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Elyas Elyasiani\*, Luca Gambarelli\*\*, Silvia Muzzioli\*\*\*

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\* Fox School of Business and Management  
Temple University, Philadelphia, PA, USA  
email: [elyas@temple.edu](mailto:elyas@temple.edu)

\*\* University of Modena and Reggio Emilia  
Address: Viale Berengario 51, 41121 Modena, Italy  
email: [luca.gambarelli@unimore.it](mailto:luca.gambarelli@unimore.it)

\*\*\* University of Modena and Reggio Emilia  
CEFIN Centro Studi Banca e Finanza  
Address: Viale Berengario 51, 41121 Modena, Italy  
email: [silvia.muzzioli@unimore.it](mailto:silvia.muzzioli@unimore.it)

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# The use of option prices in order to assess the skewness risk premium

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Elyas Elyasiani,<sup>a</sup> Luca Gambarelli,<sup>b</sup> Silvia Muzzioli<sup>c\*</sup>

<sup>a</sup> Fox School of Business and Management, Temple University, Philadelphia, PA, US, [elyas@temple.edu](mailto:elyas@temple.edu).

<sup>b</sup> Department of Economics, University of Modena and Reggio Emilia, Italy, [luca.gambarelli@unimore.it](mailto:luca.gambarelli@unimore.it)

<sup>c</sup> Department of Economics and CEFIN, University of Modena and Reggio Emilia, Italy, [silvia.muzzioli@unimore.it](mailto:silvia.muzzioli@unimore.it)

## Abstract:

The objectives of this study are twofold. First, to determine the sign and to assess the magnitude of the skewness risk premium (SRP) in the Italian index option market using two methods: (i) skewness swap contracts, and (ii) option trading strategies. Second, to investigate the behavior of the skewness risk premium for short and medium-term maturities in order to provide investors with a proper time horizon for skewness trading strategies. Several results are obtained. First, the SRP, defined as the difference between the physical and the risk-neutral measure of skewness, is positive and it is both statistically and economically significant. This indicates that SRP does exist, it is positive in sign, and it can be quantified. Second, SRP is the highest in magnitude for the 30-day maturity (€35 on a €100 of notional) while it is lower for 60-day and 90-day maturity (both close to €27 on a €100 of notional). Third, skewness trading strategies confirm our finding of a positive and economically significant risk premium for skewness. In particular, the profitability of trading strategies is concentrated on the left tail of the distribution, suggesting a considerable overvaluation of out-of-the-money put options. Fourth, as regards the proper time horizon for skewness trading, we find that a strategy that sells out-of-the-money puts is more profitable, if options with maturity ranging from 30 to 70 days are used. On the other hand, a strategy that takes a long position in out-of-the-money calls, and a short position in out-of-the-money puts, yields a higher return, if options with short-term maturity are used. This suggests that investors are more averse to tail risk for short-term horizons than they are for medium-term horizons.

*Keywords: physical skewness, risk-neutral skewness, skewness risk premium, trading strategies.*

*JEL classification: G12, G13*

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\* Corresponding author: Department of Economics and CEFIN, University of Modena and Reggio Emilia, Viale Berengario 51, 41121 Modena (I), Tel. +390592056771 Fax +390592056947, ORCID iD: 0000-0003-0738-6690.

## 1. Introduction

After the US stock market crash of October 1987, many authors directed their attention to discontinuity in both the risk-neutral skewness and risk-neutral kurtosis<sup>1</sup> in the S&P 500 index option market, indicating that there was a significant downward shift in the investors' risk perception (e.g. Jackwerth and Rubinstein (1996)). This phenomenon, termed "crash-o-phobia", is manifested in an asymmetrical pattern of market index option implied volatility smile. In particular, out-of-the-money put options are generally more expensive than out-of-the-money call options and the implied volatility tends to be a decreasing function of the option moneyness, resulting in the so-called volatility skew or smirk. The skew is reflected in a (negatively) skewed risk-neutral distribution, indicating the need for hedging against negative realizations of the underlying asset (tail risk). To elaborate, investors are willing to pay a premium (i.e. the skewness risk premium) in order to hedge against variation in skewness.

