary statistics including the annualized mean and standard deviation, daily minimum and maximum, skewness, kurtosis and stationarity test (ADF) of market returns and market implied volatility series. "ADF" denotes the Augmented Dickey-Fuller test. Daily data is obtained from DataStream and span the period January 2000–May 2014 in most cases; ***, ** and * denote statistical significance at 1% level, 5% and 10% level respectively.

Table 3
OLS results for the asymmetric contemporaneous risk-return relationship.

Two-partitional asymmetric regressions

Market/variable	Downside markets					Upside markets					Auxiliary testing
	D		D′			U		U′			
	α	R_{it}^{-}	α	R_{it}^{-}	$(R_{it}^{-})^2$	α	R_{it}^{+}	α	R_{it}^{+}	$(R_{it}^{+})^2$	$\bar{\eta}_0 = \eta_U - \eta_D$
Panel A: advanced markets											
AU	−0.09 (−1.09)	−0.13** (−1.95)	0.01 (0.067)	0.67 (0.53)	0.05* (1.75)	0.19** (2.55)	−0.26*** (−4.23)	0.10 (1.09)	−0.07 (−0.49)	−0.05 (−1.38)	−0.13*** (−7.45)
CN	−0.09 (−1.36)	−1.03*** (−14.12)	−0.07 (−0.84)	−0.98*** (−5.22)	0.02 (0.32)	−0.13* (−1.66)	−0.61*** (−6.13)	0.23** (2.33)	−1.73*** (−8.41)	0.47*** (6.16)	0.42*** (6.42)
EU	−0.41*** (−10.49)	−1.20*** (−48.62)	−0.10** (−2.16)	−0.65*** (−11.61)	0.12*** (10.79)	−0.09** (−2.82)	−0.76*** (−34.97)	−0.17*** (−4.26)	−0.64*** (−14.54)	−0.03*** (−3.38)	0.44*** (2.52)
FR	−0.18*** (−3.77)	−0.88*** (−28.88)	−0.19** (−3.24)	−0.89*** (−13.16)	−0.01 (−0.34)	−0.16*** (−3.48)	−0.56*** (−17.52)	−0.09 (−1.54)	−0.68*** (−10.81)	0.02** (2.23)	0.32*** (3.24)
GR	−0.28*** (−7.31)	−0.10** (−2.60)	−0.03* (−7.84)	−0.64*** (−11.51)	0.07*** (6.63)	−0.20*** (6.57)	−0.52*** (−25.11)	−0.05 (1.33)	−0.78*** (−19.79)	0.05*** (7.89)	−0.42*** (−6.43)
HK	0.49*** (10.49)	−0.09*** (−7.72)	−0.48*** (−10.47)	−1.03*** (−34.62)	−0.02*** (−33.09)	−0.43*** (−15.49)	−0.04*** (−4.49)	−0.14*** (−4.39)	−0.40*** (−16.33)	0.01*** (15.62)	0.05*** (3.84)
JP	−0.88*** (−19.25)	−1.39*** (−48.25)	−0.35*** (−6.93)	−0.59*** (−11.72)	0.14*** (18.89)	−0.14*** (−3.02)	−0.46*** (−13.75)	−0.18*** (−3.06)	−0.40*** (−5.94)	−0.01 (0.39)	0.93*** (7.43)
NL	−0.19*** (−4.96)	−0.94*** (−37.95)	−0.17*** (−3.61)	−0.91*** (−16.63)	0.01 (0.70)	−0.19*** (−5.51)	−0.58*** (−25.31)	−0.13** (−3.09)	−0.68*** (−14.23)	0.02** (2.33)	0.36*** (10.09)
SW	−0.44*** (−18.72)	−0.52*** (−28.17)	−0.30*** (−10.49)	−0.23*** (−5.69)	0.07*** (8.23)	−0.51*** (−23.69)	0.61*** (33.02)	−0.35*** (−13.94)	0.28*** (8.39)	0.08*** (11.76)	1.13*** (43.28)
UK	−0.26*** (−6.48)	−1.20*** (−39.52)	−0.17*** (−3.60)	−1.04*** (−16.52)	0.038** (3.01)	−0.17*** (−4.80)	−0.70*** (−23.69)	−0.04*** (−1.00)	−0.95*** (−17.05)	0.06*** (5.35)	0.5*** (29.11)
US	−0.07** (−2.90)	−1.27*** (−32.55)	−0.10** (−2.12)	−1.06*** (−21.99)	0.05*** (5.15)	0.01 (0.47)	−1.02*** (−43.90)	−0.09** (−2.780)	−0.80*** (−19.02)	−0.05*** (−6.05)	0.25** (4.78)
Panel B: emerging markets											
Asia											
CH	0.03 (0.62)	−0.12*** (−5.32)	−0.10* (−1.69)	−0.26*** (−7.08)	−0.01*** (−4.76)	−0.22*** (−5.42)	0.03 (1.46)	−0.08* (−1.67)	−0.14*** (−3.95)	0.01*** (5.71)	0.15** (2.39)
IN	0.05 (0.45)	−0.32*** (−4.66)	−0.36** (−2.74)	−0.94*** (−7.55)	−0.11*** (−5.91)	−0.11 (−1.35)	−0.27*** (−5.21)	0.06 (0.63)	−0.52*** (−6.23)	0.04*** (3.84)	0.05 (0.59)
KR	−0.36*** (−6.93)	−0.99*** (−29.28)	−0.11** (−1.85)	−0.56*** (−8.64)	0.08*** (7.66)	−0.05 (−1.24)	−0.57*** (−19.06)	−0.04 (−0.89)	−0.59*** (−10.66)	0.00 (0.28)	0.42*** (9.33)
ML	−0.21*** (−9.53)	−0.42*** (−21.47)	−0.46*** (−20.97)	−0.88*** (−32.57)	−0.03*** (−27.76)	−0.35*** (−15.64)	0.58*** (20.19)	−0.21*** (−7.69)	0.10 (1.53)	0.21*** (8.26)	1.00*** (24.51)
Latin America											
BR	−0.71*** (−22.24)	−0.58*** (−33.22)	−0.56*** (−14.83)	−0.39*** (−10.98)	0.03*** (6.15)	−0.75*** (−24.05)	0.54*** (30.12)	−0.64*** (−17.17)	0.38*** (11.79)	0.03*** (5.97)	1.12*** (44.75)
MX	−0.10** (−2.45)	−0.44*** (−14.99)	−0.04 (−0.83)	−0.33*** (−4.71)	0.03** (1.77)	−0.16*** (−4.78)	−0.12*** (−4.58)	−0.03 (−0.83)	−0.34*** (−7.17)	0.05*** (5.56)	0.32*** (8.24)
Europe and South Africa											
GR	−0.11 (−1.25)	−0.23*** (−4.75)	−0.07 (−0.57)	−0.15 (−1.01)	0.02 (0.49)	−0.06 (−0.82)	−0.13*** (−3.66)	0.19** (2.11)	−0.44*** (−6.22)	0.04*** (5.04)	0.1 (1.59)
RS	−1.07*** (−7.52)	−1.30*** (−22.43)	−0.25 (−1.52)	−0.45*** (−4.34)	0.09*** (9.54)	0.01 (0.05)	−0.63*** (−10.98)	0.15 (1.06)	−0.78*** (−7.78)	0.02** (1.89)	0.67*** (8.26)
SA	−0.12*** (−4.12)	−0.49*** (−25.65)	−0.1** (−2.90)	−0.46*** (−10.81)	0.01 (0.72)	−0.08*** (−3.60)	−0.28*** (−17.36)	−0.00 (−0.07)	−0.42*** (−11.78)	0.03*** (4.44)	0.21*** (8.43)

Notes: Regression results incorporate daily percentage changes in market implied volatility $\%IV_{it}$ for two partitions of contemporaneous market returns R_{it} (upside and downside) for eleven developed markets i.e., United States (US), the United Kingdom (UK), Switzerland (SZ), Japan (JP), Hong Kong (HK), Germany (GR), Canada (CN), France (FR) and Australia (AU), four Asian markets including China (CN), India (ID), Korea (KR), Malaysia (ML), two Latin American markets i.e., Brazil (BR) and Mexico (MX) and three emerging markets from Europe and Mideast Africa namely South Africa (SA), Russia (RS) and Greece (GR) over the entire sample period. The *t*-statistics are presented in parentheses. *, ** and *** denotes statistical significance at 10%, 5% and 1% levels respectively.

For instance, the Japanese (JP) market exhibits a downside slope η_D of −1.39 suggesting that a decline of 1% in Nikkei 225 returns increases the volatility index (VXJ) by 1.39%, while a positive 1% increase is accompanied by only a 0.46% decrease in the VXJ. Similarly, for the Mexican (MX) market, the downside slope is almost four times larger ($\eta_D = -0.44$) than its upside value ($\eta_U = -0.12$), indicating that a drop of 1% causes a raise in implied volatility (VIMEX) by almost four times than a 1% increase. In general, the *auxiliary test of the slope difference* (η_0) by Low (2004) is positive and highly significant (except only for GR and IN), hence we concur that the downside slope is steeper than the upside one ($\eta^- < \eta^+ < 0$). This stronger relationship revealed particularly in downside markets indicates that risk perception is clearly more sensitive to losses than expected profits. A further interesting result is the highly significant positive $\eta_U > 0$ for the upside markets for SW, ML and BR. This implies that volatility increases in response to a positive return shock. Low (2004) indicated that as the increase in the implied volatility index signifies and gauges fear sentiment, consequently realized gains fuel agent reactions. In our work, we attribute this unusual positive correlation to the endogenous characteristics of options markets and the idiosyncratic trading behavior in the corresponding equity markets. Specifically, it appears that investors exhibit an overconfident behavior when they realize gains, thus tend to trade excessively and unprofitably stocks with high-risk, which eventually increases implied volatility. One other explanation could be options buyers' overreaction to market signals. Indeed, under uncertainty, uninformed or less informed traders, in response to unexpected gains, tend to buy call options massively in an excessive way causing the implied index to increase.

The presence of nonlinearity can be also inferred by Table 3. The quadratic terms $R_{it}^2$are highly significant at 5% and 1% levels both for advanced and emerging countries. A pronounced convexity profile emerges in the downside partition for the advanced, Latin American, European and South African markets, with the exceptions of FR and HK. Nevertheless, since an upside curvature is observed only for AU, EU, JP and UN, we infer that these markets demonstrate an "acceleration feature" in their fear sentiment when potential losses are imminent, and an increase in their exuberance or over-confidence when markets turn profitable. A similar result is reported in Low (2004) who revealed a "*downward-sloping reclined S-curve*" in the US market. As the quadratic term in the downside partition is relatively steeper for losses than for gains, this result might suggest that investors' risk perception is influenced by a "framing behavior" associated with the so-called "*loss aversion phenomenon*", in which investors relate a higher weight to losses rather than gains.

Interestingly, the Asian markets (including HK) demonstrate a different behavioral pattern compared to the rest; the coefficient of the quadratic term $(R_{it}^{-})^2$ is highly significant but negative (except for KR) in downside markets revealing concavity, whereas for upside markets is convex with $(R_{it}^{+})^2$ being positive and significant, similarly to an inverse reclined S-curve.[6] Accordingly, investors in Asian markets "feel" unrest and worried if and when the market generates gains, while they do not seem to perceive an imminent excessive risk or pessimism if the market closes with losses. Finally, the curvature pattern in CN, NL, GR and SA markets remains convex yet insignificant, which indicates that market agents are most likely indifferent to realized negative returns. Overall, our findings are in full accordance with prior surveys on risk perception, re-affirming that developed and emerging markets exhibit a nonlinear asymmetric return-risk linkage, while this asymmetry pattern differs across regions.

3.2. The extreme-tail effect

We attempt to assess whether the tail pattern of return distributions affects future expectations of volatility. In line with Low (2004)'s approach, we re-examine the risk-return relationship by including extreme quantiles on each regression partition namely downside and upside. In particular, we refine the previous OLS regressions (Eqs. (1.a) to (1.d)) by incorporating four "patterns" of asymmetric behavior vis-à-vis the magnitude of gain/losses:

$$(D_x)\text{: } \%IV_{it}^{x-} = \alpha_{it}^{x-} + \eta^{x-}R_{it}^{x-} \tag{2.a}$$

$$(D_0)\text{: } \%IV_{it}^{-} = \alpha_{it}^{-} + \eta^{-}R_{it}^{-} \tag{2.b}$$

$$(U_x)\text{: } \%IV_{it}^{x+} = \alpha_{it}^{x+} + \eta^{x+}R_{it}^{x+} \tag{2.c}$$

$$(U_0)\text{: } \%IV_{it}^{+} = \alpha_{it}^{+} + \eta^{+}R_{it}^{+} \tag{2.d}$$

$\%IV_{it}^{x-}$ and R_{it}^{x-} symbolize the $\%IV_{it}$ and R_{it} for the extreme 5% quantile of the negative tail of the return distribution, while $\%IV_{it}^{-}$ and R_{it}^{-} account for the remaining 95%. Similarly, $\%IV_{it}^{x+}$ and R_{it}^{x+} denote the $\%IV_{it}$ and R_{it} in the extreme 5% quantile of the gains while $\%IV_{it}^{+}$ and R_{it}^{+} for the 95% level. The estimation results of the extreme market risk-return relationship and its impact on risk perception are reported in Table 4. It is observed that investor risk attitude clearly differs in case of gains vs. losses for both developed and emerging markets. The extreme risk-return linkage captured by (U_x) and (D_x) shows the best fit (as depicted by R^2) for all markets (except JP and SW), thus asymmetry features are strongly associated with extreme returns. We find that the downside slope difference (η_d) in Table 4, Panel A is negative and significant for the American (US), European (EU, SW, UK), East Asian (JP, KR) and RS markets. This result is consistent with our prior findings (Table 3) and our expectations (Appendix 1) suggesting that an increase in losses triggers "deep fear" illustrated by an acceleration in %IV and fuels significantly high perceived risk among these markets. However, surprisingly, the slope difference in the up-side return partition does not point to any exuberance (i.e., the decelerating in %IV) as gains increases, in all advanced and emerging markets, except for US. Indeed, Table 4 shows that the upside auxiliary test for the (η_u) is insignificant or positively significant for advanced except (US), European, Asian, emerging Latin American, Eastern-Europe and South-African markets. Therefore, estimation results of up-side slope difference (η_u) conclude that large gains do not systematically fuel exuberance in international markets. Indeed, among all advanced and emerging global markets, the US market exhibits both high fear (exuberance) towards actual big losses (gains) only. This result is consistent with our prior findings (Table 3) and our predictions (Appendix 1). Indeed, the US market is the most individualistic country, highly indulgent, highly overconfident and significantly dictated by affect and extrapolation biases, which explain that US investors easily fell prey to fear/exuberance towards loss/gain situation.

Additionally, estimation results in Table 4 report dramatic acceleration of fear sentiment towards high losses for JP and RS among other countries. For instance, among the developed markets, JP exhibits the steepest downside ($\eta_{d,\ JP} = 6.52$) and the largest significant positive up-side ($\eta_{u,\ JP} = 9.71$) slopes. This finding indicates an extreme reluctance and fear towards increasing losses and the persistence of fear (no exuberance) towards increasing gains. This feature is due to a weak institutional system and a cultural particularity of the Japan (Appendix 1). Indeed, Japanese economic system is an insider economic regime with relatively low minatory governance and weak investor' right protection. Most importantly, Japan, exceptionally exhibits the highest masculine and uncertainty avoidance scores (Hofstede, 2001). Hence, they are extremely reluctant towards failure/loss and to unknown future expectations. At the same time Japanese investors are classified as highly under-confident (pessimistic) and cynic (low indulgent) individuals, hence high gains does not mitigate their anxiety/fear level. Similarly, the Russian society exhibits a huge discrepancy between the least and top powerful individuals (i.e., high degree of power distance), weak institutional system, an extremely high uncertainty avoidance and significant low indulgent level. Therefore, Russian investors become highly tolerant towards perceive risk.

Interestingly, unexpected findings emerge from Table 4. First, unlike our predictions in Appendix 1, our findings in Table 4 confirm highly significant and negative downside slope difference for the UK ($\eta_{d,\ UK} = -0.17$) and KR ($\eta_{d,\ KR} = -0.78$). These results indicate that when market agents face big future losses, UK and KR exhibit an acceleration in their fear sentiment (high perceived risk), rather than easy "anxiety" degree. This "unexpected" conservative behavior in UK and KR may suggest that even within strong legal, institutional regulatory regimes and relative-weak cultural metrics, perceived risk can be amplified through behavioral attributes.[7] Second, it is worth noting that advanced European region (especially FR, GR and NL) unlike other regions shows quite unexpected uniform low risk perception wherein it

[6] We note that the weighting function can have two forms: an *S-shape* and *inverse S-shape* (Gang et al., 2012; Gang & Li, 2011; Low, 2004). Both types in all cases allow capturing *framing effects*, preferences as well as how investors react and make biased irrational decisions under uncertainty. In this way, they illustrate a realistic description of investor's attitude towards risk; an attitude which is dynamic, non-constant and depends on whether outcomes are perceived as gains or losses.

[7] We note that the UK is considered an "outsider economy" with strong legal enforcement (see Appendix 1), therefore investors reveal a decreased disposition towards uncertainty. Similarly, Korea is classified as robust institutional system with weakly significant behavioral biases, low individualism and masculinity scores. Hence, Both UK and KR are expected to exhibit low/moderate fear sensitivity.

