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THE RISK-ASYMMETRY INDEX

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Abstract

The aim of this paper is to propose a simple and unique measure of risk, that subsumes the conflicting information in volatility and skewness indices and overcomes the limits of these indices in correctly measuring future fear or greed in the market. To this end, we exploit the concept of upside and downside corridor implied volatility, which accounts for the asymmetry in risk-neutral distribution, i.e. the fact that investors like positive spikes in returns, while they dislike negative ones. We combine upside and downside implied volatilities in a single asymmetry index called the risk-asymmetry index (RAX). The risk-asymmetry index (RAX) plays a crucial role in predicting future returns, since it subsumes all the information embedded in both the Italian skewness index $ITSKEW$ and the Italian volatility index ($ITVIX$). The RAX index is the only index that is able to indicate (when reaching very high values) a clearly risky situation for the aggregate stock market, which is detected neither by the $ITVIX$ index nor by the $ITSKEW$ index.

Keywords: risk-neutral moments, model-free implied volatility, corridor implied volatility, skewness, skewness risk premium.

JEL classification: G13, G14

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1. Introduction

The CBOE skewness index ($SKEW$) is intended to measure the perceived tail risk, i.e. the probability that investors attach to extreme negative returns. As such, it is intended to supplement the information of the CBOE volatility index (VIX), which measures the overall risk in the 30-day S&P500 log-returns. Despite its critical role in describing the return distribution, the $SKEW$ index has not acquired the same outstanding reputation as the VIX index. This may be at least partially due to the positive relationship between changes in the $SKEW$ index and those of the market returns (see e.g. Chang et al. (2013), Faff and Liu (2016)). In this connection, two points are worthy of note. First, while the volatility index (VIX) spikes during periods of market downturn, the skewness measure ($SKEW$) has been found to spike in both calm and turmoil periods. Second, the US risk-neutral distribution of returns[1] has been found to be more negatively skewed (indicating higher levels of risk) during bullish market periods than during bearish market periods. These two points raise questions about the validity of the $CBOE\ SKEW$ index as an indicator of US market fear, casting light on the importance of investigating alternative asymmetry measures better suited to describe market fear. Similar questions have been raised about the nature of the $SKEW$ index in the Italian market: Elyasiani et al. (2015) find that, for the 2011-2014 period, the Italian $SKEW$ index ($ITSKEW$) performed more as a barometer of investor greed (excitement) due to the possible market upturn, than as a measure of investors' fear of a market downturn. Moreover, from the investors' point of view it is difficult to combine VIX and $SKEW$ information. High levels of VIX may be associated with both high and low levels of $SKEW$ and this may give rise to more confusion than confidence.

The aim of this paper is to offer to investors a simple measure of risk, that subsumes the information in the VIX volatility index, while disentangling good (positive returns) and bad volatility (negative returns), and overcoming the limits of both the VIX and the $SKEW$ index in

[1] The risk-neutral distribution of the returns on an asset is the expectation under the risk-neutral measure of the future distribution of the stock returns. It can be obtained from option prices listed on the underlying asset.

correctly measuring fear or greed in the market. To this end, we exploit the concept of upside and downside corridor implied volatility measures which accounts for the asymmetry in the risk-neutral distribution, i.e. the fact that investors like positive spikes in the returns, while they dislike negative ones by focusing on positive and negative returns above and below the forward price. We then combine upside and downside implied volatilities in an asymmetry index called the risk-asymmetry index (RAX), which is our proposed new measure of risk.

The paper proceeds as follows. First, we compute a skewness index similar to the $CBOE\ SKEW$ index for the Italian stock market, which we call $ITSKEW$, and we use it as a benchmark for measuring skewness. Second, we introduce upside and downside corridor implied volatilities and we combine them in the risk-asymmetry index (RAX) which is intended to disentangle the contribution of positive and negative shocks to the risk-neutral distribution of returns on the FTSE MIB (Milano Indice Borsa). Third, in line with Rubbaniy et al. (2014), we investigate the relationship between market returns, the proposed risk-asymmetry index (RAX), the Italian $SKEW$ index ($ITSKEW$), the Italian volatility index ($ITVIX$) and the two corridor upside and downside indices (CIV_{UP} and CIV_{DW}).

Fourth, in order to provide investors with a sound indicator of future fear or greed, we examine whether extremely high or low levels of the risk-asymmetry index may be related to positive or negative future returns. Rubbaniy et al. (2014) test the relation between volatility (proxied by VIX, VXN and $VDAX$ indices) and future market returns and find that implied volatility indices are good predictors of future market returns. We complement their analysis by investigating the predicting power of volatility indices, the skewness index and our new proposed risk-asymmetry index. In order to provide investors with a time-frame for the relation between the risk-asymmetry index and future returns, we investigate their relation in the short, medium or long term.

This allows us to address two interesting and controversial issues in literature: the relation between skewness and future returns, and the forecast horizon of the returns predictability. In this connection, while Bali and Murray (2013) and Conrad et al. (2013) find a negative relation between risk-neutral skewness and future stock returns (i.e. stocks with a left skewed risk-neutral distribution earn higher future returns to compensate for their higher left-tail risk), many authors find the opposite relationship: Xing et al. (2010), Yan (2011), Cremers and Weinbaum (2010), Rehman and Vilkov (2012), Faff and Liu (2016) and Stilger et al. (2016)) find a positive relation between future stock returns and risk-neutral skewness or other proxies for skewness. Regarding the forecast horizon of returns predictability, Pan and Poteshman (2006) find that publicly observable option signals are able to predict stock returns only for the next one or two trading days, before stock prices subsequently reverse. Other papers (Xing et al. 2010) find that the predictive content of volatility smirks persists for a period much longer (six months).

Our data set consists of daily FTSE MIB (Milano Indice Borsa) index options data over the period 2005-2014. In order to estimate skewness and corridor implied volatility measures, we exploit the model-free formula of Bakshi et al. (2003), adapted to the Italian market, as outlined in Sections 2 and 3. We obtain several results. First, we find a negative relationship between changes in the Italian volatility index $ITVIX$ and changes in the Italian $ITSKEW$ index. Specifically, an increase in the Italian volatility index is associated with a decrease in the Italian $ITSKEW$ index (risk-neutral distribution becomes more symmetrical). This suggests that volatility and $ITSKEW$ move together but in opposite directions, and as a result combining their information on future fear could be problematic. We find a neat result for the risk-asymmetry index RAX, which, unlike the $ITSKEW$, is only marginally positively related to the Italian volatility index.

Second, the volatility indices ($ITVIX$, upside and downside corridor volatilities CIV_{UP} and CIV_{DW}) provide useful information about future returns only in the high volatility period and for the long-term forecast horizon (60 and 90 days), while the RAX index provides useful information throughout the sample.

Third, the risk-asymmetry index RAX subsumes all the information in $SKEW$ and $ITVIX$ in predicting future market returns. This suggests that the risk-asymmetry index RAX is the only index investors should trust for the purpose of predicting future returns, without having to complement the information in the implied volatility index with that of the skewness index.

Fourth, when we consider very low values in the volatility indices, we find a positive relation between volatility levels and future returns, consistent with a buy signal for the stock market index. On the other hand, when volatility is very high, the relation becomes negative, suggesting a sell-signal. However, when volatility reaches extremely high values, the relation between volatility levels and future market returns becomes positive, suggesting positive future returns, consistent with an oversold market and a buy opportunity for investors (similar to the findings in Rubbaniy et al. (2014) for the VIX index). As a result, the volatility index does not provide a clear signal for investors, who are not in a position know in advance whether the level of volatility can be considered high or extremely high.

On the other hand, the RAX index gives a clear and unambiguous signal. When considering extremely low values of the risk asymmetry index RAX, we find a positive relation between the RAX and future market returns, suggesting a buy opportunity. On the other hand, for extremely high values of the risk-asymmetry index RAX, we find a strong negative relation between the RAX and future market returns, suggesting a sell opportunity. As a result, the risk-asymmetry index can be interpreted as an early warning for future aggregate market returns. This means that the RAX index performs better than both the $ITSKEW$, which shows a negative relation with future market returns only for extremely low values, and the $ITVIX$ index, that displays changes in the sign of the relation with future returns for high and very high volatility levels, leaving investors without a clear indication.