As detailed in the literature review section, two main methods have been proposed to assess the sign and the magnitude of the skewness risk premium, one of which recalls the concept of skewness swap, the other exploits trading strategies<sup>2</sup>. First, as proposed in Kozhan et al. (2013) and Zhao et al. (2013), a generalization of the variance swap<sup>3</sup> contract to skewness can be exploited to assess the skewness risk premium. In a skewness swap, at maturity, the long side pays a fixed rate and receives a floating rate. The fixed rate is the skewness swap rate, which equals the risk-neutral expectation of skewness. The floating rate is the realized or physical skewness. The difference between the two rates, which is observed at the swap's maturity, represents the skewness risk premium. This method of derivation of skewness risk premium is totally model-free both in the implied moment estimation and in the realized moment computation. Second, the existence of the skewness risk premium (SRP) can be investigated using portfolio strategies consisting of positions in options, and positions in the underlying asset, where the average profit from the strategy can be interpreted as the premium for being exposed to skewness risk (see e.g. Bali and Murray, and Conrad et al. (2013)).

The evidence about the sign and the magnitude of the skewness risk premium is mixed in the literature. In particular, studies that exploit the first method (skewness swap contract) find that risk-neutral skewness is generally greater in absolute terms than physical skewness indicating a positive sign

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<sup>1</sup> Risk-neutral skewness and kurtosis are the third and the fourth order moments, respectively, of an asset return distribution obtained from option prices listed on that underlying asset.

<sup>2</sup> Given the aim of the paper to use option prices, other methods based on portfolio sorting techniques (see e.g. Chang et al. (2013)) used to evaluate the skewness risk premium are not investigated in this paper.

<sup>3</sup> We recall that in a variance swap, at maturity, the long side pays a fixed rate (the variance swap rate) and receives a floating rate (the realized or physical variance); for further details see Section 4.

for the skewness risk premium (see e.g. Foresi and Wu (2005), Kozhan et al. (2013) and Zhao et al. (2013)). However, Kozhan et al. (2013) points out that the strategy that aims to capture the skewness risk premium and simultaneously hedge out exposure to the variance risk premium earn insignificant trading profits. On the other hand, authors who investigate the sign of the skewness risk premium by means of portfolios consisting of positions in options and those in the underlying asset find mixed evidence about the sign of the skewness risk premium (SRP) (see e.g. Bali and Murray (2013), Conrad et al. (2013)).

To the best of our knowledge, Zhao et al. (2013) are the only ones who have shed light on the term structure of the skewness risk premium, by investigating the skewness pattern for different maturities. They find that the risk-neutral measure of skewness is more negatively skewed than the physical one, both for short-term and medium-term maturities. Moreover, the skewness risk premium is found to be the highest for the 30-day maturity and lower for longer maturities. It is notable that most of the cited studies investigate the existence of the skewness risk premium using US data, and mainly data on individual stocks, instead of the market index. There are few studies (Foresi and Wu (2005), Javaheri (2005), Liu (2007)) on the European markets and market indices, manifesting a vacuum on the subject for these markets. The present paper aims to fill this void. To this end, we take the following steps. First, we assess the sign and the magnitude of the skewness risk premium in the Italian index market by exploiting the skewness swap contract (i.e. the difference between physical and risk-neutral skewness). Second, we assess the sign and the magnitude of the skewness risk premium by means of option trading strategies. Both approaches will help us to evaluate the term structure of the skewness risk premium.

We obtain several results. First, in the Italian market, both the option implied and the subsequently realized measures of skewness are negative, pointing to a left-skewed return distribution. In addition, the risk-neutral measure of skewness (i.e. the measure obtained from option prices) is greater in absolute value than the physical one, suggesting the existence of a risk premium for the third-order moment. Second, the skewness swap contract attains a positive and significant payoff for all the maturities under investigation (short-term and medium-term), indicating the existence of a positive skewness risk premium in the Italian index market. In particular, the skewness risk premium is the highest in magnitude for the short-term (30-day) maturity and it is lower, close to €27, for the 60-day and 90-day forecast maturities.

Third, we find that selling out-of-the-money puts and buying out-of-the-money calls (a long position in risk-neutral skewness) is on average profitable. Moreover, the better performance of the portfolio composed of only put options, compared to the portfolio consisting of only call options, indicates that the source of the skewness risk premium is mainly concentrated in the left part of the distribution,

meaning that investors are more concerned about shocks in the left tail of the distribution, than those in the right side. As a result, buying risk-neutral skewness yields a positive return. This is consistent with the findings in Kozhan et al. (2013) but contradicts the results in Bali and Murray (2013), who find that buying risk-neutral skewness yields a negative return. However, differently from Kozhan et al. (2013), we find that the skewness risk premium is not explained by the variance risk premium because the proposed strategies have zero variance exposure. This suggests that the skewness risk premium originates from an independent source of risk, namely the risk associated to the left tail events. This result is important for risk-averse investors since it highlights the need to simultaneously hedge out exposure to both variance and skewness. To elaborate, taking a long position in a skewness swap (selling physical skewness i.e. receiving a floating rate, and buying the risk-neutral one, i.e. paying a fixed rate) yields a positive profit. As a result, the skewness risk premium, defined as the difference between physical and risk-neutral skewness, is positive. The positive sign on the skewness risk premium means that investors consider an increase in skewness (a shift to the right of the risk-neutral distribution) as a favorable shock. Investors are willing to pay a premium to hedge against drops (negative peaks) in market skewness.