Table 4
Regression estimates for the extreme-tail impact on risk perception.

Market	Four-partitional regressions												Auxiliary testing	
	Downside markets						Upside markets						Downside markets	Upside markets
	D_x			D_0			U_x			U_0			η_u	η_d
	α_d	R_{it}^{x-}	R^2	α_d	R_{it}^{-}	R^2	α_u	R_{it}^{x+}	R^2	α_u	R_{it}^{+}	R^2	$\eta^{x+} - \eta^{+}$	$\eta^{x-} - \eta^{-}$
Panel A: advanced markets														
AU	−0.93 (−0.62)	−0.39 (−1.03)	0.02	−0.01 (−0.07)	−0.00 (−0.03)	0.03	2.11 (1.11)	−0.81 (−1.50)	0.00	0.15** (1.94)	−0.22** (−2.46)	0.06	−0.39 (−0.98)	−0.59 (1.08)
CN	0.40 (0.29)	−0.938* (−1.761)	0.14	−0.03 (−0.47)	−0.91*** (−8.86)	0.17	−4.28** (−2.16)	1.35 (1.54)	0.09	0.07 (0.99)	−1.03*** (−8.76)	0.10	−0.03 (0.05)	2.37** (2.69)
EU	−4.56** (−3.34)	−2.15*** (−7.43)	0.38	−0.25*** (−7.29)	−1.024*** (−34.71)	0.41	0.52 (0.68)	−0.90*** (−5.42)	0.24	−0.11** (−3.26)	−0.75*** (−24.88)	0.26	−1.13*** (−3.87)	−0.15 (0.87)
FR	1.23 (0.78)	−0.60* (−1.76)	0.03	−0.17*** (−3.86)	−0.86*** (−22.98)	0.24	−0.44 (−0.48)	−0.46** (−2.33)	0.05	−0.09** (−1.85)	−0.65*** (−13.86)	0.10	0.26 (0.76)	0.19 (0.91)
GR	−1.30 (−1.02)	−0.36 (−1.34)	0.02	−0.07 (−1.11)	−0.04 (−0.83)	0.00	0.53 (0.83)	−0.13 (−0.93)	0.01	0.01 (0.10)	0.041 (0.47)	0.00	−0.32 (1.17)	−0.17 (0.59)
HK	5.05*** (9.15)	0.061* (1.85)	0.04	−0.31*** (−7.69)	−0.78*** (−23.02)	0.27	−1.69*** (−6.09)	0.02 (0.80)	0.01	−0.13*** (−3.82)	−0.42*** (−12.13)	0.07	0.85*** (17.85)	0.43*** (11.07)
JP	−5.32*** (−5.79)	−2.43*** (−13.02)	0.65	−0.46*** (−10.90)	−0.91*** (−25.46)	0.27	5.48 (1.10)	9.29*** (7.21)	0.36	−0.13*** (−3.82)	−0.42*** (−12.13)	0.07	−1.52*** (−7.99)	9.71*** (4.86)
NL	−0.45 (−0.47)	−0.99*** (−5.16)	0.23	−0.19*** (−4.67)	−0.94*** (−25.99)	0.29	−0.37 (−0.51)	−0.51** (−3.28)	0.10	−0.13*** (−3.55)	−0.66*** (−19.07)	0.17	−0.05 (0.25)	0.15 (0.94)
SW	−1.76* (−2.75)	−0.89*** (−5.48)	0.26	−0.36*** (−15.71)	−0.41*** (−16.56)	0.24	−1.82*** (−5.95)	1.03*** (12.41)	0.69	−0.37*** (−15.40)	0.39*** (13.61)	0.09	−0.49*** (−2.96)	0.64*** (7.27)
UK	−0.72 (−0.70)	−1.33*** (−5.22)	0.25	−0.227*** (−5.78)	−1.16*** (−28.28)	0.33	−1.56* (−1.80)	−0.29 (−1.27)	0.02	−0.08** (−2.27)	−0.83*** (−21.53)	0.21	−0.17*** (−5.00)	0.54** (2.29)
US	−3.48 (−1.49)	−2.43** (−2.51)	0.07	−0.10** (−2.91)	−1.08*** (−32.55)	0.40	1.25 (1.64)	−1.36*** (−7.11)	0.31	−0.08** (−2.88)	−0.88*** (−28.60)	0.35	−1.36** (−2.25)	−0.48** (−2.48)
Panel B: emerging markets														
Asia														
CH	1.25** (2.09)	0.031 (0.42)	0.00	−0.12* (−1.91)	−0.26*** (−5.80)	0.01	−1.216** (−2.68)	0.17** (2.80)	0.01	−0.079 (−1.62)	−0.12** (−2.90)	0.07	0.29*** (3.36)	0.29*** (3.95)
IN	3.25 (1.29)	0.442 (0.89)	0.02	−0.12** (−1.91)	−0.69*** (−7.33)	0.06	−2.864** (−3.08)	0.317 (1.668)	0.04	0.08 (0.86)	−0.49*** (−5.89)	0.06	0.70** (2.24)	0.80*** (3.89)
KR	−1.86 (−1.32)	−1.47*** (−4.95)	0.17	−0.27** (−2.36)	−0.69*** (−7.34)	0.27	0.23 (0.27)	−0.64** (−3.03)	0.11	−0.06 (−1.45)	−0.56*** (−13.62)	0.11	−0.78** (2.69)	−0.09 (0.39)
ML	1.64*** (5.54)	−0.04 (−0.76)	0.07	−0.25*** (−11.40)	−0.40*** (−11.28)	0.07	−1.67*** (−4.70)	1.25*** (8.13)	0.02	−0.26*** (−10.64)	0.37*** (8.82)	0.42	0.36*** (5.99)	0.88*** (4.85)
Latin America														
BR	−1.30** (−2.05)	−0.76*** (−6.37)	0.18	−0.59*** (−17.69)	−0.46*** (−19.55)	0.32	−0.57 (−1.01)	0.58*** (5.12)	0.15	−0.64*** (−19.51)	0.42*** (17.64)	0.21	−0.30** (2.51)	0.17 (1.42)
MX	0.16 (0.16)	−0.439* (−1.83)	0.05	−0.03 (−0.67)	−0.33*** (−7.94)	0.06	−1.52** (−2.00)	0.22 (1.19)	0.02	−0.08** (−2.38)	−0.22*** (−6.34)	0.03	−0.11 (0.43)	0.44** (2.34)
Europe & South Africa														
GR	−3.52 (−1.23)	−0.78* (−1.75)	0.02	−0.11 (−1.25)	−0.23*** (−4.745)	0.05	−2.80 (−1.59)	0.35 (1.32)	0.03	0.15* (1.89)	−0.32*** (−6.34)	0.03	−0.55 (1.23)	0.68** (2.49)
RS	−8.22** (−2.84)	−2.41*** (−6.76)	0.04	−0.09 (−0.66)	−0.486*** (−6.14)	0.48	−1.26 (−0.55)	−0.47 (−1.42)	0.04	0.01 (0.10)	−0.62*** (−7.20)	0.05	−1.94*** (5.28)	0.15 (0.43)

(continued on next page)

Table 4 (*continued*)

Market	Four-partitional regressions												Auxiliary testing	
	Downside markets						Upside markets						Downside markets	Upside markets
	D_x			D_0			U_x			U_0			η_u	η_d
	α_d	R_{it}^{x-}	R^2	α_d	R_{it}^{-}	R^2	α_u	R_{it}^{x+}	R^2	α_u	R_{it}^{+}	R^2	$\eta^{x+}-\eta^{+}$	$\eta^{x-}-\eta^{-}$
SA	0.17 (0.20)	−0.44** (−2.80)	0.16	−0.11*** (−3.78)	−0.48*** (−19.03)	0.31	−1.44** (−3.28)	0.04 (0.35)	0.00	−0.03* (−1.89)	−0.32*** (−13.53)	0.16	0.05 (0.32)	0.35*** (3.37)

Notes: Regression results display daily percentage changes in market implied volatility for four partitions of contemporaneous market returns (upside, downside, extreme right and left tails) for eleven developed markets i.e., United States (US), the United Kingdom (UK), Switzerland (SZ), Japan (JP), Hong Kong (HK), Germany (GR), Canada (CN), France (FR) and Australia (AU), four Asian markets including China (CN), India (ID), Korea (KR), Malaysia (ML), two Latin American markets i.e., Brazil (BR) and Mexico (MX), and three emerging markets from Europe and Mideast Africa namely South Africa (SA), Russia (RS) and Greece (GR) over entire sample period. The *t*-statistics are presented in parentheses. *, ** and *** denote statistical significance at 10%, 5% and 1% levels respectively.

treats extreme returns indifferently (i.e., insignificant upside/downside slope difference). The UK market which is expected to exhibit low perceived risk, displays an exceptional dramatic fear behavior in downside market. Our results are in sharp difference versus Aussenegg et al. (2013) who report that GR displays the most conservative behavior while UK exhibits the least sensitivity towards extreme market conditions; the FR, NL, SW fall in between. We note that unlike UK, the Latin Europe (i.e., FR, GR, NL, SW) are highly integrated countries with strong historical and religious linkage. Besides, the Latin Europe region has similar cultural dimensions attributes and institutional clusters.

Thirdly, we find that Asian markets show an inverse risk attitude towards extreme losses when the trend is downward. The results of the auxiliary tests displayed in Table 4 reveal that Asian markets unlike other ones, have a significant positive downside slope difference (η_d) which implies that Asian markets (i.e., CH, HK, IN, ML) exhibit significant sentimental unrest when big losses are imminent, but no signs of dramatic behavioral effects as shown for the US. Interestingly, the slope difference in the upside return partition (η_u) for Asian region is positive and highly significant (high profits may fuel investor exuberance but in a moderate way). Hence, Asian markets appear neither too pessimistic when prices are decreasing, nor over-confident (no exuberance) when expected prices are rising. The profound behavioral difference of the Asian towards risk is consistent with our predictions in Appendix 1, and is justified by many works in cross-culture literature (e.g., Hofstede, 2001). Indeed, unlike other world-regions, Asian investors are the least overconfident in their beliefs and do not follow a particular path or a special trend in their perception over time (i.e., weakly significant affect and extrapolation). Importantly, Asian Markets (especially CH, HK, IN) exhibit the least cultural dimension of uncertainty avoidance, masculinity and individualism among other countries (Hofstede, 2001). Hence, they are strongly integrated culture with a high degree of loyalty and commitment to cohesive group, social and tradition norms. Therefore, they are more tolerant/less exuberant towards high losses/gains (Olsen, 2011).

Interestingly, market agents show more evidence in western markets and RS (i.e., US, UK and RS) while Latin American ones are characterized by a pronounced uncertainty avoidance, hence agents they tend to reveal a high degree of anxiety, bias and excess fear when future is highly unforeseeable. On the contrary, Asian markets deal with uncertainty in a more pragmatic[8] way demonstrated by a more "relaxed attitude" (Hofstede, 2001).

Lastly, based on the auxiliary text for the slope difference concerning the downside return partition, we fail to reject the null of inexistence of slope variation ($H_0 : \eta_d = 0$) for AU, CN, GC and SA. Accordingly, a weak impact or absence of any effect of fear can be deduced for these markets. The upside auxiliary test for the (η_u) in AU, EU, KR, BR and RS concludes in favor of insignificance, thus large gains do not fuel exuberance in these markets.

In general, our empirical results are partially in accordance with Low (2004); in particular the fact that actual information does not provide evidence of fear (exuberance) in the investigated markets cannot be considered a domestic characteristic, albeit stems from global spillovers. Interestingly though, as opposed to previous studies we find that for some countries (e.g., AU, EU, KR) consecutive gains actually fuel agents' fear sentiment ($R_{it}^{x+} < R_{it}^{+} < 0$) instead of exuberance, while for other markets the extreme negative losses lead to low (normal) fear levels or even into complete absence of panic (e.g., for Asian or AU, CN, FR, GR, NL markets). We may thereby assume that the risk-return relationship is not monotonic across global markets.

[8] We note that, Hofstede (2001)'s culture dimension surveys of Asian culture especially China, report that these cultures are very pragmatic culture (China has high pragmatism score of 87). Hence, Asian individuals tend often to change their beliefs, easily adapt their tradition and adjust their behaviors based on the change in market situation and time more frequently than their peers.

3.3. Provisional market behavior in “normal” and crisis periods

While Low (2004) indicated that consecutive gains (losses) boost market exuberance (fear) in the US markets, Gang et al. (2012) in their seminal study came up with rather controversial results when they tested a similar rationale. Specifically, they observed that before the global financial crisis as opposed to US traders' behavior, HK market participants showed no fear conditional on the prior day's outcome i.e., when markets closed with losses (gains) for two days consecutively. On the contrary, after the global crisis Gang et al. (2012) did not detect any fear traits towards consecutive losses in both examined markets (US and HK) and on top of that, exuberance in the US shifted to be significant. Gang et al. (2012) argued that just before consecutive losses occur investors tend to anticipate a stock price rebound, thus fear perception is not persistent. As their results were mixed and targeted on one Asian market, in our work we probe into a further analysis.

We introduce the notion of “*provisional market behavior*”, and in doing so we re-examine Low's (2004) framework by splitting the asymmetric regressions into two-subsamples which will be conditioned upon the sign of the previous day's return, i.e., R_{t-1}. Formally, a new set of lagged asymmetric regressions are produced and examined as follows:

$$(D_L)\text{: } \%IV_{it}^{--} = \alpha_d^{--} + \eta^{--}R_{it}^{--} \tag{3.a}$$

$$(D_G)\text{: } \%IV_{it}^{-+} = \alpha_d^{-+} + \eta^{-+}R_{it}^{-+} \tag{3.b}$$

$$(U_G)\text{: } \%IV_{it}^{++} = \alpha_u^{++} + \eta^{++}R_{it}^{++} \tag{3.c}$$

$$(U_L)\text{: } \%IV_{it}^{+-} = \alpha_u^{+-} + \eta^{+-}R_{it}^{+-} \tag{3.d}$$

where $\%IV_{it}{}^{--}$ and $R_{it}{}^{--}$ represent the $\%IV_{it}$ and R_{it} when $R_{it-1} < 0$ and $R_{it} < 0$. Accordingly, $\%IV_{it}{}^{-+}$ and $R_{it}{}^{-+}$ denote the above when $R_{it-1} < 0$ and $R_{it} > 0$, $\%IV_{it}{}^{++}$ and $R_{it}{}^{++}$ symbolize the $\%IV_{it}$ and R_{it} when $R_{it-1} > 0$ and $R_{it} > 0$ and finally $\%IV_{it}{}^{+-}$ and $R_{it}{}^{+-}$ represent the $\%IV_{it}$ and R_{it} conditioned upon $R_{it-1} > 0$ and $R_{it} < 0$. The OLS results for the D_G, D_L, U_G and U_L models are reported in Table 5. We consider the period between August 2007–May 2009 as the onset and burst of the financial crisis following Authers (2010), Dungey and Gajurel (2014), while the period June 2009–May 2014 as the aftermath of the crisis period, even though the aftershocks are still persistent and the current global economic situation is characterized by stagnation rather than by a recovery phase (Hirshleifer, 2008; Krugman, 2011). We therefore implicitly assume the post-crisis period is a sluggish continuation of the global crisis, or what emphatically Krugman (2011) considered as “a *global recession period not surmounted thus far*”.

The generic evidence emerging from the reported results indicates that the expected significant and negative downside-slope coefficient η_d holds only for advanced US, UK, JP, HK and emerging KR, ML, BR, SF markets. This implies that investors' fear sentiment increases abnormally during bear market conditions, when prices fall for two days in row (Low, 2004). While prior gains do not mitigate investor's fears triggered by previous losses, a fact that can be justified by the “*confirmative psychological bias phenomenon*” wherein investor beliefs tend to perceive risk in “conformity” with previous signals (e.g., previous daily loss). Consequently, market agents follow an instinctive impression of pessimism and expect an increase in future volatility (anxiety). Consistently with our prior results, Table 5 shows that the US and JP stock markets exhibit the highest fear perception ($R_{it,\ US}{}^{--} = -1.32$ and $R_{it,\ JP}{}^{--} = -1.52$) compared to the other. Our findings, support our prediction that investors' perceptual judgments are dictated by affect emotional bias and intuitions. Interestingly, an exception is observed for AU, CN and RS where the downside slope difference (η_d) is statically significant and positive, implying perceived risk turns to dramatically rise (i.e., acceleration in %IV) when market realizes unexpected loss preceded by a prior gain. Hence, investors in these markets are more confused and worried about their gains rather than about their losses. We note that AU and CN being highly individualistic and indulgent countries (Appendix 1), tend to be highly emotional and stressed towards the sudden shift in returns. Additionally, we notice that Advanced European market (EU, FR, GR, SW, NL) and emerging Asian ones (CH, IN), MX and GC exhibit quite homogenous indifferent/unchanged risk perception in downward markets regardless of conditionality. This is rationalized by the statistical insignificance of downside slope difference η_d. These results are perfectly aligned with our previous findings in Table 4.