The structure of the paper is as follows. In Section 2, we introduce the risk-asymmetry index RAX. In Section 3, we describe the data and the methodology used to compute the $ITSKEW$, the RAX, the Italian volatility index ($ITVIX$) and upside and downside corridor implied volatility indices (CIV_{UP} and CIV_{DW}). In Section 4, we analyze the properties of the risk-asymmetry index and the other indices. In Section 5, we investigate the relationship between the indices and future market returns in both high and low volatility periods. In Section 6 we investigate the relationship between extreme levels of the RAX index and future aggregate market returns, and compare the results with the volatility indices and the $ITSKEW$. The final section concludes.

2. The risk-asymmetry index (*RAX*)

In this section we introduce the risk-asymmetry index (RAX), which is based on upside and downside corridor implied volatilities. Corridor implied volatility (CIV), introduced in Carr and Madan (1998) and Andersen and Bondarenko (2007) is obtained from model-free implied volatility due to Britten-Jones and Neuberger (2000) by truncating the integration domain between two barriers. These authors show that it is possible to compute the expected value of corridor variance (CIV) and, consequently, the corridor implied volatility measure as its square root, under the risk-neutral probability measure. This objective is achieved by using a portfolio of options with strikes ranging from B_1 to B_2, as described by:

$$\hat{E}[CIV(0,T)] = \hat{E}\left[\frac{1}{T}\int_0^T \sigma^2(t,\dots)\, I_t(B_1 B_2)\, dt\right] = \frac{2e^{rT}}{T}\int_{B_1}^{B_2} \frac{M(K,T)}{K^2} dK \qquad (1)$$

In this specification, $M(K,T)$ is the minimum between a call or put option price, with strike price K and maturity T, r is the risk-free rate, and B_1 and B_2 are the barrier levels within which the variance is accumulated. In particular, if B_1 and B_2 are set equal to 0 and ∞, respectively, the corridor variance coincides with model-free variance. The square root of model-free variance is model-free implied volatility ($MFIV$) .

In order to compute the downside corridor implied volatility measure $\sigma_{DW}(0,T)$, we set B_1 equal to 0 and B_2 equal to F_t, which is equal to the forward price. On the other hand, we compute upside corridor volatility measure $\sigma_{UP}(0,T)$ by setting B_1 equal to F_t and B_2 equal to ∞:

$$\sigma_{DW}(0,T) = \sqrt{\frac{2e^{rT}}{T}\int_0^{F_t} \frac{M(K,T)}{K^2} dK} \qquad (2)$$

$$\sigma_{UP}(0,T) = \sqrt{\frac{2e^{rT}}{T}\int_{F_t}^{\infty}\frac{M(K,T)}{K^2}dK} \tag{3}$$

with $F_t = K^* e^{rT} \cdot difference$ where K^* is the reference strike price (i.e. the strike at which the $difference$ in absolute value between the at-the money call and put prices is the smallest).[2] The sum of upside and downside corridor implied variance coincides with model-free implied variance.

The volatility of the left tail part of the distribution (downside corridor implied volatility, σ_{DW}) and the volatility of the right part of the distribution (upside corridor implied volatility, σ_{UP}) are used in order to compute the risk-asymmetry index (RAX) measure as follows:

$$RAX(0,T) = \frac{\sigma_{UP}(0,T) - \sigma_{DW}(0,T)}{\sigma_{TOT}(0,T)} \tag{4}$$

In order to have a constant 30-day measure for implied skewness, we derive the RAX_{30} index by using a linear interpolation of near and next term options, with the same formula adopted for the computation of the $CBOE\ SKEW$ index:

$$RAX_{30} = w\, RAX_{near} + (1-w)RAX_{next} \tag{5}$$

with $w = \frac{T_{next}-30}{T_{next}-T_{near}}$, and T_{near} (T_{next}) is the time to expiration of the near (next) term options, RAX_{near} (RAX_{next}) is the annualized index measure which refers to the near (next) term options, respectively.

$$RAX = 100 - 10 \times RAX_{30} \tag{6}$$

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[2] In this application, corridor implied volatility is computed as a discrete version of equations (2) and (3) with integration domain equal to [K_{min}, F] and [F, K_{max}]. K_{min} and K_{max} correspond to the minimum and maximum strike price ensuring an insignificant truncation error (for more details see Muzzioli (2015)).

3. Data description and methodology

The data set consists of closing prices on FTSE MIB[3]-index options (MIBO) and closing prices of the FTSE MIB-index recorded from 3 January 2005 to 28 November 2014. The FTSE MIB is adjusted for dividends as follows:

$$\hat{S}_t = S_t e^{-\delta_t \Delta t} \quad (7)$$

where S_t is the FTSE MIB index value at time t, whereas δ_t is the dividend yield at time t, and Δt is the time to maturity of the option. We use Euribor rates with maturities of one week, and one, two, and three months as a proxy for the risk-free rate (the appropriate yield to maturity is computed by linear interpolation). The data-set for the MIBO is kindly provided by Borsa Italiana S.p.A. The time series of the FTSE MIB index, the dividend yield and the Euribor rates are obtained from Datastream.

We apply several filters to the option data set in order to eliminate arbitrage opportunities and other irregularities in the prices. First, consistently with the computational methodology of other indices (such as the $CBOE\ SKEW$), we eliminate options close to expiry that may suffer from pricing anomalies that might occur close to expiration (options with time-to-maturity of less than eight days). Second, following Ait-Sahalia and Lo (1998), only at-the-money and out-of-the-money options are retained (put options with moneyness lower than 1.03 and call options with moneyness higher than 0.97). Last, option prices violating the standard no-arbitrage constraints and positive prices for butterfly spreads (Carr and Madan, 2005) are eliminated. Following Muzzioli (2013a), we interpolate the volatility-strike knots by using cubic splines, and extrapolate outside the existing domain of strike prices by using a constant extrapolation scheme. In this way, we ensure an insignificant truncation and discretization error. For more details see Muzzioli (2013a, 2013b).

In order to obtain 30-day constant maturity indices, each day we compute by linear interpolation between near-term and next-term maturity options, the Italian $SKEW$ index ($ITSKEW$) by using the

[3] **F**inancial **T**imes **S**tock **E**xchange **M**ilano **I**ndice di **B**orsa: it is a capital-weighted index consisting of 40 major stocks listed on the Italian market

formula of the $CBOE\,SKEW$ index, adapted to the Italian market, the Italian volatility index ($ITVIX$)[4], as $MFIV * 100$, the upside and downside corridor implied volatility indices CIV_{UP}=$\sigma_{UP} * 100$ and CIV_{DW}=$\sigma_{DW} * 100$. Further details of the computation of the $ITSKEW$ index are provided in Appendix A.

Physical skewness is obtained from daily FTSE MIB (Milano Indice Borsa) log-returns by using a rolling window of 30 calendar days that is then annualized. In this way the physical measure refers to the same time-period covered by the risk-neutral counterparts. Following the methodology adopted by the CBOE, we compute the $ITSKEW$ index as in equations (5 and 6). Also the skewness index ($SKEW_{PH}$) is computed as in equation (6) for ease of comparison.

5. Descriptive analysis of the *RAX* index, the *ITSKEW* and the implied volatility indices

Table 1 provides the descriptive statistics of the FTSE-MIB index returns (R), the index of physical skewness ($SKEW_{PH}$) and the levels and the initial differences compared to the Italian volatility index ($ITVIX$), the upside and downside corridor implied volatility indices (CIV_{UP}, CIV_{DW}), the Italian skewness index ($ITSKEW$) and the risk-asymmetry index (RAX). Physical returns are far from normality, displaying a slightly negative skewness and a pronounced excess kurtosis. The hypothesis of a normal distribution is strongly rejected also for implied volatility indices, indicating the presence of extreme movements in volatility, i.e. fat tails. When we split the Italian volatility index ($ITVIX$) into its two components (upside and downside corridor implied volatilities), it may be seen that each component is far from the normality assumption, with downside corridor implied volatility being on average higher than the upside one. This indicates that extreme movements are more often present in the left part (downside) of the risk-neutral distribution, suggesting that peaks of volatility are more often associated with increases in the volatility of the left-hand side of the distribution (bad news).