Finally, portfolios that take a long position in out-of-the-money call options and a short position in out-of-the-money put options are found to be more profitable for short-term maturities, suggesting that the skewness risk premium is the highest for the short-term maturities. This suggests that investors are more averse to tail risk for short-term horizons than they are for longer term horizons.

On the other hand, short selling out-of-the-money puts yields a better return if next-term options (usually comprised between 30 and 70 days) are used. These results are important for investors, who can set up a proper strategy in order to take profit from the difference between physical and risk-neutral skewness, or sell-short overvalued put options using an appropriate time horizon for their trades. The plan of the paper is as follows: in Section 2, we highlight our contribution to the literature. In Section 3, we provide a detailed description of the physical and risk-neutral skewness measures used. In Section 4, we investigate the existence and magnitude of the skewness risk premium, by using swap contracts. In Section 5 we investigate the profitability of skewness trading strategies and in Section 6 we provide a comparison of our results with the findings in Bali and Murray (2013). The last section concludes.

## 2. Literature gap

Two main methods are proposed in the literature to investigate the skewness risk premium. First, skewness risk premium can be computed by generalizing the notion of variance swap (Carr and Wu (2009)) to higher order moments where the fixed leg is the option-implied moment and the floating leg is the realized moment. The average profit from the third moment swap can be interpreted as the premium for being exposed to the moment's risk. In this framework, the skewness risk premium is computed as the simple difference between physical and risk-neutral skewness. Second, the existence of the skewness risk premium can be investigated using portfolio strategies consisting of positions in options and in the underlying asset, where the average profit from the strategy can be interpreted as the premium for being exposed to changes in skewness risk.

Most of the studies that use the skewness swap contract in order to evaluate the skewness risk-premium find that risk-neutral skewness is generally greater in absolute value than physical skewness, producing a positive skewness risk premium. Foresi and Wu (2005) are the first to point to the existence of a positive premium charged by the market on downside index movements. They analyze twelve major equity indices using ten years of data (May 1995-May 2005). The marked discrepancy between these two skewness measures suggests that the market charges a high risk premium on downside index movements. Similarly, Zhao et al. (2013) propose computing the skewness risk premium as the negative difference between the physical and risk-neutral third cumulants, in order to ensure that the swap rate of the contract is positive. Therefore, they find the skewness risk premium and the risk-neutral skewness in the S&P500 index option market between January 1996 and December 2005 to be significantly negative and time-varying for all considered sub periods, and for the 30, 60, and 90 day time to maturity windows. This evidence is consistent with a risk-neutral distribution, which is more negatively skewed than the physical one, both for short-term and medium-term maturities. Moreover, the skewness risk premium, computed as the difference between physical and risk-neutral third cumulants, is found to be the highest for the 30-day maturity and lower for longer maturities (it is close to 0.009 in absolute value for both 60 days and 90 days maturity). To the best of our knowledge, Zhao et al. (2013) are the only authors who shed light on the term structure of the skewness risk premium, by investigating the skewness pattern for different maturities. In fact, most of the studies investigate only the 30-day maturity, which corresponds to the one of the Chicago Board of Options (CBOE) SKEW index.

Evidence of a positive skewness risk premium is found also in Kozhan et al. (2013), Wolff et al. (2014) and Sasaki (2016) for the S&P500 equity index option market. In general, they find the average

realized skewness to be negative and substantially smaller, in absolute terms, than the average implied skewness, being the realized distribution more symmetrical than the implied one. Differently from the previous contributions, Kozhan et al. (2013) show that the skewness risk premium is closely related to the variance risk premium: they both vary over time and in the same direction. In particular, they are driven by a common factor: a strategy that captures the one and hedge out exposure to the other factor, earns an insignificant risk premium. A positive relation between risk-neutral skewness and the variance risk premium is detected also in Neumann and Skiadopoulos (2013)). These results suggest the need to hedge variance market risk, but not skewness, because skewness risk is insignificant, once variance risk is hedged. Therefore, in index options markets the evidence is mainly in favor of the presence of a significant and positive skewness risk premium. With respect to other markets, the only paper which investigates the presence of a skewness risk premium on foreign currency markets is Broll (2016), who finds that currency crash risk is priced.