On the other hand, considering the upside return partition, we find the slope difference (η_U) unexpectedly highly significant and negative for US, Europe (EU, GR), Asia (JP, HK, CH, IN) and RS. The negative and significant sign of the upside slope difference implies that consecutive gains may shift investors' risk perception to increase their fear sentiment rather exuberance. Indeed, continuous increase in positive returns may trigger investor's worries to believe that a looming correction is imminent after consecutive gains (Gang et al., 2012). This feature is consistent with our prior assumptions that some countries especially Asian market (CH, IN, JP, HK) are less exuberant and less inclined to believe in continuity of returns over-time (Nisbett, 2003), hence consecutive gains/losses may disturb their fear sentiment. Notably, the upside slope difference is statistically insignificant for AU, NL, KR and MX which reveals that in bull markets, investors react to past gains and losses equally in a passive manner. Intuitively, the upside slope difference (η_U) for the remaining of advanced (CN, FR, SW, UK) and emerging (ML, GC, SF) markets is highly significant and positive. Thus, in bull market, investor's sentiment in these markets shifts to exuberance when a sequential profit is observed.

Seemingly our empirical findings encountered peculiar difference from Gang et al. (2012)'s results that point into no evidence of fear/exuberance in US and HK markets under different market conditions. Most importantly, using updated dataset we extend Low's (2004) survey on the S&P100 equity market, who reported that US investor's risk perception increases dramatically towards realized consecutive losses in downward market, but it remains unchanged in upside-return partition. We were able to show that in upside markets, risk perception rises significantly when an unexpected loss is realized preceded by prior profits. Then, investors seem to care much more about their gains rather than about their losses. Moreover, after exploring both upside and downward market conditions, we notice that the downside slope difference, generally, is steeper than the upside one ($\eta_d < \eta_u < 0$). As a result, the marginal effect of consecutive negative returns upon the increase of market risk perception (%*IV*) is much higher than the mitigating effect of consecutive gains, the risk-return relationship is not only affected by the sign but also by the magnitude of the change in the implied volatility.

In an attempt to perform a robustness analysis, we investigate the prevailing role of the global financial crisis in generating a shift in investors' strategies worldwide probably through the risk perception channel. For example, Hoffmann et al. (2013) reported that during the global crisis period, investor risk perception significantly increased in the NL market, yet the effect was only temporary as it sharply decreased to its pre-crisis levels near the end of the crisis. Hence, we run our estimated models (Eqs. (3.a)–(3.d)) separately during and after the crisis period and we report our findings in Table 6. Specifically, the slope for the downside return partition regression $R_{it,\ crisis}{}^{--}$ indicates an abnormal increase in fear sentiment (acceleration in $\%IV_{it}$) during the crisis. It seems that during the crisis, risk perception has strongly increased in East Asia - especially in Japan ($R_{it,\ JP}{}^{--} = -1.75$) - as well as in the EU - especially in the UK ($R_{it,\ UK}{}^{--} = -1.47$). This is further substantiated by the (significant) negative sign of the downside slope difference η_d across all markets except AU, HK, GR, NL and SW which exhibit a reversal significant positive sign. On the contrary, Latin American markets showed a lower degree of anxiety. In prior findings, we demonstrated that advanced Europe (EU, FR, GR, SW, NL) and Asian (CH, IN, KR) markets exhibited the most relaxed (easy worries)

Table 5
Estimates for conditional market behavior.

	Asymmetric regressions												Auxiliary testing	
	1-Daily lagged loss						1-Daily lagged profit						Downside markets	Upside markets
Markets	D_L			D_G			U_G			U_L			η_d	η_u
	α_d	R_{it}^{--}	R^2	α_d	R_{it}^{-+}	R^2	α_u	R_{it}^{++}	R^2	α_u	R_{it}^{+-}	R^2	$\eta^{--}-\eta^{+-}$	$\eta^{-+}-\eta^{++}$
Panel A: advanced markets														
AU	−0.17	−0.11	0.00	0.15	−0.28**	0.02	0.22**	−0.24**	0.02	−0.21***	−0.97***	0.43	0.86***	−0.04
	(−1.34)	(−1.29)		(1.18)	(−2.82)		(2.57)	(−3.03)		(−4.24)	(−26.62)		(9.01)	(−0.34)
CN	−0.07	−0.92***	0.35	−0.24	−0.24	0.01	0.03	−0.93***	0.22	−0.08	−1.15***	0.34	0.23*	0.69***
	(−0.81)	(−10.12)		(−1.54)	(0.12)		(0.33)	(−8.85)		(−1.002)	(−11.44)		(1.73)	(3.77)
EU	−0.44***	0.15**	0.02	−0.12**	−0.80***	0.47	−0.08*	−0.69***	0.29	−0.48***	0.29**	0.02	−0.14	−0.11***
	(−8.29)	(2.01)		(−2.76)	(−29.51)		(−1.67)	(−19.43)		(−6.31)	(2.24)		(−0.93)	(−2.54)
FR	−0.21**	−0.81***	0.33	−0.15**	−0.51***	0.13	−0.12*	−0.65***	0.16	−0.14**	−0.85***	0.32	−0.06	0.14***
	(−2.85)	(−20.11)		(−2.32)	(−12.68)		(−1.89)	(−13.47)		(−2.45)	(−21.77)		(−0.85)	(2.82)
GR	0.03	−0.78***	0.61	−0.14**	−0.59***	0.41	−0.24***	−0.42***	0.12	−0.13**	−0.82***	0.44	0.32	−0.17***
	(1.45)	(−53.04)		(−3.77)	(−25.95)		(−4.99)	(−12.13)		(−3.09)	(−27.57)		(0.99)	(−11.99)
HK	0.55***	−0.12***	0.05	−0.71***	−0.02**	0.00	−0.26***	−0.01	0.00	0.43***	−0.05***	0.02	−0.07***	−0.01***
	(7.22)	(−6.05)		(−13.75)	(−1.99)		(−8.64)	(−1.22)		(8.04)	(−3.84)		(−3.96)	(−5.95)
JP	−1.01***	−1.52***	0.59	−0.17**	−0.59***	0.12	−0.13**	−0.31***	0.05	−0.72***	−1.22***	0.52	−0.3***	−0.28***
	(−14.36)	(−36.46)		(−2.30)	(−11.47)		(−2.25)	(−7.42)		(−12.52)	(−31.32)		(−5.29)	(−6.79)
NL	−0.14**	−0.91***	0.31	−0.24***	−0.58***	0.33	−0.11***	0.51***	0.26	−0.14**	−1.04***	0.43	0.13	−1.09
	(−2.47)	(−27.66)		(−4.68)	(−17.68)		(−2.85)	(19.95)		(−3.00)	(−27.41)		(1.14)	(−0.27)
SW	−0.41***	−0.41***	0.31	−0.50***	0.62***	0.39	−0.41***	0.51***	0.25	−0.36***	−0.47***	0.28	−0.04	0.62***
	(−11.68)	(−19.65)		(−15.56)	(24.52)		(−15.17)	(19.64)		(−13.46)	(−19.18)		(−1.16)	(3.30)
UK	−0.28***	−1.31***	0.37	−0.25***	−0.61***	0.21	−0.02	−0.83***	0.27	−0.14**	−1.04***	0.33	−0.28***	0.22***
	(−4.88)	(−30.35)		(−5.14)	(−16.12)		(−0.53)	(−19.84)		(−3.00)	(−27.41)		(−4.73)	(3.90)
US	−0.22***	−1.32***	0.63	0.07*	−1.17***	0.59	−0.09**	−0.71***	0.35	−0.18***	−1.35***	0.63	−0.07***	−0.46***
	(−4.41)	(−37.25)		(1.79)	(−38.02)		(−2.91)	(−24.10)		(−4.86)	(−41.65)		(−5.37)	(−10.69)
Panel B: emerging markets														
Asia														
CH	0.07	−0.11***	0.01	−0.30***	−0.03	0.00	−0.14**	0.07**	0.01	0.00	−0.13***	0.02	0.02	−0.1**
	(0.88)	(−3.53)		(−4.39)	(−1.01)		(−2.87)	(3.01)		(0.05)	(−3.97)		(0.15)	(−2.50)
IN	0.07	−0.32**	0.02	−0.11	−0.41***	0.05	−0.09	−0.16**	0.01	0.03	−0.32***	0.03	0.00	−0.25**
	(0.39)	(−3.10)		(−0.77)	(−4.59)		(0.32)	(−2.63)		(0.26)	(−3.69)		(0.04)	(2.24)
KR	−0.41***	−0.98***	0.43	−0.11**	−0.57***	0.21	0.03	−0.56***	0.18	−0.14**	−0.86***	0.33	−0.12*	−0.01
	(−5.71)	(−22.56)		(−2.00)	(−14.59)		(0.83)	(−14.49)		(−2.37)	(−20.18)		(−1.99)	(0.13)
ML	−0.54***	−0.94***	0.49	−0.37***	0.67***	0.40	−0.33***	0.53***	0.12	−0.09***	−0.11***	0.06	−0.83***	0.78**
	(−15.67)	(−28.81)		(−16.17)	(22.12)		(−9.76)	(12.05)		(−4.76)	(−6.98)		(−3.27)	(2.55)
Latin America														
BR	−0.71***	−0.49***	0.44	−0.77***	0.58***	0.38	−0.72***	0.49***	0.25	−0.72***	−0.56***	0.33	−0.03**	0.14**
	(−16.26)	(−26.22)		(−16.61)	(23.28)		(−16.94)	(18.74)		(−15.21)	(−20.90)		(−2.67)	(2.37)
MX	−0.08	−0.43***	0.16	−0.24***	−0.10**	0.01	−0.08**	−0.16***	0.03	−0.09**	−0.44***	0.18	−0.01	0.09
	(−1.36)	(−10.81)		(−4.80)	(−2.61)		(−1.98)	(−5.20)		(−1.99)	(−11.91)		(−0.22)	(1.27)
Europe& South Africa														
GR	−0.09	−0.21***	0.03	−0.02	−0.04	0.00	0.04	−0.28***	0.05	−0.08	−0.26***	0.04	0.05	0.06***
	(−0.77)	(−4.34)		(−0.18)	(−0.91)		(0.47)	(−6.26)		(−0.85)	(−5.27)		(0.77)	(3.54)
RS	−0.94***	−1.21***	0.12	−0.12	−0.70***	0.32	0.04	−0.51***	0.08	−1.14***	−1.42***	0.36	0.21*	−0.33***
	(−4.37)	(−15.38)		(−0.67)	(−8.50)	0.12	(0.24)	(−7.49)		(−6.71)	(−17.11)		(1.94)	(−7.04)
SA	−0.10**	−0.56***	0.52	−0.07**	−0.25***	0.21	−0.06**	−0.33***	0.31	−0.09**	−0.39***	0.37	0.24**	0.24**
	(−2.48)	(−21.91)		(−2.26)	(−11.69)		(−2.21)	(−15.84)		(−2.94)	(−17.12)		(2.06)	(2.41)

Notes: Regression results are illustrated for two-partitional provisional asymmetric regressions of daily changes in $\%IV_{it}$ upon contemporaneous market returns R_{it} conditional upon 1-day lagged positive/negative returns. The dataset covers the entire period under investigation. The *t*-statistics are included in parentheses. *, ** and *** denotes statistical significance at 10%, 5% and 1% levels respectively.

behavior against future losses during "*normal times*". However, the shift observed in term of fear attitude confirms the theoretical assumptions that during turmoil periods under panic, investors deviate from full rationality and become extremely risk-averse or reluctant to invest whatsoever (Orlean, 2009). Now, regarding the upside regressions, we observe that the risk-return link sharply declines when agents realize consecutive gains for Latin-spoken countries including European ones e.g., FR, NL, UK, SW as well as Latin American markets as well as KR, ML, RS and SA. Indeed, the η_u coefficient for the latter markets is positive and highly significant. We infer that during the crisis period a significant swing in market behavior occurs from extreme fear - when investors realize consecutive losses - to exuberance (or even greed) when the market experiences consecutive gains. However, for AU, North-American (CN, US), East Asia (CH, HK, JP, IN), EU and GR markets an inverse risk-return linkage is indicated during the crisis with η_u being negative and significant. The variability in the sign and magnitude of the slope difference across markets can be attributed to the effect of "*heterogeneous beliefs*"; indeed individuals tend to interpret the same result differently and act differently in terms of their trading behavior.

Moreover, we show that R_{it}^{--} is steeper after the onset of the financial crisis i.e., ($R_{it,\ after-crisis}^{--} < R_{it,\ crisis}^{--} < 0$) for most

Table 6
Estimates for conditional market behavior during and after the global financial crisis.

Panel A	Subprime crisis period				Recession period and sluggish rise			
	1-Daily lagged loss		1-Daily lagged loss profit		1-Daily lagged loss		1-Daily lagged loss profit	
Markets/variables	D_L	D_G	U_G	U_L	D_L	D_G	U_G	U_L
	R_{it}^{--}	R_{it}^{-+}	R_{it}^{++}	R_{it}^{+-}	R_{it}^{--}	R_{it}^{-+}	R_{it}^{++}	R_{it}^{+-}
Advanced markets								
AU	−0.14	−0.40*	−0.27	−0.36*	−0.11	−0.17	−0.14	0.19
	(−1.10)	(−1.89)	(−1.59)	(−1.73)	(−0.75)	(−1.60)	(−1.27)	(1.47)
CN					−0.92***	−0.23	−0.93***	−1.15***
					(−10.12)	(−1.55)	(−8.85)	(−11.44)
EU	0.40*	−0.78***	−0.80***	0.58	0.10	−0.91***	−0.69***	0.32**
	(1.45)	(−11.18)	(−5.18)	(0.73)	(0.75)	(−17.15)	(−12.96)	(2.09)
FR	−1.11***	−0.56***	−0.81**	−0.88***	−1.09***	−0.75***	−0.56***	−1.16***
	(−7.51)	(−4.93)	(−3.33)	(−5.85)	(−14.15)	(−12.41)	(−10.34)	(−19.45)
GR	−0.90***	−0.53***	0.33	−0.92***	−0.91***	−0.81***	−0.57***	−1.10***
	(−18.65)	(−9.17)	(0.23)	(−8.33)	(−33.34)	(−18.92)	(−12.07)	(−22.67)
HK	−0.11**	−0.03	0.01	−1.02***	−1.58***	−0.00	−0.02	−0.03
	(−2.34)	(−1.07)	(0.39)	(−9.41)	(−17.76)	(−0.04)	(−1.50)	(−1.32)
JP	−1.75***	−1.14***	−0.46***	−1.67***	−1.92***	−0.13	0.02	−1.10***
	(−18.24)	(−9.33)	(−3.91)	(−21.66)	(−21.66)	(−1.23)	(0.12)	(−13.54)
NL	−0.95***	−0.47***	−0.69***	−1.14***	−1.23***	−0.77***	−0.74***	−1.44***
	(−11.74)	(−5.53)	(−7.82)	(−12.58)	(−17.22)	(−10.06)	(−11.77)	(−14.73)
SW	−0.48***	0.77***	0.42***	−0.48***	−0.51***	0.59***	0.51***	−0.48***
	(−5.88)	(13.52)	(6.06)	(−8.03)	(−13.63)	(11.66)	(12.03)	(−10.98)
UK	−1.47***	−0.32**	−0.74***	−1.17***	−1.34***	−0.77***	−1.01***	−1.29***
	(−10.12)	(−2.95)	(−4.38)	(−9.50)	(−17.99)	(−10.83)	(−16.98)	(−19.06)
US	−1.30	−1.24***	−0.65***	−1.29***	−1.80***	−1.44***	−0.87***	−1.62***
	(−13.83)	(−17.34)	(−6.72)	(−17.17)	(−25.56)	(−19.92)	(−16.79)	(−27.89)
Emerging markets								
Asia								
CH	−0.88***	−0.50**	0.03	−0.34**	−0.02	0.11***	−0.07**	−0.03
	(−4.21)	(−2.94)	(0.83)	(−2.21)	(−0.40)	(3.21)	(−3.17)	(−0.89)
IN	−0.17	−0.43**	−0.04	−0.40**	−0.88***	−0.63***	−0.30***	−0.25**
	(−0.61)	(−2.44)	(−0.29)	(−2.04)	(−9.62)	(−8.12)	(−4.23)	(−2.53)
KR	−1.19***	−0.56***	−0.69***	−1.12***	−1.00***	−0.68***	−0.62***	−0.78***
	(−11.96)	(−5.12)	(−8.81)	(−8.41)	(−14.66)	(−12.20)	(−12.32)	(−12.89)
ML	−1.08***	0.78***	0.62**	−0.66***	−0.77***	0.73***	0.47***	−0.68***
	(−17.29)	(7.85)	(−3.06)	(−9.85)	(−19.07)	(15.58)	(0.06)	(−12.65)
Latin America								
BR	−0.42***	0.61***	0.38***	−0.56***	−0.68***	0.69***	0.53***	0.55***
	(−8.99)	(9.35)	(5.37)	(−7.19)	(−16.47)	(14.60)	(10.23)	(11.29)
MX	−0.53***	−0.01	−0.43***	−0.44	−0.70***	−0.49***	−0.46***	−0.75***
	(−4.91)	(−0.13)	(−4.99)	(−5.16)	(−16.58)	(−7.29)	(−9.58)	(−13.76)
Europe and South Africa								
GC	−0.13	0.03	−0.23**	0.13*	−0.28**	−0.08	−0.28***	−0.43**
	(−1.54)	(0.32)	(−2.39)	(1.65)	(−3.79)	(−1.04)	(−3.68)	(−5.24)
RS	−1.48***	−0.58**	−0.53**	−1.73**	−1.09***	−1.00***	−0.56***	−1.36***
	(−9.08)	(−3.18)	(−3.03)	(−8.73)	(−9.49)	(−9.76)	(−6.89)	(−9.53)
SA	−0.54***	−0.23***	−0.30***	−0.39***	−0.60***	−0.30***	−0.34***	−0.46***
	(−11.72)	(−5.48)	(−7.15)	(−9.85)	(−16.61)	(−9.79)	(−10.43)	(−12.52)