[4] The Italian Volatility Index *(IVI)* which is the Italian version of the *VIX* index is currently quoted in the Italian market. However, we prefer to use our *ITVIX* index for consistency with the computational methodology of upside and downside corridor implied volatilities.

Turning our attention to the skewness index and the risk-asymmetry index, we can observe that they are on average higher than the threshold level of 100 (103.44, and 101.72 for $ITSKEW$, and RAX, respectively) pointing to a highly negatively skewed risk-neutral distribution. On the other hand, the physical skewness index ($SKEW_{PH}$) is close to 100 (100.06), pointing to an almost symmetrical distribution of physical returns. This suggests the presence of a positive skewness risk premium (i.e., the difference between physical and risk-neutral skewness) which is mainly attributable to the negative asymmetry of the risk-neutral distribution, i.e. to investor expectations that overestimate the real probability of negative returns. This result is consistent with the evidence from the US market provided by Foresi and Wu (2005) and Kozhan et al. (2013). The excess kurtosis in all the risk-neutral asymmetry measures indicates the presence of extreme movements not only in implied volatility, but also in higher moments.

The fact that RAX is on average higher than 100, suggests that downside corridor implied volatility is on average higher in percentage terms than the upside corridor implied volatility. In fact, downside corridor implied volatility attains an average of 0.19, whereas upside corridor implied volatility an average of 0.15. The evidence of the difference between the volatility of the left and right part of the distribution is supported by a t-test, where errors are corrected by Newey West (t-stat = -81.70, p-value = 0.00).

Figure 1 depicts the FTSE MIB index along with the Italian volatility index ($ITVIX$) and the upside and downside corridor implied volatility indices (CIV_{UP} and CIV_{DW}). It may be seen that downside movements of the FTSE MIB index are associated with spikes of the three implied volatility indices; downside corridor implied volatility is on average higher than upside volatility, and during turbulent periods the difference between downside and upside corridor measures is exacerbated. This is also clear if we look to Figure 2 where a plot of the Italian skewness index $ITSKEW$ and the risk-asymmetry index RAX is provided, along with physical skewness. It is apparent that the risk-asymmetry index (RAX), being normalized by model-free implied volatility, spikes when downside corridor implied volatility increases as a percentage of the total (or upside corridor implied volatility decreases as a percentage of the total). This represents an initial advantage of the risk-asymmetry index, which is not only able to account for volatility, but also for the asymmetric behaviour of upside and downside volatility parts.

In Table 2 we report the correlation coefficients between returns, physical skewness and the levels and the initial differences of the RAX index, the $ITSKEW$ index and the model-free implied volatility indices ($ITVIX, CIV_{UP}$ and CIV_{DW}). It may be observed that both the RAX and the $ITSKEW$ index display a positive significant correlation with the realized skewness index ($SKEW_{PH}$), and as a result they can be used as predictors of future realized skewness. Notably, while the $ITSKEW$ index displays a negative significant correlation with the Italian volatility index (-0.16), the RAX index is positively and significantly correlated (0.099). The low positive correlation of both the levels and the daily changes of the RAX index with implied volatility represents a second advantage of the latter: it goes in the same direction as implied volatility, and is negatively related to returns, but it contains additional information beyond the information in volatility. As a result, according to the RAX index, the risk-neutral distribution of the FTSE-MIB index returns is riskier when the implied volatility index is high. For the $ITSKEW$ index the relation is exactly the opposite. This can be considered as a third advantage of the RAX since we expect the risk-asymmetry measure to positively spike in periods of turmoil (when $ITVIX$ is high). This is confirmed by the positive relation between changes in the RAX index and changes in the Italian volatility index (on the other hand, the relation between changes in the $ITSKEW$ index and changes in the $ITVIX$ index is negative), suggesting that an increase in the volatility index is associated with a riskier risk-neutral distribution (the opposite is true if we use the $ITSKEW$, suggesting that the risk-neutral distribution is less negatively skewed). The correlation between the Italian volatility index ($ITVIX$) and upside and downside corridor implied volatilities is close to 1, showing a higher degree of association between them.

6. Can we use the risk-asymmetry index as an indicator of future index returns?

In this section, we examine the forecasting power of the risk-asymmetry index RAX, the skewness index $ITSKEW$, and the model-free implied volatility indices on future stock returns by estimating the following regression:

$$R_{t,t+n} = \alpha + \beta_1 index_t + \varepsilon_t \tag{8}$$

where $R_{t,t+n}$ is the market aggregate log-return computed between day t and day $t + n$, and n is equal to 1, 7, 30, 60 and 90 calendar days, in order to consider both short (1, 7 days), medium (30 days) and long-term (60-90 days) returns; $index_t$ is proxied by levels of $ITSKEW$, RAX, $ITVIX$, CIV_{UP} and CIV_{DW}. Equation (8) is intended to establish whether index values are associated with positive or negative future returns, thus highlighting the possibility of profits or losses in the market on a short-, medium- or long-term forecast horizon. As noted by Cremers and Weinbaum (2010), options have a predictive power on future market returns, since informed investors trade first in the option market and only subsequently is the relevant information reflected in stock prices.

The results are reported in Table 3, Panel A. None of the implied volatility indices has any explanatory power on future stock returns in any forecast horizon. As a result, neither the Italian volatility index ($ITVIX$), nor upside corridor implied volatility index (CIV_{UP}), nor downside corridor implied volatility index (CIV_{DW}) can be used to forecast returns over the next 90 days. On the other hand, we find that the RAX index shows a significant negative relationship at the 1% level for all the forecast horizons. The $ITSKEW$ index displays a highly significant relation in the short term (1-, 7- and 30- days), that weakens for longer time horizons (60- and 90- days). These results suggest that high (low) values in the RAX and in the $ITSKEW$ index are reflected in low (high) future market returns in the short-, medium- and long–term forecast horizons.

The unexpected results for the information content of model-free implied volatility indices drive the investigation further, since we expect them to be informative at least during turmoil periods. As a result, in this section we investigate whether the volatility level can affect the predictability of returns. Two main volatility regimes are evident during the sample period: one regime is characterized by low volatility and positive market returns (2005-2007 and 2013-2014), the second regime is characterized by high volatility and a decline of about 70% in the stock market (2008-2012). Figure 1, which reports the comparison between FTSE MIB index and the model-free implied volatility indices, helps to enucleate the two sub-periods. In order to contrast the predictive power of skewness and volatility indices under calm and intense market volatility conditions, we estimate the models described by regression (8) in both sub-periods.

Overall, both the RAX and the Italian skewness index $ITSKEW$, outperform volatility indices in forecasting future market returns in both high and low volatility periods. The results for the calm period, reported in Table 3, Panel B, confirm the predictive power of the RAX and the $ITSKEW$ indices only for medium- and long-term forecast horizons (30-, 60- and 90- days), while the results for the volatility indices do not exhibit any significant relationship with future market returns.

The results for the high volatility period, reported in Table 3, Panel C show that both the $ITSKEW$ and RAX indices embed useful information for predicting future market returns in any considered forecast horizon. In this case, also the model-free implied volatility indices ($ITVIX$, CIV_{DW} and CIV_{UP}) display a significant relation, but only with long-term future returns. Among the volatility indices, the corridor upside volatility index (CIV_{UP}) achieves the better forecasting performance, since it embeds useful information to predict both short- and medium-term aggregate market returns. The positive sign of the relationship between model-free implied volatility indices and future returns is consistent with the findings in Rubbaniy et al. (2014) who document a significant positive long-term relation between volatility indices and future stock returns in both the German and the US market.

In order to establish whether the RAX index subsumes all the information contained in the $ITSKEW$ and in the Italian volatility index ($ITVIX$) in predicting future market returns, we estimate the following regression:

$$R_{t,t+n} = \alpha + \beta_1 ITSKEW_t + \beta_2 RAX_t + \beta_3 ITVIX_t + \varepsilon_t \quad (9)$$

and test if $\beta_1 = 0$ and $\beta_3 = 0$.