Panel B: auxiliary testing of slope difference between downside and upside markets								
	Subprime crisis period				Recession period and sluggish rise			
	Downside market		Upside market		Downside market		Upside market	
Markets/variables	η_d		η_u		η'_d		η'_u	
Advanced markets								
AU	0.22***	(15.36)	−0.03***	(16.30)	−0.20	(−1.01)	−0.08	(−0.47)
CN					0.23*	(1.73)	−0.69***	(−3.77)
EU	−0.04***	(−3.34)	−0.11***	(−4.73)	−0.29	(−1.29)	0.22**	(2.83)
FR	−0.26***	(−8.68)	0.09***	(9.35)	0.13	(1.30)	0.09	(0.98)
GR	0.02***	(11.31)	−0.86***	(−4.30)	−0.83**	(−2.90)	0.22**	(3.20)
HK	0.91***	(17.73)	−0.04**	(−2.77)	−1.63***	(−17.16)	−0.02	(−0.89)
JP	−0.08***	(−19.33)	−0.68***	(−7.87)	−0.85***	(−7.02)	0.09	(0.63)
NL	0.19***	(3.09)	0.22***	60.92	−0.05	(−0.83)	−0.10	(−1.58)
SW	0.00***	(4.05)	0.35***	(9.62)	0.24*	(1.93)	0.05	(0.46)
UK	−0.3***	(−9.63)	0.40***	17.42	−0.08**	(−2.76)	−0.30**	(−2.99)
US	−0.02***	(−14.60)	−0.59***	(−9.93)	−0.14**	(−3.43)	0.54***	(3.45)
Emerging markets								

(*continued on next page*)

Table 6 (*continued*)

Panel B: auxiliary testing of slope difference between downside and upside markets

	Subprime crisis period				Recession period and sluggish rise			
	Downside market		Upside market		Downside market		Upside market	
Markets/variables	η_d		η_u		η'_d		η'_u	
Asia								
CH	−0.54*	(−2.01)	−0.13***	(−8.27)	−0.08**	(−2.39)	−0.14**	(−2.89)
IN	−0.09*	(−1.95)	−0.22**	(−2.37)	−0.50***	(−3.74)	0.14	(0.99)
KR	−0.51***	(−5.57)	0.66***	(3.93)	−0.39***	(−4.12)	−0.07	(−0.83)
ML	−1.73***	(−9.02)	1.18***	(10.94)	−1.26***	(−16.54)	−1.32***	(−17.72)
Latin America								
BR	−0.76***	(−9.08)	1.13***	(11.79)	−1.20***	(−18.28)	−1.36***	(−19.40)
MX	−0.48***	(−3.59)	0.42***	(3.44)	−0.22***	(−3.06)	−0.29***	(−3.08)
Europe & South African								
GC	0.11	(0.81)	−0.08	(−0.70)	0.02	(0.19)	−0.34**	(−2.64)
RS	−1.06***	(−3.88)	0.92***	(3.36)	−0.29**	(−2.93)	−0.56***	(−3.96)
SA	−0.25**	(−4.22)	0.16**	(2.91)	−0.27***	(−5.06)	−0.18***	(−3.47)

Notes: Panel A reports the asymmetric regression results of daily changes in $\%IV_{it}$ vis-à-vis contemporaneous market returns R_{it} conditional upon 1-day lagged positive/negative returns, during and after the global financial crisis. Panel B presents auxiliary testing of the significance for the slope difference for the provisional asymmetric regressions in the two partitions during and after the global crisis. The *t*-statistics are in parentheses. *, ** and *** denote statistical significance at 10%, 5% and 1% levels respectively.

advanced markets except AU, FR and UK as well as for the emerging markets with the exceptions of CH, KR, ML and RS. Similarly, R_{it}^{-+} is larger after the crisis for the developed markets and for the emerging economies. These results imply that the financial crisis did not only stimulate the acceleration in %*IV* during the crisis, but it demonstrated a profound persistency following the crisis, in accordance with Hirshleifer (2008) who suggests that as a consequence of the crisis investors exhibit *short memory* and *fear bias*. Under stricter government regulations those biases are prone to be wax and wane in strength, and that's why regulatory strategies may fail and financial recessions can persist even after their reinforcement. Overall, our results countervail Hoffmann et al. (2013) who indicated that towards the end of the crisis risk perception returned to its pre-crisis levels. Among all markets, the US reveals the highest level of fear anxiety provisional upon its previous position (statistically significant $R_{it,\ after-crisis}{}^{--} = -1.80$ and $R_{it,\ after-crisis}{}^{+-} = -1.62$). In response to the detrimental effect of the global crisis, the rise in risk perception expressed as an increase in %*IV* or via the downside slope difference, was greater for the developed markets rather for the emerging ones.

In general, the change in market sentiment vis-à-vis previous gains/losses in all international financial markets except the EU, US and GR, became far less exuberant ($\eta'_u < \eta_u < 0$) after the crisis. The dramatic shock experienced during the subprime crisis has radically changed investors' perception towards becoming less confident, pessimistic and depressed. Indicatively, even when they realized consecutive gains, their risk sensitivity increased rather than the other way round.

Interestingly, the magnitude of pessimism in case of the Asian markets - including HK and JP - has significantly decreased after the crisis ($\eta_d < \eta'_d < 0$ and $\eta'_u < \eta_u$), hence "depression" was only temporary for these markets and not a lasting phenomenon as in US. We can attribute the different behavioral patterns of Asian markets to culturally normative phenomena. Indeed, as we mentioned in our previous analysis, Asian societies compared to the westerns, have high abilities to control their urges and sentiments (e.g., fear sentiment towards loss) as well as high abilities to cope with change in market outcomes. Therefore, they are neither too overconfident (exuberant) nor too anxious (fear) in bull/bear markets. Additionally, Asian market are more prone to herding and group convention as noted in Nisbett (2003).

Overall, a general pattern seems to emerge from our results: risk perception in the aftermath of the crisis tends to increase. This result is in accordance with Slovic (2000), Bouyer and Bagdassaian (2001) and Ho and Keller (2002) in that risk perception varies with ambiguity/uncertainty due to psychological factors and tends to increase when perceived decision complexity is encountered. While several modern studies assert that markets are driven by the interplay of greed and fear, e.g., Hirshleifer (2008), Authers (2010) etc.; our empirical results show that during or after global crises, most international markets (except Asian ones) are affected by fear swamps rather than exuberance. This phenomenon is what Authers (2010) called "*a fearful rise*" in the global interlinked financial markets' system.

4. Behavioral inference vs. leverage or feedback hypotheses

According to *leverage or feedback hypotheses* in behavioral finance the "anomalies" in the return-volatility relationship can be better explained by agent extrapolation, heuristic biases etc., rather than by "fundamentals". Hibbert et al. (2008), Badshah (2013), Bekiros et al. (2017) showed that a lagged change in the implied volatility affects the expectations of future volatility. When Low (2004) and Gang et al. (2012) examined the classical leverage theory, they both concluded upon the weak explanatory power of non-behavioral approaches. Thereby, we contribute to the relevant literature by investigating whether behavioral-based prediction involving affect and extrapolation biases, can significantly explain the risk-return liaison. Specifically, aside from the Low's model we introduce the *Modified* model, incorporating lagged returns and daily changes in *IV* as follows[9]:

$$\text{Low's model } M_1\text{: } \%IV_{it} = \alpha + \eta_1 R_{it} \tag{4}$$

$$\text{Modified Low's model } M_2\text{: } \%IV_{it} = \alpha + \alpha_1 R_{it} + \alpha_2 R_{it-1} + \alpha_3 \%IV_{it-1} \tag{5}$$

Under this context R_{it-1} and $\%IV_{it-1}$ variables capture respectively the previous day's return and the volatility impact on the underlying risk-return relationship. Our results are reported in Panels A and B of Table 7, where the *R-squared* values of the two models are included. The findings indicate that the modified Low's model (M_2) exhibits a better fit in estimating the daily return-volatility relation, as it yields the highest *R-squared* value versus (M_1), which basically depicts the explanatory utility of the past implied volatility variable solely. Table 7

[9] Similar approaches – yet with different numbers of lags in the models - have been employed in several studies including Kim and Kim (2003), Hibbert et al. (2008), Badshah (2013). The common logic is that the lagged implied volatility can be considered as the actual volatility measure. Moreover, return and implied volatility variables reflect current price changes.

shows clearly that the contemporaneous return (R_{it}) is negative, highly significant at the 1% level, with a high absolute value. On the other hand, the lagged return (R_{it-1}) presents lower statistical significance (and magnitude) for both developed and emerging markets. This result may imply that the asymmetric risk-return dependence is a contemporaneous rather than a lagged phenomenon.

Importantly, the aforementioned findings emerge in direct disparity vis-à-vis the classical leverage hypothesis explanation, which advocates in favor of a statistically significant lagged risk-return relationship. The significant negative values of $\%IV_{it-1}$found support the *behavioral paradigm* of representativeness and affect biases. Indeed, representativeness bias could lead investors to perceiving negative actual returns (losses) and large past volatility ($\%IV_{it-1}$) as evidence of future market decline. Furthermore, under uncertainty investors tend to rely on their intuitive emotions, hence they often associate negative returns with high risk i.e., the so-called "*bad affect*". Consequently, they precipitate into buying put options in order to protect their portfolios against further price declines, without directly realizing that this is exactly the cause of fueling the rise of implied volatility. When considering "normal" vs. "crisis" periods, the risk-return relationship appears to be more peaked during the crisis rather than after its breakout for all international markets except for UK, US, IN and MX. Behavioral theory advocates that under extreme volatility (crisis periods), the affect sentiment increases rapidly in response to a stimulus such as actual losses or against the fear of imminent negative returns. Thereby, it gives rise to a reaction which has a valence that enhances investors to move away from this stimulus. Evidently, during crisis periods we observe large purchases of put options as an insurance mechanism for trading portfolios. In turn, the high demand for put options subsequently increases $\%IV_{it}$ and therefore accentuates the asymmetric risk-return relationship.

Empirical findings in Table 7 suggest that the influence of affect emotion on investors' risk perception (i.e. the significant negative sign of $\%IV_{it-1}$) is more prevalent for advanced, Emerging Latin American and European market, than for the Asian market. We notice that the Asian markets (i.e., JP, HK, CH, ML, KR), possess a weakly significant or insignificant $\%IV_{it-1}$. This finding confirms the exceptional non-trading behavior in the Asian risk-return behavior over time. Additionally, the Asian culture (Except JP) exhibits the lowest cultural metrics (i.e., uncertainty avoidance, individualism, masculinity, indulgence) among other countries which provides them with most relaxed attitude towards high risk/uncertainty (Hofstede, 2001).

5. Contagion and spillover effects

5.1. Herding and the role of the US market

We aim to investigate the impact of fear exuberance derived from the US markets, on market risk perception ($\%IV$) in various international markets, especially during the global crisis. This feature has not been properly investigated in the literature of risk-return linkages and spillovers. We begin with the latent approach of Low (2004) and modify it by including foreign market variables. In this way, we try to distinguish the role and significance of the "*global factor*" i.e., the US market in a similar fashion to Chiang and Zheng (2010). We also explore *herding behavior* and how it affects contagion from the US to other markets. Our modified model is:

$$(A'): \%IV_{it} = \alpha + \eta_1 R_{it} + \eta_2 R^2_{it} + \eta_3 \%VIX_{it} + \eta_4 R^2_{it,m,us} \tag{6}$$

where $\%VIX_{it}$ and $R^2_{it,m,us}$ denote the innovations of risk perception and realized volatility in the US market, respectively. To overcome the geographical time difference problem we employ a one-day lag of $\%VIX_{it-1}$ and $R^2_{it-1,m,us}$ for the Asian markets including Japan (JP) and Hong Kong (HK), while the other variables are defined in the same way as before. We assume that negative (positive) shocks in the US market as well as an increase (decrease) in the *VIX* leads to a rise (decline) in foreign markets' risk perception ($\%IV_{it}$). As a consequence, we expect a positive and significant relationship between $\%VIX_{it}$ and its change in $\%IV_{it}$.

The estimation results are displayed in Table 8. The negative relationship between the changes in implied volatility and its corresponding actual market returns remains highly significant at the 1% level for all markets except the SW. This suggests that implied volatility moves in the opposite direction of market returns, namely when returns are negative its implied volatility goes up leading to an increase in fear sentiment. The modified Low (2004) model if applied in Eq. (6), generates a higher *R-squared* during the entire explored period (e.g.,$R_{EU}{}^2 = 67\% > 63\%$), which further substantiates the explanatory power of the US-added variable. The coefficient term of the US sentiment ($\%VIX_{it}$) in Table 8 is positive and highly significant across all markets except ML, MX and GC. This positive correlation implies a co-varying risk perception associated with implied volatility in global markets. Indeed, investors appear to monitor closely the US market fluctuations. The HK market shows the highest value of $\%VIX_{it} = 0.35$ (*t*-statistic = 25.09) thus domestic risk perception is highly influenced by US market sentiment, as also validated by Gang et al. (2012) who argue that fear in the HK market is basically "*imported from the US market*". Interestingly, we find significant values for the quadratic term ($R^2_{it,m,us}$) as well across all advanced and emerging markets, albeit with different signs. This also suggests that US sentiments (fear or exuberance) are transmitted across global markets, yet at a different degree of influence.

Furthermore, both the presence and magnitude of an inverse risk-return link is highly significant during the crisis period, a fact that adds more insight on contagion effects.[10] In Panel A of Table 8 we display the influence of the US market which appears to be stronger upon the four major advanced economies[11] (GR, FR, JP and the UK). A significantly high positive correlation is indicated vis-à-vis a rise in US sentiment i.e., $R_{it,\ JP} = -1.06$ with $\%VIX_{it,\ JP} = 0.09$ and $R_{it,\ UK} = -0.77$ with $\%VIX_{it,\ UK} = 0.16$. Also, cross-market evidence for the HK economy during the crisis period shows that previous US losses were translated in an abnormal increase in fear sentiment as indicated by the significant convex quadratic term $R^2_{it,m,us} = 0.05$. The HK market presents the highest positive correlation vs. the US implied volatility ($\%VIX_{it,\ crisis} = 0.39$). Our results follow Gang et al. (2012) who confirmed that the implied volatility spillover effect was only unidirectional from the US to HK and not vice-versa.

Similarly, among the emerging markets, we find that the Russian (RS) one experienced the highest increase in its risk perception during the crisis ($R_{it} = -0.89$). Indeed during the crisis, the RS market recorded the largest losses (around 70%) in its capitalization compared to all other international markets. Moreover, the high negative risk-return relationship between the US and Russian markets is substantiated by the high value of the $\%VIX_{it} = 0.41$ (*t*-statistic = 4.98). This outcome shows the significant positive correlation (contagion effect) of fear sentiment between the US and Russia.[12] The contagion effect of the US market is less pronounced in Latin American, European and South African markets. In fact, we find that $\%VIX_{it}$ and $R^2_{it,m,us}$ values are almost insignificant. This could be attributed to the difference in the institutional framework structure of those countries, among other reasons (Dungey & Gajurel, 2014).[13] Overall, it can be concluded that a shock initiated in the US affects significantly risk perception in global equity markets, especially during crisis periods. The spread of fear or panic sentiments (increase in $\%IV_{it}$) is more evident in advanced

[10] According to Dungey and Gajurel (2014), when the cross-market correlation during "crisis" periods is greater than "tranquil" periods it indicates cross country contagion effect.

[11] France, Germany, UK and Japan are qualified to be considered the largest developed economies based on their size (in terms of GPD) and in terms of market structure (Dungey & Gajurel, 2014). The French, German, and Japanese financial sectors experienced a drop of > 58%, 50% and 45% respectively, while the UK financial sector declined the most among developed countries i.e., 66%.

[12] Hwang et al. (2013) also report strong evidence of contagion between US and Russian equity markets, and Dungey and Gajurel (2014) find that US shocks explain about 57% of the Russian market volatility.

[13] For instance, European countries in their institutional framework are quite homogeneous (European Union), hence are more integrated.

Table 7
Low's and modified low's conditional OLS models for behavioral vs. leverage/feedback hypotheses during & after the global crisis.