The results for the full sample period are reported in Table 4, Panel A. It may be seen that only the RAX index shows a significant relation with future market returns. The coefficient is negative and statistically significant at the 1% level for both the medium- and the long-term forecast horizons (30, 60 and 90-days). In line with equation (8), high values in the RAX index are associated with low future market returns. Both $ITSKEW$ and $ITVIX$ indices appear to be ineffective in terms of forecasting market index (FTSE MIB) returns in the future. This is confirmed by a joint Wald test (β_1=0, β_3=0) which suggests that the risk-asymmetry index (RAX) subsumes all the information of $ITSKEW$ and $ITVIX$ for any considered forecast horizon. This is clearly important for investors, who can rely on a single measure of risk, the RAX index, without having to consider two different indices: the $ITSKEW$ and the $ITVIX$.

The results for the low and high volatility periods are shown in Panels B and C, respectively. According to these results, during the low volatility period, only the RAX index is significant at the 1% level and only for the long-term forecast horizon (90-days). During the high volatility period (2008-2012), both the RAX and $ITVIX$ indices are significant, pointing to the usefulness of complementing the information in the RAX index with that provided in $ITVIX$. However, the sign in the betas shows that the information in the RAX index and $ITVIX$ move in the opposite direction: if high values of the RAX index are associated with low future market returns, high values in volatility are associated with high future returns.

To sum up, we find that the RAX index outperforms both the Italian volatility index $ITVIX$ and the $ITSKEW$ index in forecasting future market returns. This result is important for investors: they can exploit the information of the RAX index in order to set profitable trades. Moreover, when the RAX index is high, they can promptly hedge their portfolios in order to avoid large losses. This information could have dramatically improved portfolio selection procedures during the recent financial crisis.

7. The information content of extreme values of the RAX index

In the financial literature it is recognized that high levels of volatility in the market are associated with investor fear and downturns in the stock prices. This is explained by the strong negative relation between parallel changes in volatility indices and stock market returns (see e.g. Whaley (2000), Giot (2005)). However, this relation is not necessarily true if we consider future market returns. Giot (2005) suggests that high or very high implied volatility levels may indicate an oversold market and, as a result, possible positive future returns for long positions in the underlying market. This hypothesis is investigated in Rubbaniy et al. (2014), who estimate the relation between different levels of implied volatility indices (index values higher than the 90%, 95% and 99% percentiles or lower than the 1%, 5% and 10% percentiles) and the corresponding future index returns. They find that very high levels of volatility are related to positive future market returns, in line with the suggestion in Giot (2005).

In keeping with this observation, our aim is to investigate the relation between future returns and extreme levels of the RAX index. In order to make a comparison, and establish which is the most reliable index, we also include the Italian $ITSKEW$ index and model-free implied volatility indices in the analysis. We use both the Italian volatility index ($ITVIX$) and the corridor upside and downside volatility indices (CIV_{UP} and CIV_{DW}). We consider only extreme index values, namely extremely low and very low values (index values lower than the 1% and the 5% percentiles, respectively) and extremely high and very high values (index values higher than the 99% and 95% percentiles, respectively) and accordingly construct four subsamples on which to estimate equation

(8).[5] In this way we examine whether extreme upside or downside index levels can be considered as an early signal of future negative or positive returns.

The results for extremely low and very low index values (values lower than their 1%, and 5%, percentile) are shown in Table 5, Panels A and B, respectively. The results for extremely high and very high index values (values higher than their 95% and 99% percentiles) are shown in Table 6, Panels A and B, respectively. As all the indices are constructed in order to have a constant forecast horizon of 30-days, we expect them to have the highest information content on the medium-term forecast horizon.

Starting from the analysis of extremely low values (Table 5), a desirable property of a fear index is that when the index is extremely low, investors may feel safe and expect positive future returns. This is exactly what we find for the RAX index: when the level of the index is extremely low (lower than its 1% percentile), we can see a positive and marginally significant relationship between the index and future aggregate market returns only for very short and medium forecast-horizons (1-, 7- and 30- days). As a result we can interpret extremely low values of the RAX index as indicators of short- and medium-term market greed. The same relation is found for $ITVIX$, CIV_{UP} and CIV_{DW}, for the 7-day and the 30-day forecast horizon. For long-term forecast horizons, very low implied volatility index ($ITVIX$) values have a significant relationship with future aggregate market returns, which however is not constant in sign, making it difficult for investors to interpret the signal.

For extremely and very high levels of the RAX index (Table 6), we see a negative and significant relation between the RAX index and future aggregate market returns, mainly for the medium-term and the long-term forecast horizons. This suggests that extremely and very high values in the RAX index are a clear signal of low future market returns in the medium- and long-term forecast horizon. In this framework the RAX index acts as measure of medium- and long-term market fear since high value in the skewness index can be regarded as an early warning of future

[5] Results for the 10% and the 90% percentiles are not reported for reasons of space but are available upon request and are similar to the 5% and 95% percentiles, respectively.

market returns. We do not find any evidence for the $ITSKEW$ index as a warning of future negative returns. For the Italian volatility index ($ITVIX$) we find a different signal depending on the level of volatility: very high values are associated with negative future returns, but extremely high values are associated with positive future returns. This result may be interpreted as follows: if volatility becomes extremely high, then the market has already discounted all the fear, and positive returns can be expected. From CIV_{UP} and CIV_{DW} we obtain almost the same conflicting information as that obtained from $ITVIX$. However, given that from the investors' point of view it is impossible to assess whether the volatility level is very high (in this case "sell") or extremely high (in this case "buy"), the mainstream information obtained from the RAX (if high then "sell", if low then "buy") is the simplest and most valuable for investors. Moreover, given that we prefer to correctly measure fear than greed, we can state that the RAX index is the only index able to indicate (when reaching very high values) a possible risky situation for the aggregate stock market. In Figure 3 we report a comparison between the "buy" (green) and "sell" (red) signals given by the RAX index and the FTSE MIB returns. We can see that in many points the RAX index correctly signals future market returns. This result is important for investors who can promptly hedge their portfolios in order to avoid losses.

8. Conclusions

Given the importance of disentangling positive and negative shocks to volatility, which are seen by investors respectively as good or bad news, we exploit the information in upside and downside corridor implied volatilities in order to measure the asymmetry of the return distribution. Upside and downside corridor implied volatilities are aggregated into the risk-asymmetry index (RAX) which measures the difference between upside and downside corridor implied volatilities standardized by total volatility. Standardization is intended to isolate the asymmetric effect from the volatility level. Given that the two risk measures that capture the second and the third moments (the

$ITVIX$ and the $ITSKEW$) may provide conflicting information (it is difficult to interpret a high $ITVIX$ index, which is meant to measure fear, together with a low $ITSKEW$ index, which is intended to measure additional tail risk), the RAX index is meant to be the only risk measure that investors should trust for determining portfolio strategies. We compare the properties of the RAX index with the Italian skewness index ($ITSKEW$), the Italian volatility index ($ITVIX$), and the two corridor upside and downside implied volatilities indices (CIV_{UP} and CIV_{DW}).

We obtain several findings. First, the risk-asymmetry index presents many advantages: it is positively correlated with realized skewness (as a result, it can be considered a market-based forecast of the subsequently realized measure), and it is positively but weakly related with the Italian volatility index ($ITVIX$). Therefore, according to the RAX index, the risk-neutral distribution of the FTSE-MIB index returns is riskier when model-free implied volatility is high, and as a result we expect the RAX index to positively spike in turmoil periods.

Second, the RAX index subsumes all the information in the Italian volatility index and in the $ITSKEW$ index in forecasting future market returns at any forecast horizon (1, 7, 30, 60 and 90 days). This result is important for investors who could rely on just one simple indicator in order to plan profitable trades.

Third, the RAX index can be considered as a greed index in the short and medium term (up to 30 days) and a fear index in the medium and long-term (from 30 to 90 days), since extremely low values of the RAX index can be interpreted as indicators of future positive returns over the next 30-days and extremely high values of the RAX index indicate future negative returns over the next 30 to 90-days.

Last, unlike the $ITVIX$ index which cannot be easily used by investors since it indicates future negative returns if very high, but future positive returns if extremely high, the RAX index is the only index able to indicate (when reaching very high values) a clear possibly risky situation for the aggregate stock market. This result is important for investors who can hedge their portfolios in order to avoid losses.

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Appendix A. The Italian skewness index (*ITSKEW*)

Currently, the only skewness index quoted is the $CBOE\ SKEW$ index for the S&P500 market, defined as:

$$SKEW = 100 - 10 \times SK \tag{A1}$$

where SK is the 30-day measure of risk-neutral skewness. Risk-neutral skewness measures the asymmetry in the returns distribution obtained from option prices. It is equal to zero for a normal distribution, indicating the symmetry in the returns. If skewness is negative it means that the mass of the distribution is concentrated in the left tail; to elaborate, the left tail is longer or thicker, or both, compared to the right tail. Symmetrically, if skewness is positive, it means that the right tail is longer or thicker, or both, with respect to the left tail (the mass of the distribution is concentrated in the right tail. In order to have a 30-day measure of risk-neutral skewness, SK is computed by linear interpolation between two values of risk-neutral skewness: the first refers to near-term options, with maturity possibly less than 30 days, the second refers to next-term options with time to maturity possibly greater than 30 days. As the risk-neutral skewness attains typically negative values for equity indices, the $SKEW$ index attains in general a value above 100; the higher the value of the $SKEW$, the higher the riskiness of the returns distribution. The risk-neutral skewness (SK) is computed by means of the Bakshi et al. (2003) formula.

According to Bakshi et al. (2003) model-free skewness is obtained from the following equation as:

$$SK(\mathrm{t},\ \tau\ ) \equiv \frac{E_t^q\{(R(\mathrm{t},\ \tau\ ) - E_t^q[R(\mathrm{t},\ \tau\ )])^3\}}{\{E_t^q(R(\mathrm{t},\ \tau\ ) - E_t^q[R(\mathrm{t},\ \tau\ )])^2\}^{3/2}} = \frac{e^{r\,\tau}\,W(\mathrm{t},\ \tau\ ) - 3e^{r\,\tau}\,\mu(\mathrm{t},\ \tau\ )V(\mathrm{t},\ \tau\ ) + 2\mu(\mathrm{t},\ \tau\ )^3}{[e^{r\,\tau}\,V(\mathrm{t},\ \tau\ ) -\ \mu(\mathrm{t},\ \tau\ )^2]^{3/2}} \tag{A2}$$

Where $\mu(t,\tau)$, $V(t,\tau)$, $W(t,\tau)$ and $X(t,\tau)$ are the prices of the contracts, at time t with maturity τ, based on first, second, third and fourth moment of the distribution, respectively; their value are computed as:

$$\mu(t,\tau) \equiv\ E^q\ ln[S(t+\ \tau)/S(t)] =\ e^{r\tau} - 1 - \frac{e^{r\tau}}{2}V(t,\tau) - \frac{e^{r\tau}}{6}W(t,\tau) - \frac{e^{r\tau}}{24}X(t,\tau) \tag{A3}$$

$$V(t,\tau) = \int_{S(t)}^{\infty} \frac{2(1 - ln[K/S(t)])}{K^2}\ C(t,\tau;\ K)\ dK + \int_0^{S(t)} \frac{2(1 + ln[S(t)/K]}{K^2} P(t,\tau;\ K)dK \tag{A4}$$

$$W(t,\tau) = \int_{S(t)}^{\infty} \frac{6\ ln[K/S(t)] - 3\ ln[K/S(t)]^2}{K^2} C(t,\tau;\ K)dK - \int_0^{S(t)} \frac{6\ ln\ [S(t)/K] + 3\ ln\ [S(t)/K]^2}{K^2} P(t,\tau;\ K)dK \tag{A5}$$

$$X(t,\tau) = \int_{S(t)}^{\infty} \frac{12\ ln[K/S(t)]^2 - 4\ ln[K/S(t)]^3}{K^2} C(t,\tau;\ K)dK + \int_0^{S(t)} \frac{12\ ln\ [S(t)/K]^2 + 4\ ln\ [S(t)/K]^3}{K^2} P(t,\tau;\ K)dK \tag{A5}$$

where $C(t,\tau;\ K)$ and $P(t,\tau;\ K)$ are the prices of a call and a put option at time t with maturity τ and strike K, respectively, $S(t)$, is the underlying asset price at time t.

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Table 1 – Descriptive statistics

	$SKEW_{PH}$	$ITSKEW$	RAX	$ITVIX$	CIV_{UP}	CIV_{DW}	R	Δ $ITSKEW$	Δ RAX	Δ $ITVIX$	Δ CIV_{UP}	Δ CIV_{DW}
Mean	100.06	103.44	101.72	24.90	15.08	19.35	-0.00	-0.00	-0.00	0.01	0.00	0.00
Median	100.06	103.17	101.66	23.15	14.11	17.93	0.00	0.02	0.01	-0.05	-0.03	-0.04
Maximum	101.32	110.98	105.46	80.36	50.25	61.18	0.11	5.00	1.75	27.51	16.59	21.19
Minimum	98.74	100.08	100.11	8.76	4.78	6.95	-0.09	-8.37	-2.89	-14.96	-9.16	-11.20
Std. Dev.	0.34	1.43	0.56	10.77	6.32	8.40	0.02	0.95	0.30	1.77	1.12	1.41
Skewness	-0.04	1.30	1.47	1.23	1.06	1.31	-0.05	-0.61	-0.64	1.72	1.31	1.69
Kurtosis	3.85	5.55	8.55	5.08	4.50	5.38	7.72	10.71	11.73	34.39	30.82	31.26
Jarque-Bera	76	1365	4054	1070	693	1284	2291	6259	8006	102487	80307	83278
p-value	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Note: The table shows the descriptive statistics of the physical skewness index, the Italian skewness index $ITSKEW$, the risk asymmetry index RAX, the Italian implied volatility index $ITVIX$ and the corridor upside and downside implied volatility indices CIV_{UP} and CIV_{DW}, along with FTSE MIB returns. We indicate as $SKEW_{PH}$ the index of subsequently realized skewness in the next 30 days, $ITSKEW$ is the skewness index computed using the CBOE method, adapted to the Italian market, RAX is the risk-asymmetry index defined as: $RAX = 100 - 10 * (CIV_{UP} - CIV_{DW})/MFIV$, $MFIV$ is the model-free implied volatility, R is the FTSE MIB daily return (continuously compounded). The p-value refers to the Jarque-Bera test for normality (the null hypothesis is that both skewness and kurtosis are zero).

Table 2 – Correlation table

	$SKEW_{PH}$	$ITSKEW$	RAX	$ITVIX$	CIV_{UP}	CIV_{DW}	R	Δ $ITSKEW$	Δ RAX	Δ $ITVIX$	Δ CIV_{UP}	Δ CIV_{DW}
$SKEW_{PH}$	1.000											
$ITSKEW$	0.154^{***}	1.000										
RAX	0.073^{***}	0.674^{***}	1.000									
$ITVIX$	-0.104^{***}	-0.162^{***}	0.099^{***}	1.000								
CIV_{UP}	-0.111^{***}	-0.253^{***}	-0.036^{*}	0.988^{***}	1.000							
CIV_{DW}	-0.103^{***}	-0.128^{***}	0.154^{***}	0.998^{***}	0.977^{***}	1.000						
R	0.041^{**}	0.090^{***}	0.034^{*}	-0.074^{***}	-0.081^{***}	-0.072^{***}	1.000					
$\Delta ITSKEW$	0.024	0.331^{***}	0.152^{***}	-0.000	-0.019	0.006	0.230^{***}	1.000				
ΔRAX	0.006	0.153^{***}	0.268^{***}	0.007	-0.026	0.021	0.170^{***}	0.515^{***}	1.000			
$\Delta ITVIX$	-0.019	-0.035^{*}	0.006	0.080^{***}	0.078^{***}	0.080^{***}	-0.552^{***}	-0.051^{**}	0.059^{***}	1.000		
ΔCIV_{UP}	-0.022	-0.095^{***}	-0.096^{***}	0.070^{***}	0.086^{***}	0.064^{***}	-0.620^{***}	-0.248^{***}	-0.321^{***}	0.894^{***}	1.000	
ΔCIV_{DW}	-0.018	-0.012	0.050^{**}	0.079^{***}	0.070^{***}	0.082^{***}	-0.499^{***}	0.0228	0.222^{***}	0.983^{***}	0.800^{***}	1.000