	Subprime crisis period									Recession period and sluggish rise								
	M_1				M_2					M_1				M_2				
	α	R_{it}	R_{it-1}	R^2	α	R_{it}	R_{it-1}	$\%IV_{it-1}$	R^2	α	R_{it}	R_{it-1}	R^2	α	R_{it}	R_{it-1}	$\%IV_{it-1}$	R^2
Panel A: advanced markets																		
AU	−0.01	−0.20**	0.07 (1.13)	0.03	−0.03	−0.34***	0.02 (0.34)	−0.21**	0.06	−0.01	−0.02	0.03 (0.90)	0.00	−0.01 (−0.24)	−0.22***	0.02 (0.82)	−0.18***	0.01
	(−0.05)	(−3.19)			(−0.26)	(−4.45)		(−3.11)		(−0.33)	(−0.60)				(−4.78)		(−5.82)	
CN										0.02	−0.85***	−0.02	0.31	0.02 (0.89)	−0.85***	−0.17***	−0.18***	0.33
										(0.74)	(−28.81)	(−0.73)			(−29.14)	(−4.73)	(−7.43)	
EU	−0.13	−1.07***	−0.16***	0.63	−0.14	−1.10***	−0.19**	−0.03	0.63	(0.32)	−1.00***	0.02 (0.56)	0.66	0.01 (0.31)	−1.00***	0.03 (1.17)	0.02 (1.05)	0.66
	(−1.60)	(−27.96)	(−4.02)		(−1.63)	(−27.73)	(−3.03)	(−0.67)			(−68.29)				(−68.29)			
FR	−0.12	−0.86***	−0.36***	0.35	−0.14	−0.86***	−0.62***	−0.32***	0.42	0.02	−0.91***	−0.05**	0.55	0.02 (1.01)	−0.90***	−0.15***	−0.13***	0.56
	(−0.93)	(−15.15)	(−6.28)		(−1.18)	(−16.12)	(−9.77)	(−7.69)		(0.86)	(−54.58)	(−2.15)			(−55.26)	(−6.20)	(−6.40)	
GR	(0.28)	−0.74***	−0.06***	0.52	0.05	−0.74***	−0.01	0.08***	0.53	−0.10	−0.73***	−0.27***	0.36	−0.10 (−0.44)	−0.74***	−0.20**	0.10***	0.36
		(−64.28)	(−6.08)		(0.25)	(−63.23)	(−0.84)	(4.68)		(−0.46)	(−9.48)	(−3.54)			(−9.58)	(−2.17)	(4.79)	
HK	0.01	−0.19***	−0.01	0.11	0.01	−0.19***	−0.02	−0.08*	0.12	−0.01	−0.11***	0.01 (0.98)	0.05	−0.01 (−0.49)	−0.11***	−0.00	−0.10***	0.06
	(0.09)	(−7.73)	(−0.28)		(0.10)	(−7.76)	(−0.86)	(−1.75)		(−0.45)	(−11.32)				(−11.39)	(−0.17)	(−5.06)	
JP	−0.12	−1.24***	0.16***	0.65	−0.13	−1.23***	0.07 (1.01)	−0.08*	0.65	0.02	−0.77***	−0.08***	0.30	0.02 (0.51)	−0.77***	0.03 (0.89)	0.14***	0.32
	(−1.18)	(−29.33)	(3.89)		(−1.28)	(−29.27)		(−1.65)		(0.56)	(−32.25)	(−3.51)			(−32.31)		(7.05)	
NL	−0.10	−0.78***	−0.11**	0.55	−0.11	−0.78***	−0.16**	−0.07***	0.55	0.02	−0.99***	0.00 (0.24)	0.51	0.03 (1.17)	−1.00***	−0.13***	−0.13***	0.52
	(−1.29)	(−23.69)	(−3.26)		(−1.36)	(−23.66)	(−2.38)	(−3.57)		(1.00)	(−50.61)				(−51.17)	(−4.53)	(−6.57)	
SW	(0.09)	−0.07**	−0.07**	0.02	0.00	−0.07**	−0.09*	−0.23***	0.07	−0.00	−0.01	−0.08***	0.01	−0.00 (−0.11)	−0.02*	−0.07***	−0.18***	0.04
		(−2.20)	(−2.26)		(0.03)	(−2.11)	(−1.83)	(−5.18)		(−0.21)	(−1.04)	(−5.61)			(−1.65)	(−5.39)	(−8.85)	
UK	−0.06	−0.90***	−0.16**	0.38	−0.07	−0.85***	−0.37**	−0.24***	0.42	0.04**	−1.08***	−0.05**	0.60	0.04** (2.01)	−1.09***	−0.04	0.00 (0.17)	0.61
	(−0.55)	(−17.01)	(−3.06)		(−0.63)	(−16.13)	(−3.75)	(−5.35)		(2.02)	(−61.05)	(−2.72)			(−61.03)	(−1.57)		
US	−0.09	−1.16***	0.03 (0.47)	0.73	−0.10	−1.15***	−0.10	−0.10**	0.74	0.07**	−1.35***	0.08***	0.70	0.08***(4.28)	−1.34***	−0.04	−0.09***	0.71
	(−1.25)	(−36.48)			(−1.37)	(−36.55)	(−1.57)	(−2.15)		(3.92)	(−77.20)	(4.63)			(−76.78)	(−1.31)	(−4.59)	
Panel B: emerging markets																		
CH	−0.01	−0.38***	0.16**	0.08	−0.01	−0.39***	0.17 (1.42)	−0.02	0.09	−0.02	−0.02	−0.00	0.00	−0.02 (−0.52)	−0.02	−0.00	0.06* (1.98)	0.00
	(−0.06)	(−6.21)	(2.66)		(−0.06)	(−6.22)		(−0.48)		(−0.55)	(−1.23)	(−0.12)			(−1.18)	(−0.05)		
IN	−0.01	−0.24***	−0.11	0.03	−0.01	−0.22**	−0.17**	−0.24***	0.09	−0.01	−0.48***	0.11***	0.17	−0.01 (−0.19)	−0.49***	0.11**	−0.00	0.17
	(−0.06)	(−3.39)	(−1.56)		(−0.08)	(−3.18)	(−2.45)	(−4.87)		(−0.19)	(−16.32)	(3.33)			(−16.31)	(3.04)	(−0.01)	
KR	−0.05	−0.94***	0.04 (0.90)	0.45	−0.06	−0.91***	−0.07	−0.12**	0.46	0.00	−0.73***	0.03 (1.12)	0.43	0.00 (0.08)	−0.73***	0.02 (0.75)	−0.00	0.43
	(−0.48)	(−19.52)			(−0.53)	(−18.87)	(−1.13)	(−2.64)		(0.08)	(−31.00)				(−30.75)		(−0.14)	
ML	−0.01	−0.25***	−0.05	0.05	−0.01	−0.25***	−0.04	0.06 (1.39)	0.06	−0.00	−0.07**	−0.09***	0.02	−0.00 (−0.03)	−0.07**	−0.08***	0.16***	0.05
	(−0.23)	(−4.91)	(−1.10)		(−0.23)	(−5.03)	(−0.73)			(0.92)	(−3.10)	(−4.35)			(−3.26)	(−3.78)	(5.98)	
BR	0.01	−0.00	−0.07**	0.01	0.02	−0.08**	−0.01	0.09**	0.02	−0.01	−0.05**	−0.09***	0.01	−0.01 (−0.49)	−0.05**	−0.08***	0.11***	0.03
	(0.33)	(−0.14)	(−2.46)		(0.29)	(−2.45)	(−0.22)	(1.99)		(−0.53)	(−2.51)	(−4.43)			(−2.57)	(−4.19)	(3.81)	
MX	0.01	−0.23***	−0.00	0.08	0.01	−0.25***	−0.04	−0.21***	0.11	0.01	−0.59***	0.00 (0.15)	0.43	0.02 (0.84)	−0.59***	−0.04	−0.07**	0.44
	(0.14)	(−6.17)	(−0.02)		(0.16)	(−6.91)	(−1.25)	(−4.61)		(0.78)	(−31.35)				(−31.45)	(−1.59)	(−2.60)	
GR	0.01	−0.05	−0.20***	0.08	0.01	−0.05	−0.20***	−0.03	0.08	−0.03	−0.25***	0.02 (0.72)	0.05	−0.03 (−0.44)	−0.23***	−0.03	−0.19***	0.09
	(0.12)	(−1.64)	(−5.93)		(0.14)	(−1.61)	(−5.97)	(−0.78)		(−0.36)	(−8.12)				(−8.08)	(−0.88)	(−6.96)	
RS	−0.03	−1.01***	0.06 (0.86)	0.29	−0.04	−1.03***	−0.05	−0.10**	0.30	−0.03	−0.85***	0.03 (0.73)	0.28	−0.03 (−0.47)	−0.84***	−0.15**	−0.19***	0.30
	(−0.12)	(−14.05)			(−0.15)	(−14.11)	(−0.46)	(−2.17)		(−0.39)	(−22.40)				(−22.74)	(−3.17)	(−7.20)	
SA	−0.01	−0.35***	−0.08***	0.55	−0.01	−0.35***	−0.12**	−0.11***	0.56	0.01	−0.41***	−0.06***	0.48	0.02 (1.63)	−0.41***	−0.14***	−0.18***	0.49
	(−0.34)	(−22.97)	(−5.16)		(−0.36)	(−22.96)	(−2.49)	(−5.38)		(1.40)	(−34.26)	(−5.20)			(−34.69)	(−8.33)	(−6.54)	

Notes: We report M_1 and M_2 model regressions incorporating as well 1-day lagged implied volatility $\%IV_{it-1}$ as in Eqs. (7.a) and (7.b). The dataset comprises four market regions: the developed markets category i.e., United States (US), the United Kingdom (UK), Switzerland (SZ), Japan (JP), Hong Kong (HK), Germany (GR), Canada (CN), France (FR) and Australia (AU), the Asian markets including China (CN), India (ID), Korea (KR), Malaysia (ML), the Latin American markets i.e., Brazil (BR) and Mexico (MX), and the European and South African markets including South Africa (SA), Russia (RS) and Greece (GR). We utilize two disjoint sample periods i.e., 19/07/2007–29/05/2009 and the post-crisis period 01/06/2009–05/16/2014. The *t*-statistics are presented in parentheses; *, ** and *** denotes statistical significance at 10%, 5% and 1% levels respectively.

Table 8
The role of the US Market in risk perception & herding: empirical estimates.

	Total sample period						Financial crisis period					
Market	α	R_{it}	R^2_{it}	$\%VIX_{it}$	$R^2_{it,m,us}$	R^2	α	R_{it}	R^2_{it}	$\%VIX_{it}$	$R^2_{it,m,us}$	R^2
Panel A: contagion/spillover effects from the US to advanced markets												
AU	0.00 (0.01)	−0.13***	−0.01	0.18***	0.10**	0.01	−0.04	−0.23***	−0.02	0.12**	0.01 (1.44)	0.07
		(−4.08)	(−0.63)	(5.35)	(2.06)	0.04	(−0.28)	(−3.67)	(−0.99)	(3.24)		
CN	−0.06	−0.68***	0.15***	0.13***	−0.03	0.33						
	(−1.56)	(−12.80)	(4.38)	(4.64)	(−1.56)	0.35						
EU	−0.08***	−0.81***	0.05***	0.20***	−0.04***	0.63	−0.22**	−0.99***	0.07*** (8.85)	0.13***	−0.04***	0.67
	(−4.27)	(−62.42)	(16.07)	(17.26)	(−9.18)	0.67	(−2.58)	(−23.12)		(4.32)	(−5.61)	
FR	−0.07**	−0.63***	0.02*** (3.65)	0.16***	0.02*** (4.14)	0.36	−0.26*	−0.71***	0.01 (0.47)	0.16**	0.03** (2.95)	0.30
	(−2.85)	(−36.07)		(9.98)		0.39	(−1.88)	(−10.45)		(3.07)		
GR	−0.11***	−0.64***	0.56***	0.18***	−0.01***	0.56	−0.30**	−0.73***	0.83*** (8.78)	0.10**	−0.02**	0.46
	(−5.84)	(−51.84)	(16.78)	(15.65)	(−4.12)	0.59	(−3.27)	(−14.87)		(3.04)	(−2.50)	
HK	0.03 (0.15)	−0.08***	6.90E-05 (0.95)	0.35***	0.04*** (4.92)	0.06	0.05	−0.14***	0.00 (0.79)	0.39***	0.05** (2.99)	0.14
		(−13.85)		(25.09)		0.08	(0.39)	(−6.15)		(9.52)		
JP	−0.23***	−0.61***	0.11***	0.18***	0.04*** (5.23)	0.50	−0.47***	−1.06***	0.07*** (8.37)	0.09**	−0.01	0.73
	(−10.15)	(−37.88)	(29.11)	(12.57)		0.52	(−4.70)	(−22.68)		(2.68)	(−0.62)	
NL	−0.05**	−0.67***	0.03***	0.17***	−0.02***	0.51	−0.13 (0.10)	−0.66***	0.03*** (4.59)	0.16***	−0.02**	0.58
	(−2.60)	(−49.40)	(10.69)	(14.24)	(−4.62)	0.54		(−17.43)		(5.49)	(−2.62)	
SW	−0.16***	0.02** (2.17)	0.12***	0.02**	−0.02***	0.35	−0.31***	0.05** (1.90)	0.11***	0.03	−0.01**	0.51
	(−13.63)		(42.40)	(2.94)	(−6.38)	0.36	(−6.24)		(16.98)	(1.53)	(−2.28)	
UK	−0.05**	−0.84***	0.07***	0.15***	−0.02***	0.52	−0.22**	−0.87***	0.08*** (6.71)	0.16***	−0.02**	0.66
	(−2.72)	(−50.20)	(14.01)	(12.08)	(−6.13)	0.54	(−1.91)	(−13.12)		(4.09)	(−3.07)	
Panel B: contagion/spillover effects from the US to emerging markets												
CH	−0.01	−0.07***	0.00** (2.41)	0.43***	−0.05***	0.01	−0.24	−0.33***	0.03** (2.52)	0.26***	0.00 (0.21)	0.48
	(−0.25)	(−6.09)		(29.41)	(−5.48)	0.20	(−1.36)	(−5.40)		(5.13)		
IN	0.00 (0.03)	−0.28***	−0.00	0.18***	0.03** (2.39)	0.06	−0.01	−0.20**	−0.00	0.19***	0.00 (0.01)	0.04
		(−8.86)	(−0.15)	(7.45)		0.07	(−0.04)	(−2.85)	(−0.11)	(3.34)		
KR	−0.09***	−0.63***	0.03*** (7.74)	0.18***	0.04*** (6.66)	0.43	−0.36**	−0.81***	0.02** (3.32)	0.17***	0.03*** (4.08)	0.53
	(−3.76)	(−38.77)		(14.21)		0.45	(−3.29)	(−16.86)		(4.86)		
ML	−0.01	−0.09***	0.00** (2.75)	0.00 (0.42)	0.01** (2.39)	0.02	−0.24***	0.01 (0.20)	0.18***	0.00	−0.00	0.47
	(−0.87)	(−5.26)				0.02	(−4.68)		(18.39)	(0.29)	(−0.66)	
BR	−0.24***	−0.04**	0.08*** (4.89)	0.05***	−0.03***	0.32	−0.39***	−0.01	0.06***	0.03	−0.01	0.41
	(−13.74)	(−3.12)		(3.81)	(−5.66)	0.34	(−5.62)	(−0.16)	(11.13)	(0.56)	(−1.38)	
MX	−0.06**	−0.30***	0.04*** (9.74)	−0.02	0.01*** (3.39)	0.18	−0.22**	−0.26***	0.04*** (5.02)	−0.04*	0.01** (2.38)	0.18
	(−3.12)	(−22.27)		(−1.54)		0.21	(−2.67)	(−7.28)		(−1.69)		
GR	−0.06	−0.18***	0.02*** (4.53)	0.03 (1.17)	−0.01	0.04	0.05 (0.47)	−0.07**	0.00 (0.62)	0.05	−0.02	0.01
	(−1.39)	(−10.12)			(−1.23)	0.05		(−1.97)		(1.38)	(−0.88)	
RS	−0.14**	−0.75***	0.04***	0.21***	−0.04***	0.30	−0.24	−0.89***	0.04*** (5.67)	0.41***	−0.05**	0.41
	(−1.94)	(−23.71)	(11.71)	(6.02)	(−3.72)	0.32	(−0.91)	(−12.66)		(4.98)	(−2.40)	
SA	−0.03**	−0.37***	0.03*** (9.48)	0.02**	−0.02***	0.52	−0.10**	−0.35***	0.04*** (6.06)	0.01	−0.01**	0.56
	(−2.19)	(−40.50)		(2.74)	(−3.68)	0.53	(−2.46)	(−21.71)		(1.06)	(−2.41)	

Notes: The estimated coefficients are derived from Eq. (6) with 1-daily lag for the advanced and emerging markets. The *Adjusted R-squared* is estimated for the original and modified Low (2004) model in Eq. (6). The numbers in parenthesis are *t*-Statistics. *, ** and *** denotes statistical significance at 10%, 5% and 1% levels respectively.

markets - being highly integrated with the US - than in the emerging ones, with the sole exception of Russia.