Note: The table shows the correlation coefficients between the measures used in the study. For the definition of the measures see Table 1. Significance at the 1% level is denoted by ***, at the 5% level by **, and at the 10% level by *

Table 3 - Regression output for equation (8)

Panel A: Entire sample	$ITSKEW$	RAX	$ITVIX$	CIV_{UP}	CIV_{DW}
$R_{t,t+1}$	-0.00065*** (-2.921616)	-0.001587*** (-2.673362)	0.000025 (0.603892)	0.000071 (1.002847)	0.000022 (0.436441)
$R_{t,t+7}$	-0.001827*** (-2.583778)	-0.005424*** (-2.854139)	0.000022 (0.161209)	0.0000135 (0.543698)	-0.000000 (-0.000579)
$R_{t,t+30}$	-0.005761*** (-2.701228)	-0.020406*** (-3.690731)	0.000026 (0.064179)	0.000364 (0.482305)	-0.000068 (-0.136004)
$R_{t,t+60}$	-0.008978** (-2.546163)	-0.032146*** (-3.470575)	0.000303 (0.518663)	0.001027 (0.928293)	0.000218 (0.306702)
$R_{t,t+90}$	-0.011450** (-2.517156)	-0.037305*** (-3.277063)	0.000440 (0.604029)	0.001327 (1.008014)	0.000369 (0.408745)
Panel B: Low volatility	$ITSKEW$	RAX	$ITVIX$	CIV_{UP}	CIV_{DW}
$R_{t,t+1}$	-0.000277 (-1.424649)	-0.000421 (-0.868950)	0.000054 (0.962620)	0.000098 (1.077808)	0.000066 (0.900893)
$R_{t,t+7}$	-0.000971* (-1.780910)	-0.002274 (-1.599408)	0.000139 (0.702255)	0.000279 (0.868187)	0.000160 (0.620922)
$R_{t,t+30}$	-0.004620*** (-2.923938)	-0.010010*** (-2.605760)	0.000216 (0.374499)	0.000622 (0.673962)	0.000209 (0.278664)
$R_{t,t+60}$	-0.005738** (-2.494838)	-0.016705*** (-3.309428)	-0.000152 (-0.209936)	0.000321 (0.280836)	-0.000368 (-0.387932)
$R_{t,t+90}$	-0.007349** (-2.531650)	-0.028578*** (-3.828066)	0.000214 (0.271997)	0.001178 (0.919506)	-0.000037 (-0.036209)
Panel C: High volatility	$ITSKEW$	RAX	$ITVIX$	CIV_{UP}	CIV_{DW}
$R_{t,t+1}$	-0.001232*** (-2.997762)	-0.002473** (-2.557477)	0.000097 (1.480084)	0.000234** (1.998150)	0.000104 (1.272882)
$R_{t,t+7}$	-0.003314** (-2.524932)	-0.007758** (-2.507862)	0.000248 (1.138857)	0.000638 (1.604815)	0.000257 (0.949498)
$R_{t,t+30}$	-0.008773** (-2.295404)	-0.027956*** (-3.060369)	0.000976 (1.624556)	0.002375** (2.081653)	0.001030 (1.414919)
$R_{t,t+60}$	-0.016015** (-2.510918)	-0.043048*** (-2.900375)	0.002525*** (2.628935)	0.005506*** (3.002638)	0.002851** (2.465019)
$R_{t,t+90}$	-0.021104*** (-2.625392)	-0.042060** (-2.264853)	0.003732*** (2.850310)	0.007740*** (3.314539)	0.004350*** (2.689793)

Note: The table shows the estimated output of the following regressions: $R_{t,t+n} = \alpha + \beta_1 index_t + \varepsilon_t$ where $index_t$ is proxied by the Italian skewness index ($ITSKEW_t$), the risk-asymmetry index (RAX_t), the Italian implied volatility index ($ITVIX$) and corridor upside and downside implied volatility indices (CIV_{UP} and CIV_{DW}); t-stats are shown in parentheses.

.

Table 4 – Regression output for equation (9)

Panel A: Entire sample	$ITSKEW$	RAX	$ITVIX$	Adj. R^2 (%)
$R_{t,t+1}$	-0.000361 (-1.322733)	-0.001002 (-1.229248)	0.000022 (0.529116)	0. 28%
$R_{t,t+7}$	-0.000648 (-0.865298)	-0.004358 (-1.806853)	0.000031 (0.219334)	0.93%
$R_{t,t+30}$	-0.000387 (-0.165645)	-0.019964*** (-2.704735)	0.000120 (0.290628)	2.60%
$R_{t,t+60}$	0.000519 (0.141122)	-0.033984*** (-2.878317)	0.000488 (0.809743)	3.34%
$R_{t,t+90}$	-0.001182 (-0.256222)	-0.036404*** (-2.847297)	0.000600 (0.830842)	3.30%
Panel B: Low vol	$ITSKEW$	RAX	$ITVIX$	Adj. R^2 (%)
$R_{t,t+1}$	-0.000327 (-1.084868)	0.000271 (0.351197)	0.000049 (0.864760)	0.00%
$R_{t,t+7}$	-0.000796 (-1.050477)	-0.000596 (-0.302059)	0.0001154 (0.584977)	0.44%
$R_{t,t+30}$	-0.004210* (-1.873242)	-0.001601 (-0.290357)	0.000104 (0.182816)	2.32%
$R_{t,t+60}$	-0.003382 (-1.047355)	-0.010327 (-1.395449)	-0.000322 (-0.443683)	2.51%
$R_{t,t+90}$	-0.001076 (-0.336401)	-0.026496*** (-2.876931)	-0.000046 (-0.059316)	4.31%
Panel C: High vol	$ITSKEW$	RAX	$ITVIX$	Adj. R^2 (%)
$R_{t,t+1}$	-0.000415 (-0.787702)	-0.002220 (-1.468014)	0.000112 (1.558574)	0.75%
$R_{t,t+7}$	-0.000342 (-0.233009)	-0.008398* (-1.940233)	0.000333 (1.416679)	2.02%
$R_{t,t+30}$	0.006541 (1.478720)	-0.043813*** (-3.349260)	0.001590** (2.487418)	6.25%
$R_{t,t+60}$	0.010034 (1.480762)	-0.071160*** (-3.939689)	0.003510*** (3.463493)	10.60%
$R_{t,t+90}$	0.004326 (0.489911)	-0.064849*** (-3.087087)	0.004531*** (3.381408)	11.86%

Note: The table shows the estimated output of the following regressions: $R_{t,t+n} = \alpha + \beta_1 ITSKEW_t + \beta_2 RAX_t + \beta_3 ITVIX_t + \varepsilon_t$; t-stats are shown in parentheses.

Table 5 - Regression output for extremely low values of skewness and volatility indices and future market returns.

Panel A: Regression output for indices values lower than their 1% percentiles					
	$ITSKEW$	RAX	$ITVIX$	CIV_{UP}	CIV_{DW}
$R_{t,t+1}$	0.014466 (1.031944)	0.035348** (2.357625)	0.008089 (1.468854)	0.002623 (0.731199)	-0.007956 (-1.250212)
$R_{t,t+7}$	0.037134* (1.835505)	0.070943** (2.233811)	0.032349*** (4.631337)	0.009490 (1.082955)	0.000305 (0.020654)
$R_{t,t+30}$	0.073227 (1.116273)	0.262788** (2.484363)	0.046702** (2.571395)	0.043354*** (2.939944)	0.018176 (0.949452)
$R_{t,t+60}$	0.131104 (1.261162)	0.232770 (1.394869)	0.011721 (1.014633)	0.011156 (1.306686)	0.031071** (2.321420)
$R_{t,t+90}$	0.099972 (0.953886)	0.253625 (1.710892)	-0.033717** (-2.251462)	-0.022765 (-1.673043)	-0.027345 (-1.318468)
Panel B: Regression output for indices values lower than their 5% percentile					
	$ITSKEW$	RAX	$ITVIX$	CIV_{UP}	CIV_{DW}
$R_{t,t+1}$	-0.009287 (-1.613375)	0.005212 (1.033078)	0.000134 (0.137745)	0.001055 (0.914814)	0.001508 (1.243269)
$R_{t,t+7}$	-0.021018 (-1.390669)	-0.011521 (-0.888116)	0.003431 (1.542787)	0.006543** (2.059015)	0.004410** (2.252417)
$R_{t,t+30}$	-0.073775** (-2.079119)	-0.014997 (-0.290577)	0.022029*** (5.886880)	0.024404*** (5.058825)	0.023516*** (5.691177)
$R_{t,t+60}$	-0.119576* (-1.819462)	-0.003855 (-0.069268)	0.009466*** (3.129890)	-0.004087 (-0.893722)	0.017622*** (4.395200)
$R_{t,t+90}$	-0.137499** (-2.247259)	-0.012432 (-0.187372)	0.028415*** (5.240268)	0.019809** (2.086106)	0.033013*** (-5.480334)

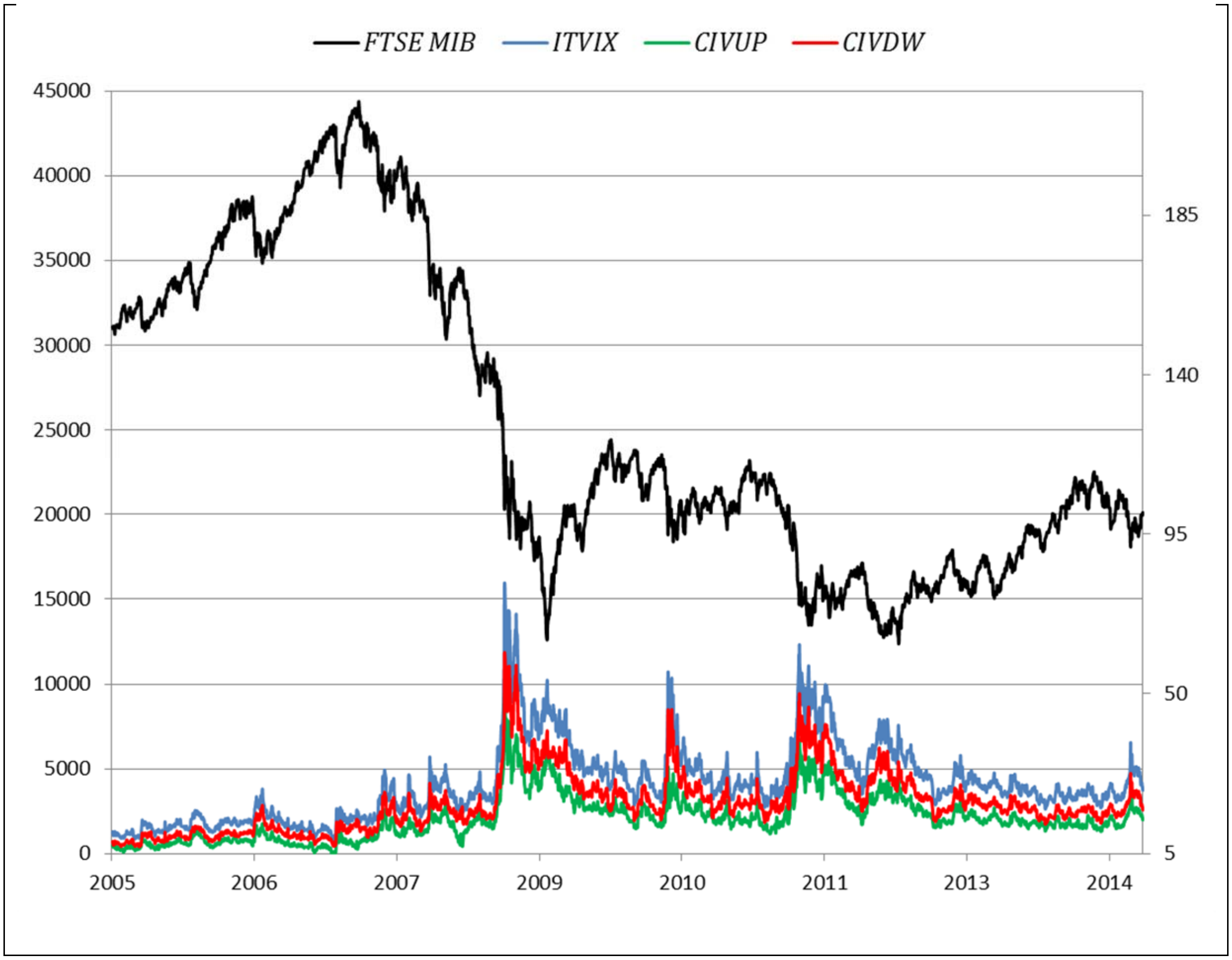
The table shows the estimated output of the following regressions: $R_{t,t+n} = \alpha + \beta_1 index_t + \varepsilon_t$ where $index_t$ is proxied by the Italian skewness index ($ITSKEW_t$), the risk-asymmetry index (RAX_t), the Italian implied volatility index ($ITVIX$) and corridor upside and downside implied volatility indices (CIV_{UP} and CIV_{DW}) on their 1% and 5% percentiles; t-stats are shown in parentheses.

Table 6 - Regression output for extremely high values of skewness and volatility indices and future market returns

Panel A: Regression output for indices values higher than their 95% percentile					
	$ITSKEW$	RAX	$ITVIX$	CIV_{UP}	CIV_{DW}
$R_{t,t+1}$	-0.000961	-0.000551	0.000620	0.001535	0.000804
	(-1.396201)	(-0.308623)	(1.35060)	(1.467557)	(1.650477)
$R_{t,t+7}$	-0.002367*	-0.009146*	0.000295	0.002109	0.000528
	(-1.925587)	(-1.881243)	(0.542678)	(1.259702)	(0.528827)
$R_{t,t+30}$	-0.001804	-0.018269***	-0.002894***	-0.003044	-0.002796**
	(-0.555332)	(-2.780934)	(-2.754037)	(-1.380144)	(-2.269866)
$R_{t,t+60}$	0.000510	-0.034288***	-0.004247***	-0.007126***	-0.002965***
	(0.115184)	(-3.254203)	(-3.735622)	(-3.003377)	(-3.044390)
$R_{t,t+90}$	-0.006114	-0.034211***	-0.006493***	-0.010193***	-0.005895***
	(-0.645176)	(-2.700623)	(-3.757592)	(3.149699)	(-3.367929)
Panel B: Regression output for indices values higher than their 99% percentile					
	$ITSKEW$	RAX	$ITVIX$	CIV_{UP}	CIV_{DW}
$R_{t,t+1}$	-0.002684	0.006160	0.003604**	0.006725***	0.003724
	(-0.903917)	(1.165369)	(2.315007)	(4.456405)	(1.655507)
$R_{t,t+7}$	-0.006287	0.000665	0.002554	0.004262	0.001971
	(-1.694173)	(0.061092)	(1.429367)	(1.088074)	(0.659539)
$R_{t,t+30}$	-0.005403	-0.048271***	0.004888***	0.006293*	0.005407*
	(-0.483798)	(-4.434558)	(3.628004)	(1.744985)	(1.857409)
$R_{t,t+60}$	0.012236	-0.076980***	0.000871	-0.001480	0.001000
	(0.943765)	(-3.369418)	(0.520089)	(-0.395555)	(0.401809)
$R_{t,t+90}$	0.018617	-0.047172*	0.002942	0.001110	0.002508
	(1.112619)	(-1.977307)	(1.320599)	(0.278492)	(0.832160)