5.2. Co-movement and volatility transmission: a causality analysis

Further attempt to detect global contagion of risk is conducted via a VAR framework and the implementation of a Granger causality set-up. We examine whether perceived risk in the US equity market ($\%VIX_{it}$) is conveyed to the other major ones especially during the crisis period. According to Granger (1980), a random variable Y_t (aka the US market in our model) causes another random variable X_t (European, Asian and other markets) through a VAR modeling approach as:

$$X_t = \gamma_0 + \sum_{i=1}^{k} \alpha_i X_{t-i} + \sum_{i=1}^{k} \beta_i Y_{t-i} + \varepsilon_t \qquad i = 1, \dots, n \tag{7.a}$$

$$Y_t = \alpha_0 + \sum_{i=1}^{k} \gamma_i Y_{t-i} + \sum_{i=1}^{k} \phi_i X_{t-i} + \varepsilon'_t \qquad i = 1, \dots, n \tag{7.b}$$

We formulate $X_t = \Delta V_{m,\ t}$ as the percentage change in foreign market implied volatility and Y_t as the $\%VIX_t$ (or $R_{t,\ us}$) US variable. Short-run causality is tested via the rejection of the null hypothesis that β_i (γ_i) equals zero using the *F*- or χ^2-square statistics. We utilize the Block Exogeneity Wald-test to measure and compare the strength of each variable's response to innovations by the other variables.[14] We use a three-dimensional VAR model ($K = 3$) where X_1 refers to r_t^{us}, X_2 represents $\%VIX_t$ and X_3 symbolizes any other market % change in the implied volatility [$\%IV_{AU,\ t}, \dots \%IV_{SA,\ t}$]. There after we illustrate the *k*th order, VAR- Causality/Block Exogeneity specification model:

$$Y_t = \begin{bmatrix} r_t^{us} \\ \%VIX_t \\ \%IV_{AU,t} \\ \vdots \\ \%IV_{SA,t} \end{bmatrix} = \alpha_0 + \alpha_1 \begin{bmatrix} r_{t-1}^{us} \\ \%VIX_{t-1} \\ \%IV_{AU,t-1} \\ \vdots \\ \%IV_{SA,t-1} \end{bmatrix} + \dots + \alpha_p \begin{bmatrix} r_{t-p}^{us} \\ \%VIX_{t-p} \\ \%IV_{AU,t-p} \\ \vdots \\ \%IV_{SA,t-p} \end{bmatrix} + \zeta_t \tag{8}$$

In the LHS we include the vector of US market returns (r_t^{us}) and nineteen implied volatility indices ($\%IV_{AU,\ t}, \dots \%IV_{SA,\ t}$) while *p* is the number of lags determined based on the Schwarz criterion. The coefficient term α_0 is a (20 × 1) vector where $\alpha_p$stands for the *i*th coefficient matrix (20 × 20) associated with the lagged independent vector. The

[14] For further discussion on VAR modeling and causality measurement see Dufour, Garcia, and Taamouti (2012).

Table 9
Granger causality/block exogeneity testing.

Variables	Panel A: total sample period					Panel B: crisis period				
	VAR model		Granger causality tests			VAR model		Granger causality tests		
	$\%VIX_t$	$R_{it-1,\ US}$	χ^2	df	Prob.	$\%VIX_t$	$R_{it-1,\ US}$	χ^2	df	Prob.
Advanced markets										
%VIX	−0.32***	0.00				0.14	0.03			
	(−4.18)	(0.01)				(0.80)	(0.14)			
US	0.10*	0.02	3.42	2	0.13	−0.01	0.00	11.33	2	0.00
	(1.98)	(0.27)				(−0.06)	(0.02)			
AU	0.17**	−0.36***	540.59	2	0.00	0.44***	−0.01	222.66	2	0.00
	(2.82)	(−4.41)				(4.21)	(−0.10)			
CN	0.19***	0.12	59.67	2	0.00					
	(3.19)	(1.42)								
EU	0.20***	−0.11	249.29	2	0.00	0.55***	−0.14	115.48	2	0.00
	(3.07)	(−1.00)				(3.30)	(−0.63)			
FR	0.17***	−0.16	254.62	2	0.00	0.25	−0.04	108.06	2	0.00
	(2.24)	(−1.44)				(1.29)	(−0.25)			
GR	0.20***	−0.11	234.36	2	0.00	0.47***	0.02	94.92	2	0.00
	(3.07)	(−1.12)				(3.13)	(0.13)			
HK	0.36***	−0.08	626.29	2	0.00	0.48***	−0.16	135.55	2	0.00
	(6.40)	(−1.08)				(3.42)	(−0.85)			
JP	0.00	−0.27*	320.45	2	0.00	0.35**	−0.30**	175.32	2	0.00
	(0.05)	(−1.92)				(2.81)	(−2.25)			
NL	0.22***	−0.14	248.11	2	0.00	0.36**	0.12	79.83	2	0.00
	(3.02)	(−1.32)				(2.86)	(1.35)			
SW	−0.07**	−0.09**	6.26	2	0.04	0.21	−0.36	6.32	2	0.04
	(−2.35)	(−2.15)				(1.28)	(−1.89)			
UK	0.22**	−0.21**	381.96	2	0.00	0.01	−0.30**	105.45	2	0.00
	(3.30)	(−2.14)				(0.07)	(−2.48)			
Emerging markets										
Asia										
CH	0.36***	−0.12	252.09	2	0.00	0.76***	0.41**	64.83	2	0.00
	(6.14)	(−1.38)				(4.42)	(2.21)			
IN	0.14**	−0.11	84.56	2	0.00	0.42**	0.12	12.99	2	0.00
	(2.60)	(−1.41)				(2.57)	(0.85)			
KR	0.25***	−0.06	478.47	2	0.00	0.53***	−0.08**	138.01	2	0.00
	(4.82)	(−0.81)				(4.05)	(−2.01)			
ML	0.00	0.03	11.50	2	0.00	0.34***	−0.03	0.77		0.67
	(0.06)	(0.99)				(3.57)	(−0.27)			
Latin America										
BR	0.03	−0.11	15.32	2	0.00	−0.02	−0.09	6.99	2	0.03
	(0.59)	(−1.66)				(−0.24)	(−079)			
MX	0.08*	0.01	44.60	2	0.00	0.01	−0.05	6.31	2	0.04
	(1.90)	(0.21)				(0.09)	(−0.46)			
Europe & South Africa										
GR	0.25	0.39*	11.08	2	0.01	−0.03	−0.22	5.63	2	0.06
	(1.77)	(1.93)				(−0.26)	(−0.42)			
RS	0.27***	−0.35**	117.84	2	0.00	0.25	−0.05	27.44	2	0.00
	(2.68)	(−2.39)				(0.55)	(−0.68)			
SA	−0.01	−0.12***	103.27	2	0.00	0.07	0.03	58.89	2	0.00
	(−0.41)	(−2.94)				(1.11)	(0.14)			

Notes: The table reports Granger causality/block exogeneity (chi-square) Wald tests for the specification in Eqs. (7.a) and (7.b). The entire sample period is used for each market as well as for the crisis period namely 19 July 2007–29 May 2009. The variables include the S&P500 Composite Index (US) and percentage changes in implied volatility %VIX (US), S&P/ASX 200 VIX (AU), S&P/TSX60VIX (CN), VSTOXX (EU), VCAC40 (FR), VDAX 30 (GR), VHSI (HK), VXJ (JP), VAEX (NL), VSMI (SW), VFTSE 100 (UK). Also for the Asian emerging markets we include ASCNCHIX (CH), India VIX (IN), VKOSPI (KR), FBMKLCIV (ML); for the Latin American markets the Brazil VIX IBOV (BR), VIMEX (MX) is included and finally for Europe & South Africa the Greek implied volatility index is incorporated as "GRIV" (GR), along with the Russell 2000 Volatility Index (RS) and the South African Index as "SAVI" (SA). The lag structure of AR indicates that no root lies outside the unit circle, hence the VAR modeling satisfies the stability condition. The *t*-statistics are in parentheses; *, ** and *** denote statistical significance at 10%, 5% and 1% level respectively.

$\zeta_t = (\zeta_{1t}, \ldots, \zeta_{kt})$ is a $(k \times 1)$ vector of independent error terms with zero means and a normally distributed covariance matrix. Under a bivariate context, we analyze each implied volatility variable vis-à-vis its response to innovations from the US market. The Schwarz criterion indicates an optimal two lagged-terms' specification for the independent variables.

VAR modeling is employed separately during normal and crisis periods in order to determine whether the lead-lag relationship in market sentiment changed or not. The results of the causality tests derived from Eqs. (7.a), (7.b) and (8) are presented in Tables 9 and 10. The pairwise Granger causality (Table 10, Panel A) shows clearly that the US market is unsurprisingly the most influential among all other markets in our sample. Indeed, the lead-lag relationship $VIX_{-1} \leftrightarrow \%IV$ is relatively large in magnitude, positive and statistically significant for most markets, except JP, ML BR, GC, SA. However, none of the European markets (except SW) or any of the emerging markets has a

Table 10
Vector Autoregression model (VAR) estimation results.

	%VIX	US	AU	CN	EU	FR	GR	HK	JP	NL	SW	UK	CH	IN	KR	ML	BR	MX	GR	RS	SF
Panel A: total sample periods																					
VIX(−1)	**−0.32**	**0.10**	**0.16**	**0.19**	**0.20**	**0.17**	**0.20**	**0.36**	0.00	**0.22**	**−0.07**	**0.22**	**0.36**	**0.14**	**0.25**	0.00	0.03	**0.08**	0.25	**0.27**	−0.01
	(−4.18)	**(1.98)**	**(2.82)**	**(3.19)**	**(2.55)**	**(2.24)**	**(3.07)**	**(6.40)**	0.05	**(3.05)**	**(−2.35)**	**(3.30)**	**(6.14)**	**(2.60)**	**(4.82)**	(0.06)	(0.59)	**(1.98)**	(1.77)	**(2.68)**	(−0.41)
US(−1)	0.00	0.02	**−0.36**	0.12	−0.11	−0.16	−0.11	−0.08	**−0.27**	−0.14	**−0.09**	**−0.21**	−0.12	−0.11	−0.06	0.03	−0.11	0.01	**0.39**	**−0.35**	**−0.12**
	(0.01)	(0.27)	**(−4.41)**	(1.42)	(−1.00)	(−1.44)	(−1.12)	(−0.96)	**(−1.92)**	(−1.32)	**(−2.15)**	**(−2.14)**	(−1.38)	(−1.41)	(−0.81)	(0.99)	(−1.66)	(0.21)	**(1.93)**	**(−2.39)**	**(−2.94)**
AU(−1)	**−0.17**	0.04	**−0.31**	0.01	−0.08	0.03	−0.06	−0.03	−0.08	−0.09	**−0.05**	−0.08	−0.04	−0.05	−0.05	0.03	0.06	−0.05	−0.15	0.03	0.00
	(−2.96)	−1.13	**(−7.26)**	(0.29)	(−1.27)	(0.49)	(−1.30)	(−0.68)	(−1.08)	(−1.68)	**(−2.07)**	(−1.69)	(−0.98)	(−1.14)	(−1.37)	(1.96)	(1.84)	(−1.55)	(−1.38)	(0.41)	(−0.03)
CN(−1)	0.10	−0.04	−0.04	**−0.31**	0.08	0.04	0.04	**−0.11**	0.12	0.10	0.03	**0.10**	**−0.17**	**−0.09**	**−0.12**	0.00	**−0.11**	−0.03	−0.01	**−0.32**	**0.05**
	(1.61)	(−1.12)	(−0.90)	**(−6.69)**	(1.40)	(0.68)	(0.87)	**(−2.58)**	(1.62)	(1.86)	(1.23)	**(1.99)**	**(−3.89)**	**(−2.24)**	**(−3.07)**	(−0.02)	**(−3.29)**	(−0.78)	(−0.08)	**(−4.17)**	**(2.24)**
EU(−1)	0.05	−0.01	**0.27**	−0.08	−0.11	**0.32**	0.04	0.11	0.06	0.14	−0.02	0.08	0.05	0.07	0.05	0.02	**−0.14**	−0.05	−0.33	0.15	−0.07
	(0.39)	(−0.18)	**(2.98)**	(−0.84)	(−0.87)	**(2.57)**	(0.40)	(1.14)	(0.39)	(1.22)	(−0.44)	(0.75)	(0.48)	(0.74)	(0.57)	(0.64)	**(−1.96)**	(−0.72)	(−1.45)	−0.91	(−1.51)
FR(−1)	0.00	0.02	**−0.25**	−0.01	0.10	**−0.33**	0.03	−0.07	**0.02**	0.14	0.04	0.06	−0.01	**−0.13**	**−0.11**	−0.03	0.03	−0.03	0.10	−0.17	0.05
	(0.03)	(0.48)	**(−4.33)**	(−0.22)	(1.21)	**(−4.34)**	(0.43)	(−1.27)	**(0.23)**	(1.89)	(1.22)	(0.87)	(−0.14)	**(−2.28)**	**(−2.05)**	(−1.09)	(0.59)	(−0.76)	(0.68)	(−1.64)	(1.82)
GR(−1)	−0.02	−0.01	0.01	0.10	−0.06	−0.17	−0.11	0.03	0.05	−0.03	0.04	−0.08	0.00	−0.04	0.05	0.00	−0.04	0.06	0.37	−0.05	0.03
	(−0.16)	(−0.09)	−0.07	(0.97)	(−0.46)	(−1.34)	(−0.96)	−0.32	(0.29)	(−0.24)	(0.76)	(−0.74)	(0.02)	(−0.45)	(0.58)	(0.07)	(−0.54)	(0.85)	(1.54)	(−0.33)	(0.73)
HK(−1)	**0.16**	**−0.10**	0.00	**−0.14**	0.00	−0.05	−0.03	**−0.39**	−0.16	0.03	0.04	0.09	0.09	0.00	−0.08	−0.02	0.02	**0.10**	0.25	0.06	0.05
	(2.06)	**(−2.05)**	(0.06)	**(−2.26)**	(0.05)	(−0.60)	(−0.49)	**(−6.77)**	(−1.59)	(0.48)	(1.22)	(1.30)	(1.56)	(−0.07)	(−1.47)	(−0.66)	(0.36)	**(2.20)**	(1.75)	(0.59)	(1.74)
JP(−1)	**0.21**	**−0.10**	**0.07**	0.04	**0.17**	**0.16**	**0.13**	0.04	**0.23**	**0.13**	0.01	**0.10**	**0.09**	0.03	0.00	−0.01	**0.04**	**0.06**	−0.01	0.04	**0.04**
	(6.50)	**(−4.65)**	**(3.05)**	(1.79)	**(5.09)**	**(5.12)**	**(4.63)**	(1.76)	**(5.73)**	**(4.34)**	(0.55)	**(3.60)**	**(3.70)**	(1.24)	(0.23)	(−0.66)	**(2.26)**	**(3.37)**	(−0.16)	(1.06)	**(3.21)**
SW(−1)	**−0.24**	0.07	**−0.20**	**−0.20**	0.08	−0.03	−0.06	**−0.20**	−0.09	−0.05	**0.11**	−0.13	**−0.20**	0.01	**−0.17**	0.01	0.05	−0.07	−0.05	−0.23	0.00
	(−2.56)	(1.20)	**(−2.95)**	**(−2.75)**	(−0.90)	(−0.35)	(−0.82)	**(−2.99)**	(−0.78)	(−0.59)	**(3.06)**	(−1.67)	**(−2.90)**	(0.16)	**(−2.69)**	(0.44)	(0.86)	(−1.28)	(−0.30)	(−1.89)	(−0.08)
UK(−1)	0.03	0.06	**0.13**	0.03	−0.03	0.00	−0.03	0.05	0.12	0.05	0.04	**−0.26**	0.06	**0.13**	**0.13**	0.00	0.09	0.06	0.03	0.17	**−0.07**
	(0.31)	(1.00)	**(1.92)**	(0.45)	(−0.35)	(0.05)	(−0.35)	(0.74)	(1.01)	(0.57)	(1.10)	**(−3.33)**	(0.85)	**(1.97)**	**(2.15)**	(0.03)	(1.69)	(1.09)	(0.21)	(1.39)	**(−2.15)**
CH(−1)	0.15	−0.06	0.00	**0.19**	0.06	0.09	0.06	**0.12**	0.14	0.10	**−0.08**	0.08	**−0.28**	0.06	**0.11**	−0.03	−0.02	0.08	−0.01	0.12	0.04
	(1.83)	(−1.07)	(0.06)	**(2.93)**	(0.74)	(1.12)	(0.84)	**(2.05)**	(1.38)	(1.30)	**(−2.45)**	(1.14)	**(−4.53)**	(0.99)	**(2.03)**	(−1.14)	(−0.42)	(1.64)	(−0.09)	(1.09)	(1.37)
IN(−1)	−0.09	0.04	0.04	−0.03	−0.09	−0.08	−0.05	0.02	−0.02	**−0.11**	−0.02	−0.03	−0.02	−0.07	0.00	0.00	0.04	0.01	−0.04	−0.01	−0.03
	(−1.64)	(1.08)	(0.95)	(−0.60)	(−1.72)	(−1.52)	(−1.16)	(0.41)	(−0.37)	**(−2.23)**	(−1.01)	(−0.75)	(−0.41)	(−1.87)	(0.02)	(−0.10)	(1.19)	(0.44)	(−0.36)	(−0.21)	(−1.67)
KR(−1)	−0.02	0.08	**−0.11**	0.08	0.04	0.09	0.06	−0.04	**−0.17**	0.08	0.03	−0.03	0.00	**−0.11**	**−0.19**	0.02	0.01	−0.03	−0.01	−0.10	**−0.05**
	(−0.33)	(1.72)	**(−2.21)**	(1.59)	(0.56)	(1.31)	(1.02)	(−0.95)	**(−1.96)**	(1.19)	(1.30)	(−0.56)	(−0.05)	**(−2.24)**	**(−4.08)**	−0.84	−0.21	(−0.76)	(−0.05)	(−1.15)	**(−2.26)**
ML(−1)	−0.09	0.07	0.04	−0.01	−0.16	−0.21	−0.11	−0.01	0.13	−0.14	−0.01	−0.12	−0.04	−0.07	−0.04	**0.14**	0.10	−0.09	0.04	0.18	−0.05
	(−0.78)	(0.91)	(0.40)	(−0.13)	(−1.25)	(−1.76)	(−1.05)	(−0.11)	(0.87)	(−1.20)	(−0.18)	(−1.09)	(−0.39)	(−0.84)	(−0.43)	**(3.90)**	(1.39)	(−1.26)	(0.19)	(1.16)	(−1.14)
BR(−1)	0.04	−0.04	0.06	**0.18**	**0.21**	**0.21**	**0.19**	**0.25**	**0.21**	**0.22**	**0.10**	**0.15**	**0.18**	**0.10**	**0.12**	**0.04**	0.05	**0.09**	−0.09	**0.31**	**0.07**
	(0.60)	(−0.87)	(1.24)	**(3.61)**	**(3.23)**	**(3.44)**	**(3.51)**	**(5.43)**	**(2.64)**	**(3.82)**	**(4.17)**	**(2.67)**	**(3.82)**	**(2.26)**	**(2.79)**	**(2.17)**	(1.38)	**(2.45)**	(−0.80)	**(3.76)**	**(3.02)**
MX(−1)	0.10	−0.06	**0.12**	0.09	0.01	0.00	0.03	**0.17**	−0.13	−0.02	−0.03	0.00	**0.14**	0.07	**0.23**	**0.08**	**0.12**	**−0.10**	−0.19	0.11	0.02
	(1.11)	(−1.04)	**(1.89)**	(1.32)	(0.13)	(0.04)	−0.37	**(2.58)**	(−1.12)	(−0.25)	(−0.92)	(−0.05)	**(2.11)**	(1.07)	**(3.81)**	**(2.87)**	**(2.41)**	**(−1.94)**	(−1.18)	(0.98)	(0.76)
GR(−1)	−0.02	0.01	−0.01	−0.01	−0.01	−0.01	−0.01	0.02	0.04	0.00	0.01	0.00	−0.01	**−0.03**	−0.02	0.00	0.00	−0.01	−0.24	**−0.06**	−0.01
	(−0.96)	(0.64)	(−0.53)	(−0.95)	(−0.58)	(−0.84)	(−0.67)	(1.38)	(1.65)	(−0.26)	(1.29)	(−0.19)	(−0.94)	**(−2.03)**	(−1.13)	(0.67)	(0.00)	(−0.53)	(−6.65)	**(−2.32)**	(−0.74)
RS(−1)	−0.06	0.00	0.00	**0.08**	0.00	−0.03	0.03	**0.05**	−0.02	0.01	0.00	0.00	0.03	−0.01	**0.10**	0.00	−0.03	−0.02	**0.12**	**−0.19**	−0.01
	(−1.75)	(0.09)	(0.16)	**(3.04)**	(0.08)	(−0.86)	(1.20)	**(1.97)**	(−0.43)	(0.47)	(0.23)	−0.01	−1.03	(−0.33)	**(4.69)**	(−0.18)	(−1.71)	(−1.29)	**(2.00)**	**(−4.51)**	(−0.85)
SF(−1)	−0.10	0.01	0.00	−0.12	−0.18	−0.17	−0.17	**−0.26**	0.12	−0.21	0.02	**−0.24**	**−0.31**	−0.14	**−0.20**	**0.10**	−0.03	**−0.14**	0.25	**−0.32**	**−0.10**
	(−0.90)	(0.16)	(−0.01)	(−1.4)	(−1.61)	(−1.55)	(−1.81)	**(−2.99)**	(0.83)	(−2.06)	(0.54)	**(−2.51)**	**(−3.70)**	(−1.71)	**(−2.67)**	**(2.93)**	(−0.39)	**(−2.30)**	(1.21)	**(−2.19)**	**(−2.49)**
Panel B: crisis period																					
VIX(−1)	0.14	−0.01	**0.44**		**0.55**	0.25	**0.47**	**0.48**	**0.35**	**0.35**	0.21	0.01	**0.76**	**0.42**	**0.53**	**0.34**	−0.02	0.01	−0.03	0.25	0.07
	(0.80)	(−0.06)	**(4.21)**		**(3.30)**	(1.29)	**(3.13)**	**(3.42)**	**(2.81)**	**(2.86)**	(1.28)	(0.07)	**(4.42)**	**(2.57)**	**(4.05)**	**(3.57)**	(−0.24)	(0.09)	(−0.26)	(0.55)	(1.11)
US(−1)	0.03	0.00	−0.01		−0.14	−0.04	0.02	−0.16	**−0.30**	0.12	−0.36	**−0.30**	**0.41**	0.12	**−0.08**	−0.03	−0.09	−0.05	−0.22	−0.05	0.03
	(0.14)	(0.02)	(−0.10)		(−0.63)	(−0.25)	(0.13)	(−0.85)	**(−2.25)**	(1.35)	(−1.89)	**(−2.48)**	**(2.21)**	(0.85)	**(−2.01)**	(−0.27)	(−0.79)	(−0.46)	(−0.42)	(−0.68)	(0.14)
AU(−1)	0.04	−0.07	**−0.20**		−0.03	0.09	−0.21	**−0.31**	0.05	−0.01	0.30	**0.18**	0.24	−0.20	−0.02	0.06	−0.07	−0.19	**−0.12**	−0.04	0.04
	(0.25)	(−0.50)	**(−3.55)**		(−0.19)	(0.63)	(−1.57)	**(−1.95)**	(0.36)	(−0.07)	(1.88)	**(2.05)**	(1.53)	(−1.60)	(−0.60)	(0.62)	(−0.80)	(−1.88)	**(−2.14)**	(−0.08)	(0.25)
EU(−1)	−0.10	0.11	**0.27**		**−0.45**	**0.51**	**0.43**	0.06	−0.06	**0.33**	−0.14	**0.55**	0.20	0.07	0.00	−0.06	**0.24**	**−0.25**	**−0.21**	−0.04	−0.10
	(−0.99)	(1.35)	**(1.99)**		**(−4.01)**	**(2.76)**	**(3.14)**	(0.64)	(−0.68)	**(2.45)**	(−1.48)	**(3.60)**	(2.09)	(1.02)	(−0.11)	(−1.19)	**(2.41)**	**(−2.59)**	**(−2.17)**	(−1.15)	(−0.99)
FR(−1)	0.52	−0.48	0.19		−0.01	**−0.43**	0.51	0.15	0.06	−0.09	0.14	0.51	0.10	**0.19**	0.00	−0.10	0.13	**−0.10**	0.26	0.16	0.52
	(2.29)	(−0.59)	(0.45)		(−0.05)	**(−5.42)**	(0.90)	(0.70)	(0.29)	(−0.87)	(0.64)	(2.34)	(0.46)	**(2.19)**	(−0.10)	(−0.83)	(1.08)	**(−2.63)**	(0.45)	(1.99)	(2.29)
GR(−1)	**0.57**	**−0.45**	**0.20**		0.15	0.15	−0.09	**0.431**	−0.03	−0.05	−0.02	0.43	**0.50**	−0.12	**0.33**	0.07	−0.15	0.30	**0.25**	0.00	**0.13**
	(3.56)	**(−3.47)**	**(2.09)**		(0.76)	(0.97)	(−0.66)	**(3.31)**	(−0.19)	(−0.55)	(−0.10)	(1.48)	**(2.91)**	(−0.95)	**(2.97)**	(0.70)	(−1.45)	(3.01)	**(2.77)**	(−0.05)	**(2.17)**
HK(−1)	0.08	−0.10	−0.01		0.17	−0.05	−0.14	**−0.29**	−0.04	−0.01	−0.17	−0.13	0.02	−0.09	**−0.25**	−0.08	0.10	−0.06	**0.27**	−0.05	0.08
	(0.72)	(−1.05)	(−0.10)		(1.39)	(−0.48)	(−1.62)	**(−2.64)**	(−0.37)	(−0.20)	(−1.54)	(−1.20)	(0.21)	(−1.11)	**(−3.01)**	(−1.33)	(1.65)	(−0.91)	**(4.45)**	(−1.25)	(0.72)
JP(−1)	−0.03	−0.27	−0.15		−0.15	−0.24	−0.09	0.08	**−0.43**	−0.10	−0.36	**−0.15**	0.11	−0.11	−0.04	−0.21	0.38	0.01	0.33	**−0.63**	−0.03
	(−0.18)	(−1.67)	(−1.29)		(−0.69)	(−1.51)	(−0.60)	(0.42)	**(−2.53)**	(−1.14)	(−1.93)	**(−2.26)**	(0.63)	(−0.80)	(−1.13)	(−2.05)	(3.51)	(0.12)	(0.66)	**(−3.47)**	(−0.18)