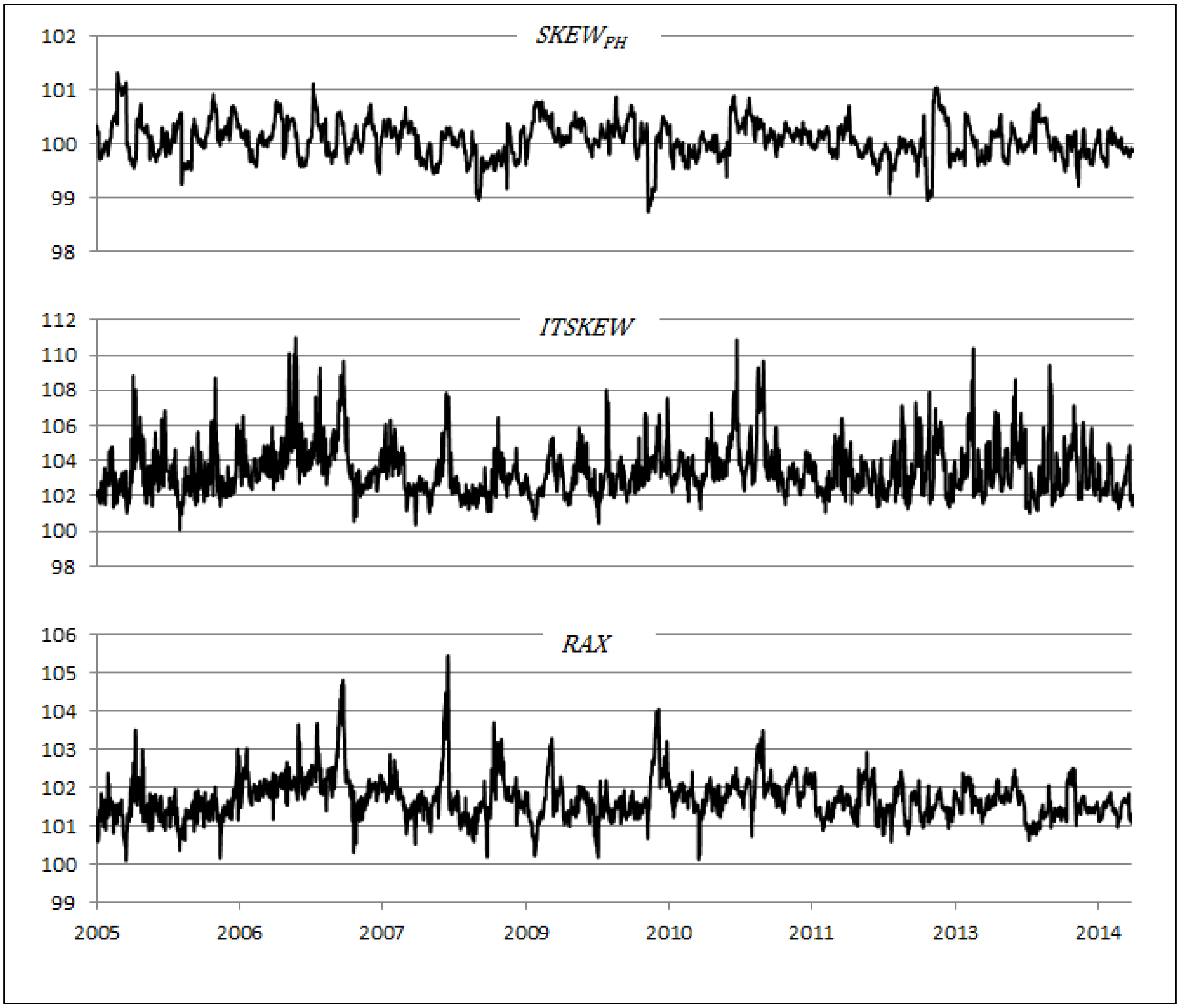
The table shows the estimated output of the following regressions: $R_{t,t+n} = \alpha + \beta_1 index_t + \varepsilon_t$ where $index_t$ is proxied by the Italian skewness index ($ITSKEW_t$), the risk-asymmetry index (RAX_t), the Italian implied volatility index ($ITVIX$) and corridor upside and downside implied volatility indices (CIV_{UP} and CIV_{DW}) on their 99% and 95% percentiles; t-stats are shown in parentheses.

Figure 1 – Comparison between the FTSE MIB index and implied volatility indices.



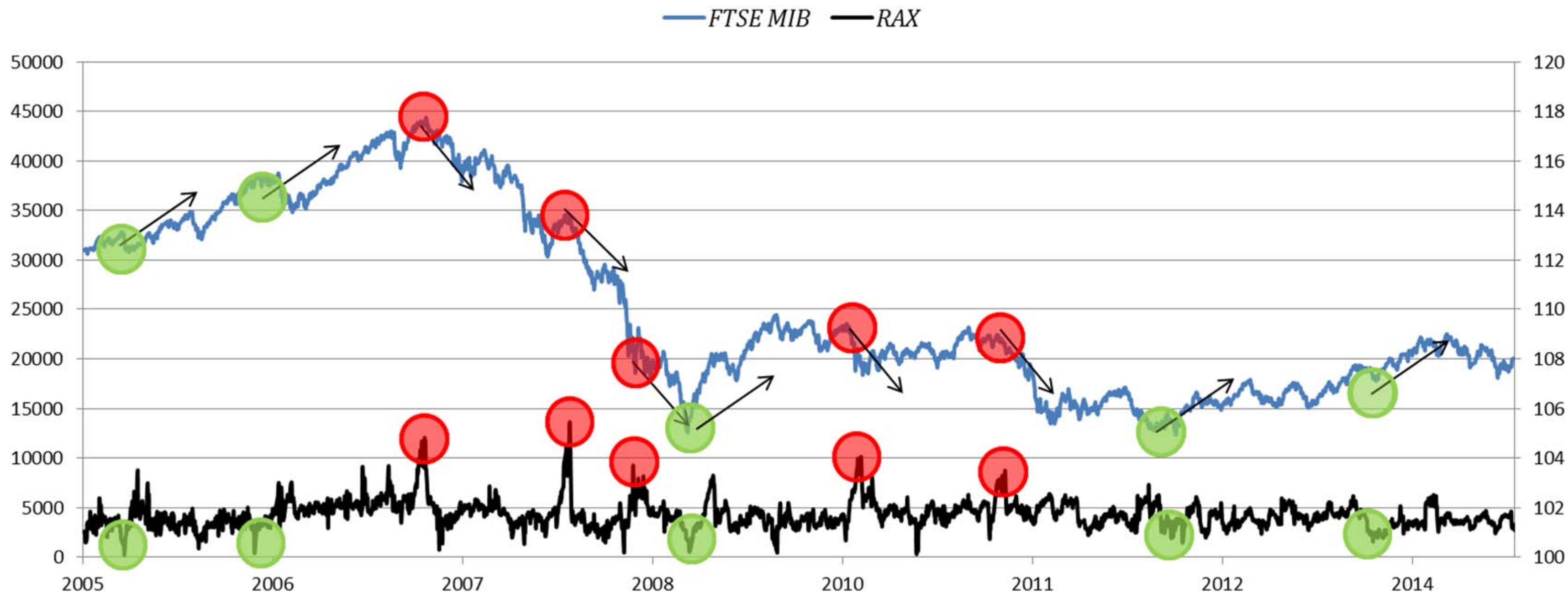
Note: The Figure shows the closing values of the Italian market index FTSE MIB, the Italian volatility index ($ITVIX$) in blue, the upside corridor implied volatility index (CIV_{UP}) in green, and the downside corridor implied volatility index (CIV_{DW}) in red. FTSE MIB index refers to the left axis, while implied volatility indices ($ITVIX$, CIV_{UP} and CIV_{DW}) refer to the right axis.

Figure 2 - Graphical comparison of physical skewness, the Italian skewness index $ITSKEW$ and the risk-asymmetry index RAX.



Note: We indicate as $SKEW_{PH}$ the index of subsequently realized skewness in the next 30 days, $ITSKEW$ is the Italian skewness index, computed using the CBOE methodology adapted to the Italian market and RAX is the risk-asymmetry index defined as: $RAX = 100 - 10 * (CIV_{UP} - CIV_{DW})/MFIV$.

Figure 3 - Graphical comparison between the FTSE MIB index and the *RAX* index.



Note: we indicate with green dots the “buy” signals, and with red dots the “sell” signals indicated by the *RAX* index.

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