(*continued on next page*)

Table 10 (*continued*)

	%VIX	US	AU	CN	EU	FR	GR	HK	JP	NL	SW	UK	CH	IN	KR	ML	BR	MX	GR	RS	SF
SW(−1)	0.38	**−0.25**	−0.03		0.25	0.28	−0.04	−0.34	0.07	**0.20**	0.18	0.18	−0.07	−0.09	0.01	0.06	−0.02	−0.05	0.07	0.03	0.38
	(1.79)	**(−2.03)**	(−0.26)		(1.10)	(1.61)	(−0.22)	(−1.72)	(0.38)	**(2.06)**	(0.93)	(0.91)	(−0.36)	(−0.59)	(0.34)	(0.56)	(−0.16)	(−0.46)	(0.12)	(0.39)	(1.79)
UK(−1)	**−0.35**	**0.22**	−0.05		**−0.42**	**−0.39**	**−0.46**	−0.10	0.02	**−0.25**	−0.17	**−0.58**	**−0.34**	0.11	**−0.24**	−0.04	**0.13**	**−0.23**	−0.03	**−0.35**	0.00
	(−2.65)	**(2.06)**	(−0.72)		**(−3.46)**	**(−2.73)**	**(−4.21)**	(−0.79)	(0.35)	**(−2.22)**	(−1.37)	**(−4.65)**	**(−2.70)**	(1.53)	**(−2.59)**	(−0.61)	**(2.63)**	**(−2.05)**	(−0.17)	**(−2.65)**	(0.04)
CH(−1)	−0.39	0.25	−0.05		−0.02	−0.18	−0.13	0.03	0.01	0.19	0.16	0.17	**−0.60**	−0.07	0.02	0.16	0.11	−0.22	**−0.19**	−0.01	−0.39
	(−1.27)	(1.77)	(−0.47)		(−0.10)	(−1.24)	(−0.99)	(0.18)	(0.09)	(1.40)	(0.98)	(1.76)	**(−3.36)**	(−0.54)	(0.45)	(1.70)	(1.18)	(−1.35)	**(−3.15)**	(−0.16)	(−1.27)
IN(−1)	−0.12	0.09	0.07		−0.01	0.07	0.01	−0.05	0.15	0.00	0.05	−0.03	−0.01	**−0.33**	0.06	0.02	0.04	0.01	**0.10**	0.03	−0.12
	(−1.34)	(1.28)	(1.37)		(−0.11)	(0.72)	(0.08)	(−0.77)	(1.77)	(0.04)	(1.17)	(−0.38)	(−0.16)	**(−4.05)**	(0.97)	(0.45)	(0.20)	(0.05)	**(2.11)**	(1.08)	(−1.34)
KR(−1)	−0.10	0.00	−0.06		−0.29	−0.25	0.13	0.02	0.00	−0.09	−0.10	−0.10	−0.09	−0.17	**−0.30**	0.00	−0.08	−0.02	0.78	−0.01	−0.10
	(−0.57)	(−0.03)	(−0.63)		(−1.59)	(−1.80)	(0.96)	(0.11)	(−0.01)	(−1.13)	(−0.62)	(−0.60)	(−0.56)	(−1.41)	**(−3.67)**	(0.04)	(−0.83)	(−0.27)	(1.80)	(−0.25)	(−0.57)
ML(−1)	−0.73	0.06	0.02		−0.04	−0.64	−0.16	0.18	−0.62	0.05	−0.13	−0.55	0.30	−0.49	−0.06	**0.44**	−0.13	−0.10	0.51	−0.13	−0.73
	(−1.79)	(0.17)	(0.08)		(−0.08)	(−1.92)	(−0.52)	(0.46)	(−1.78)	(0.27)	(−0.33)	(−1.42)	(0.80)	(−1.69)	(−0.73)	**(2.04)**	(−0.57)	(−0.45)	(0.49)	(−0.94)	(−1.79)
BR(−1)	−0.16	0.18	0.01		−0.15	0.05	−0.02	0.03	0.09	0.05	−0.02	−0.15	0.09	0.12	−0.03	0.07	0.13	**0.12**	0.27	−0.03	−0.16
	(−0.94)	(1.26)	(0.10)		(−0.81)	(0.38)	(−0.14)	(0.22)	(0.61)	(0.60)	(−0.13)	(−0.91)	(0.56)	(1.02)	(−0.81)	(0.76)	(1.35)	**(2.08)**	(0.61)	(−0.52)	(−0.94)
MX(−1)	**0.26**	0.05	−0.09		**0.26**	**0.36**	**0.18**	−0.08	**0.35**	0.07	−0.19	**0.18**	**0.34**	−0.05	0.02	0.14	0.01	**−0.13**	0.34	−0.01	0.06
	(2.77)	(0.42)	(−1.07)		**(2.91)**	**(3.56)**	**(2.38)**	(−0.64)	**(3.55)**	(1.04)	(−1.42)	**(2.06)**	**(3.27)**	(−0.45)	(0.61)	(1.93)	(0.14)	**(−2.35)**	(0.93)	(−0.11)	(0.43)
GR(−1)	−0.03	0.00	−0.02		0.02	−0.04	0.00	−0.05	−0.03	**−0.04**	−0.07	−0.02	0.07	−0.03	0.00	0.00	0.03	0.03	−0.02	−0.01	(−0.03)
	(−0.77)	(−0.04)	(−0.66)		(0.44)	(−1.18)	(0.13)	(−1.37)	(−0.96)	**(−2.34)**	(−1.71)	(−0.53)	(1.77)	(−1.02)	(0.00)	(−0.05)	(1.17)	(1.21)	(−0.16)	(−0.41)	−0.77
RS(−1)	0.27	−0.15	0.06		0.14	**0.55**	0.38	**0.68**	**−0.06**	−0.20	−0.29	0.48	−0.29	0.20	0.02	0.08	0.24	**0.52**	**0.03**	−0.11	(0.27)
	(0.97)	(−0.65)	(1.21)		(0.46)	**(2.39)**	(1.77)	**(2.55)**	**(−2.37)**	(−1.54)	(−1.09)	(1.80)	(−1.12)	(0.99)	(0.43)	(0.55)	(1.55)	**(3.40)**	**(2.01)**	(−1.09)	0.97
SF(−1)	0.27	−0.15	**0.21**		0.14	0.55	0.38	0.68	−0.09	−0.20	−0.29	0.48	−0.29	0.20	0.02	0.08	0.24	0.52	**0.41**	−0.11	0.27
	(0.14)	(−0.01)	**(2.08)**		(0.25)	(0.47)	(0.48)	(0.48)	(0.20)	(0.02)	(0.01)	(0.76)	(0.42)	(0.53)	(0.06)	(−0.02)	(0.01)	(−0.03)	**(4.32)**	(0.13)	(0.14)

Note: Estimated coefficients and statistical significance results are displayed for the VAR model of the daily percentage changes in US market as %VIX (change in US risk perception) and lagged US returns as (% IV), for both Advanced and Emerging markets. Distinctively, the entire sample period is used versus the crisis period. The numbers in parenthesis depict *t*-statistics. The bold numbers denote significance at the 5% level. The optimal number of lags is chosen via the use of the Schwarz information criterion.

significant influence upon the change in US risk perception. This indicates that during non-crisis periods there is a unidirectional causality from the US to the other international markets, albeit not vice-versa. When investors perceive risk in the US market (e.g., a rise in the %*VIX*), they "transmit" this sentiment to their own domestic market through the (%$VIX \leftrightarrow$ %IV) "*channel*". On the contrary during the crisis, our results (Table 10, Panel B) reveal a dominant contagion effect. Interestingly, for the advanced markets, the US market cannot be considered anymore a predictor for the following period's change in the implied volatility of FR, SW, UK, because the lead-lag $VIX_{-1} \leftrightarrow$ %IV relationship is insignificant. In addition, the predictive ability of VIX appears also to be insignificant for the Latin American, European and South African emerging markets during the crisis. Other results from Panel B (Table 10) suggest the presence of a bidirectional causality between the VIX and GR, UK, MX markets during the crisis. Our results are in accordance with King and Wadhwani (1990) who report the existence of a "*global rather than a regional crisis*", as was the case between US, UK and Japan during the 1987–1988 market crash. Another interesting finding is revealed as well; a significant unidirectional linkage emerges between European and Latin American markets, which implies a direct volatility spillover effect in this direction. The unidirectional causality is also significant from MX to other advanced as well as Asian markets. Consequently, as opposed to previous crises, the recent global financial crisis originating from the US was not confined only to emerging markets. Importantly, US markets or other advanced financial markets such as the EU, JP and UK contributed significantly to the transmission and spillover of contagion worldwide.

Table 9 presents more details about the predictive ability of implied volatility. The results indicate that the lead-lag link between daily VIX_{-1} and US returns is not significant (or weakly significant at the 10% level) during both pre- and post-crisis periods. Risk as perceived by %*VIX* interacts with US returns only instantaneously and not via a delayed lagged pattern. This corroborates our previous results depicted in Table 8 in that a behavioral explanation is more appropriate regarding the inverse risk-return relationship. Comparing market cross-correlation during crisis and normal periods in Table 9, we may notice that during the crisis the change in risk perception (increase in %*IV*) in advanced markets as well as in Asia, became increasingly responsive to the lagged change in the US market sentiment. For instance, during more tranquil periods the EU lead-lag linkage %$VIX_{-1} \leftrightarrow$ %IV amounts to 0.20 whereas during the crisis is highly significant and equals 0.55. Similarly, for the Asian markets, the predictive power of the US market has significantly increased during the crisis, especially for China with %$VIX_{-1} \leftrightarrow$ %$IV = 0.76 > 0.36$.

In general, our analysis shows clear evidence of an increased co-movement across markets during the crisis period. Our findings indicate that the global contagion effect which occurred with respect to fear sentiment (risk perception) originating from the US market was far more pronounced for the advanced (especially in the EU area) and Asian markets such as JP, GR, KR as well as for the UK market vis-à-vis the other, following Kalemli-Ozcan, Papaioannou, and Perri (2013). Overall, our results are in accordance with the recent studies of Hwang, GhiMin, Kim, and Kim (2013), Lee et al. (2014) and Luchtenberg and Vu (2015), on equity market contagion during the global financial crisis. Our analysis provided also with strong empirical evidence of second-moment spillover and contagion effects and in particular of the transmission of risk perception from the US to other international stock markets.

6. Conclusions

Our study introduces an alternative approach to risk-return relationship that embraces affective (emotional) and formal cognitive analysis. We propose a newly-presented measure of implied volatility changes, as a robust gauge of market risk perception. We examine the change of risk perception in 20 economies divided into four sub-groups:

Advanced, Asian, Latin American, European and African markets via the use of a daily data set covering the period January 4th, 2000 to May 16th, 2014. Our novel findings can be summarized as follows: firstly, we show that Low's (2004) finding of a symmetric and non-linear risk-return relationship is not a local feature related to the US market, but rather a global phenomenon.

Secondly, our empirical results demonstrate that most advanced (especially the US and JP markets) as well as emerging markets exhibit a dramatic increase in fear sentiment when moving from ordinary to extreme upper-quantile losses (over 95% level). Similarly, consecutive, sequential and conditional positive market returns fuel aggregate market exuberance, albeit at a lower degree. However, the Asian emerging markets reveal a different risk behavioral pattern: they exhibit "*normal*" anxiety or fear levels towards imminent big losses, but low exuberance when big profits are expected.

Thirdly, when comparing the change in market risk perception vis-à-vis previous gains/losses during and after the GFC, we find that risk perception in all international markets increased, except for the Asian ones. In addition, after the onset of the crisis we show that all financial markets except the ones of the Euro-zone were dominated by excess pessimism and became far less exuberant. However, the increase in fear response against continuous bear market conditions during and after the crisis was relatively lower among the emerging as opposed to advanced markets.

Fourthly, we show that a behavioral elucidation and a cognitive paradigm provide with a far better interpretation of the asymmetric risk-return relationship, than the classical feedback theories. In particular, affective emotions bear a higher degree during the crisis period wherein decision-making is complex and time is relatively short in terms of trading choices.

Fifthly, when we investigate the role of the US in influencing foreign risk perception, our results suggest that investors in other markets closely follow the US market conditions. Indeed, we are able to illustrate that as %VIX increases, risk perception in the rest of the world is triggered. Specifically, the effects of VIX innovations are more profound during the crisis. Cross-market evidence suggest that global contagion and spillover effects are transmitted unidirectionally from the US to the other markets. We also indicate the existence of significant volatility spillovers from EU advanced markets to the emerging ones. We find significant unidirectional causality links from the (emerging) Mexican stock market to the advanced as well as Asian markets. Consequently, as opposed to previous crises, the recent global crisis originating from the US, was not confined only to emerging markets.

Unlike previous studies on risk perception, our work associates empirical evidence to evolutionary Neuro-finance theory in order to provide alternative and parsimonious rationalizations to the change of the risk-return relationship across international markets. Our results support the basic assumption in cognitive theory, that investor risk attributes are influenced by their positive or negative feelings towards profits and losses which are not necessarily monotonic. This is also known as "*affect emotion theory*". Behavioral fads and affective features could explain the observed negative significant correlation between perceived risk and expected returns.

Finally, we show that fear sentiment is increasing in a trending fashion during and after the financial crisis, albeit the corresponding increase in market exuberance resulting from consecutive gains is relatively weak, except for the Asian economies. This outcome is consistent with findings exposed in the recent behavioral finance literature, according to which the fear of losses is not the flip side of gains' exuberance, but evolves dynamically over time. Interestingly, the inverse response of Asian markets to variant market conditions (gains/losses) can be attributed to culturally normative phenomena, such as the commitment of Asian societies to pertaining values advocating in favor of risk neutralization sentiments, lower belief, overconfidence or herding.

Appendix 1

Appendix 1.A
Summary of empirical findings based on financial theory.

Country	Hofstede cultural dimension metric				Institutional environment		Behavioral bias metric			Interpretations	
Criteria	UA	MA	IA	IN	PD	IR	OC	AF	EX	Results	References
AU	51	61	90	71	36	Strong	Weakly significant	Significant.	Significant	Moderate risk perception	Hofstede (2001); Jlassi, Ftiti, and Naoui (2018); Bekiros et al. (2017); Durand, Newby, Tant, and Trepongkaruna (2013); Rajapakse and Siriwardana (2007)
CN	48	52	80	68	39	Strong	Significant	Significant	Significant	Moderate risk perception	Hofstede (2001); Aggarwal and Goodell (2014a); Deaves, Lüders, and Luo (2008); Jlassi et al. (2018); Shiller (2015); Bekiros et al. (2017).
US	46	62	91	68	40	Strong	Highly significant	Highly significant	Highly significant	High risk perception	Hofstede (2001); Shiller (2015); Li, Griffin, Yue, and Zhao (2013); Aggarwal and Goodell (2014b); Low (2004); Hibbert et al. (2008); Badshah (2013)
FR	86	43	71	48	68	Weak	Significant	Significant	Significant	High risk perception	Gunesh and Merli (2010) Hofstede (2001); Aussenegg et al. (2013); Dungey and Gajurel (2014); Jlassi et al. (2018); Bekiros et al. (2017); Li et al. (2013)
GR	65	66	67	40	35	Average	Highly significant	Significant	Highly significant	High risk perception	Hofstede (2001); Dungey & Gajurel, 2014; Deaves et al. (2008); Badshah (2013); Jlassi et al. (2018); Bekiros et al. (2017); Glaser and Weber (2007)
NL	53	14	80	68	38		Significant	Significant	Significant		

(*continued on next page*)

Appendix 1.A (*continued*)

Country	Hofstede cultural dimension metric				Institutional environment	Behavioral bias metric			Interpretations	
Criteria	UA	MA	IA	IN	PD	IR	OC	AF	EX	Results	References
						Relatively weak				Moderate risk perception	Hofstede (2001); Aussenegg et al. (2013); Dungey & Gajurel, 2014; Jlassi et al. (2018); Bekiros et al. (2017); de Groot, Renes, Rene, and Franses (2013); Hoffmann et al. (2013); Huang (2006)
SW	58	70	68	66	34	Average	Significant	Significant	Significant	High risk perception	Huang (2006); Hofstede (2001); Dungey & Gajurel, 2014; Jlassi et al. (2018); Bekiros et al. (2017); Aussenegg et al. (2013); Rey and Schmid (2007)
UK	35	66	89	69	35	Strong	Significant	Significant	Significant	Low-moderate risk perception	Hofstede (2001) Dungey and Gajurel (2014); Jlassi et al. (2018); Bekiros et al. (2017); Li et al. (2013); Aussenegg et al. (2013); Huang (2006).
JP	92	95	46	42	54	Average	Under confident	Significant	Significant	High risk perception	Hofstede (2001) Jlassi et al. (2018); Bekiros et al. (2017); Aussenegg et al. (2013); Huang (2006), Li et al. (2013); Olsen (2011); La Porta, Lopez-de-Silvanes, Shleifer, and Vishny (1998)
HK	29	57	25	17	68	Strong	Weakly significant	Significant	Weakly significant	Low risk perception	Hofstede (2001) Jlassi et al. (2018); Bekiros et al. (2017); Gang et al. (2012); La Porta et al. (1998)
CH	30	66	20	24	80	Relatively weak	Weakly significant	Weakly significant	Weakly significant	Low risk perception	Hofstede (2001) Jlassi et al. (2018); Bekiros et al. (2017); Loh, Martellini, and Stoyanov (2013); Olsen (2011)
IN	40	56	48	26	77	Relatively strong	Significant	Significant	Weakly significant	Low-moderate risk perception	Hofstede (2001) Jlassi et al. (2018); Bekiros et al. (2017); Loh et al. (2013); La Porta et al. (1998); Olsen (2011); Huang (2006)
KR	85	39	18	29	60	Average	Weakly significant	Significant	Significant	Low risk perception	Hofstede (2001) Jlassi et al. (2018); Bekiros et al. (2017); La Porta et al. (1998); Huang (2006)
ML	36	50	26	57	100	Relatively strong	Weakly significant	Weakly significant	Significant	Moderate risk perception	Hofstede (2001) Jlassi et al. (2018); Bekiros et al. (2017); La Porta et al. (1998); Loh et al. (2013)
BR	76	49	38	59	69	Weak	Weakly significant	Significant	Weakly significant	Moderate risk perception	Hofstede (2001); Huang (2006); Dungey and Gajurel (2014); Jlassi et al. (2018); Bekiros et al. (2017); La Porta et al. (1998); Li et al. (2013)
MX	82	69	30	97	81	Weak	Weakly significant	Significant	Weakly significant	Moderate risk perception	Hofstede (2001) Dungey and Gajurel (2014) Jlassi et al. (2018); Bekiros et al. (2017); Huang (2006); La Porta et al. (1998)
GC	100	57	35	50	60	Weak	Significant	Significant	Significant	High risk perception	Hofstede (2001) Jlassi et al. (2018); Bekiros et al. (2017); Huang (2006); La Porta et al. (1998); Li et al. (2013)
RS	95	36	39	20	93	Relatively weak	Significant	Significant	Significant	High risk perception	Hofstede (2001) Jlassi et al. (2018); Bekiros et al. (2017); Liu and Rangan (2011); La Porta et al. (1998)
SF	49	63	65	63	49	Relatively strong	Weakly significant	Significant	Weakly significant	Low-moderate risk perception	Hofstede (2001), Huang (2006); Dungey and Gajurel (2014); Jlassi et al. (2018); Bekiros et al. (2017); La Porta et al. (1998).

Note: Uncertainty avoidance (UA): Societies exhibits a high uncertainty avoidance degree correspond to investors, ambiguity risky or unknown future; Masculinity (MA): Country with high masculine score are identified as society with self-image such individuals are often workaholic, seeks to excellence, perfectionist and are extremely reluctant to failure and loss; Individualism (IA): Societies exhibit the High score of individualistic are qualified as low interdependent societies; Indulgence (IN): Individuals have week control over their sentiment (fear/exuberance), individuals within low indulgent society are a priory classified as cynical or pessimistic people (Hofstede, 2001; Olsen, 2011); Power distance (PD): Power is distributed unequally and Institutional/legal Regime (IR): Institutional development determines how strongly the legal and institutional country system protect investors' rights.

Appendix 1.B
Summary of scores for the expected and estimated slope coefficient under different market conditions.

	Under extreme markets returns conditions[a]				Under previous market gain/loss[b]				Under Subprime crisis[c]				During Recession period & Sluggish rise[d]			
Country	Downside markets[a]		Upside markets		Downside markets		Upside markets		Downside markets		Upside markets		Downside markets		Upside markets	
	Exp. η_d	Est. η_d	Exp.η_u	Est. η_u	Exp. η_d	Est. η_d	Exp.η_u	Est. η_u	Exp. η_d	Est. η_d	Exp.η_u	Est. η_u	Exp. η_d	Est. η_d	Exp.η_u	Est. η_u
AU	≥0	−0.39	< 0	−0.59	≤0	0.86***	≥0	−0.04	≤0	0.22***	≤0	−0.03***	≤0	≤0	≥0	−0.08
CN	≥0	−0.03	< 0	2.37**	≤0	0.23*	≥0	0.69***					≤0	≤0	≥0	−0.69***
US	< 0	−1.36**	< 0	−0.48***	< 0	−0.07***	< 0	−0.46***	≤0	−0.02***	≤0	−0.59***	< 0	< 0	< 0	0.54***
EU	< 0	−1.13***	< 0	−0.15	< 0	−0.14	< 0	−0.11***	≤0	−0.04***	≤0	−0.11***	< 0	−0.29**	< 0	0.22**
FR	< 0	0.26	< 0	0.19	< 0	−0.06	< 0	0.14***	≤0	−0.26***	≤0	0.09***	< 0	0.13**	< 0	0.09
GR	< 0	−0.32	< 0	−0.17	< 0	0.32	< 0	−0.17***	≤0	0.02***	≤0	−0.86***	< 0	−0.83***	< 0	0.22**
SW	< 0	−0.05	< 0	0.15	< 0	−0.04	< 0	0.62***	≤0	0.00**	≤0	0.35***	< 0	0.24*	< 0	0.05
NL	≥0	−0.49***	< 0	0.64***	≤0	0.13	< 0	−1.09	≤0	0.19***	≤0	0.22***	≤0	−0.05	≤0	−0.10
UK	≥0	−0.17***	≥0	0.54**	> 0	−0.28***	> 0	0.22***	≤0	−0.3***	≤0	0.35***	> 0	−0.08***	> 0	−0.30**
JP	< 0	−1.52***	≤0	9.71***	< 0	−0.3***	< 0	−0.28***	≤0	−0.08***	≤0	−0.68***	< 0	−0.85***	< 0	0.09
HK	≥0	0.85***	≥0	0.43***	> 0	−0.07***	≥0	−0.01***	≤0	0.91***	≤0	−0.04**	> 0	−1.63***	> 0	−0.02
CH	≥0	0.29***	≥0	0.29***	> 0	0.02	≥0	−0.1***	≤0	−0.54**	≤0	−0.13***	> 0	−0.08**	> 0	−0.14**
IN	≥0	0.70**	≥0	0.80***	> 0	0.00	≥0	−0.25**	≤0	−0.09*	≤0	−0.22***	> 0	−0.50**	> 0	0.14
KR	≥0	−0.78**	≥0	−0.09	> 0	−0.12**	≥0	−0.01	≤0	−0.51***	≤0	0.66**	> 0	−0.39***	> 0	−0.07
ML	≤0	0.36***	≤0	0.88***	> 0	−0.83***	≥0	0.78**	≤0	−1.73***	≤0	1.18***		−1.26***		−1.32**
BR	≤0	−0.30**	≥0	0.17	≤0	−0.03**	≥0	0.14**	≤0	−0.76***	≤0	1.13***	≤0	−1.20***	≤0	−1.36***
MX	≤0	−0.11	≥0	0.44**	≤0	−0.01	≥0	0.09	≤0	−0.48***	≤0	0.42***	≤0	−0.22***	≤0	−0.29**
GR	< 0	−0.55	< 0	0.68**	< 0	0.05	< 0	0.06***	≤0	0.11	≤0	−0.08	< 0	0.02	< 0	−0.34**
RS	< 0	−1.94***	< 0	0.15	< 0	0.21*	< 0	−0.32***	≤0	−1.06***	≤0	0.92***	< 0	−0.29***	< 0	−0.56***
SF	≥0	0.05	≥0	0.35***	< 0	−0.17***	≥0	0.24**	≤0	−0.25***	≤0	0.16**	< 0	−0.271**	< 0	−0.18**

[a] Under extreme market condition by expected downside slope different: $\eta_d < 0$ we indicate significant acceleration in fear sentiment. However, if η_d is significant and positive that implied that market exhibits easy worries rather than persistent fear sentiment. if $\eta_d \geq 0$, we expect no evidence of fear or low fear sensitivity. Similarly, in up-side return partition, a negative and significant η_u suggest presence of exuberance, a null/positive significant or insignificant η_u suggest no evidence of exuberance.

[b] Under previous markets gains/losses for countries with low risk-perception we expect that consecutives undesirable events would not fuel their fear sentiment, hence $\eta_d \geq 0$ and vise-versa for country with highly perceived risk, η_d would be significant and negative. For countries with moderate risk perception we except the downside slope η_d to be insignificant or weakly significant. However, in the upside return partition, consecutive positives events would not significantly decrease fear sentiment of country with high perceived risk hence we except the downside slope coefficient η_u to be positive and significant and otherwise with countries with low risk perception.

[c] During the crisis period, we expect consecutive losses will fuel investor fear sentiment and hence all countries would be submerged by fear sentiment (acceleration of implied volatility), hence we except to have a negative and significant slope η_d coefficient for all financial markets. Additionally, under extreme turmoil and highly uncertainty (i.e., crisis) period we expect that the mitigating effect of consecutive gains in row would not significantly decrease investor 'fear sentiment (decelerating the implied volatility), hence we except in the upside market condition, under crisis period, that the slope coefficient.

[d] In the aftermath of crisis period we expect that investor regain their pre-crisis risk perception level and hence we except the down/up-side slope coefficient term to exhibit the same results as during tranquil period in (2).

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