The second strand of literature investigates the skewness risk premium by using portfolio strategies consisting of positions in options and in the underlying asset. The empirical evidence is mixed. A positive skewness risk premium is found in Boyer and Vorkink (2014), who find that portfolios composed of short-term options with high ex ante skewness earn significant negative returns, pointing to an investors' preference for assets characterized by high ex ante skewness. A positive skewness risk premium is found also in Javaheri (2005) and Liu (2007) in the S&P500 and in the FTSE 100 index options data, respectively, but they show that the profitability of the strategies based on skewness is eroded by bid-ask spreads.

On the other hand, empirical evidence about a negative skewness risk premium is found in Bali and Murray (2013), Chang et al. (2013), Conrad et al. (2013) and Amaya et al. (2015). In particular, Bali and Murray (2013), create delta- and vega-neutral assets, thus isolating a position in skewness (hence, the portfolios are called skewness assets). The empirical evidence performed on individual stock options in the American market, points to a robust negative relationship between risk-neutral skewness (measured with Bakshi et al. (2003) formula) and the skewness asset returns which represent a long skewness position, indicating a negative skewness risk premium. Similar results are obtained by Conrad et al. (2013) and Amaya et al. (2015). On the other hand, Chang et al. (2013) measure skewness risk premium by means of portfolio sorting techniques in the American stock market in the period from January 1996 to January 2012. They find a negative and economically significant skewness risk premium, not explained by other common risk factors.

To sum up, we can say that the majority of the existing papers have investigated the US market and, regarding the portfolio approach, they mainly focus on individual stocks (unique exceptions are Foresi and Wu (2005), Javaheri (2005) and Liu (2007)). The findings in these papers point to the existence of a significant skewness risk premium in the US market. However, the evidence on the sign of the risk premium is mixed. Evidence on skewness risk premium in the European markets and market indices remains scant.

In this paper we contribute to the existing literature in at least three respects. First, we provide evidence about the skewness risk premium on market indices in Europe, by investigating one of the most important markets in Europe, Italy. Second, we adopt both the skewness swap contract approach and the portfolio-based approach<sup>4</sup>, in order to robustly assess the existence and the economic significance of the skewness risk premium. Third, we provide empirical evidence about the existence of the skewness risk premium not only for the standard 30-day fixed maturity (the one adopted in the CBOE VIX and in the CBOE SKEW calculation), but also for longer maturities, in order to provide investors with an appropriate time framework for settling profitable trades.

### 3. Data and descriptive statistics

The option data set adopted for the analysis consists of closing prices on FTSE MIB<sup>5</sup>-index options (MIBO)<sup>6</sup> recorded from January 3, 2005 to November 28, 2014. As for the underlying asset, closing prices of the FTSE MIB-index recorded in the same time-period are used. In line with Muzzioli (2013, 2015), the FTSE MIB is adjusted for dividends as follows:

$$\hat{S}_t = S_t e^{-\delta_t \Delta t} \quad (1)$$

where  $S_t$  is the FTSE MIB index value at time  $t$ ,  $\delta_t$  is the dividend yield at time  $t$  and  $\Delta t$  is the time to maturity of the option. As a proxy for the risk-free rate, Euribor rates with maturities of one week, and one, two and three months are used. The appropriate yield to maturity of these securities are 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. For the details about the filtering criteria applied to the option data set we refer to Elyasiani et al. (2017).

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<sup>4</sup> We propose a more sophisticated strategy than the one proposed in Bali and Murray (2013), adopting a daily rebalancing procedure which ensures the skewness assets to be constantly delta and vega neutral over time.

<sup>5</sup> Financial Times Stock Exchange Milano Indice di Borsa.

<sup>6</sup> MIBO are European options on the FTSE MIB, which is a capital weighted index composed of 40 major stocks quoted on the Italian market.

For each maturity (30, 60 and 90 days) we compute the option implied and the physical measures of skewness as detailed in the Appendix.

In Table 1, we report the descriptive statistics for both the risk-neutral skewness (RN\_Skew) and the realized skewness (R\_Skew) for the Italian stock market return distribution with maturities ranging from 30 to 90 calendar days. Several considerations are noteworthy. First, we can see that both physical and risk-neutral skewness are negative. This indicates that both the option implied and the subsequently realized return distributions for the Italian stock market are skewed to the left. Second, while the physical measures of skewness for different times to maturity (30, 60, 90) attain both positive and negative values, the risk-neutral skewness measures are strictly negative in our sample for all the maturities under investigation. This indicates that, in contrast to the physical distribution of returns, the option implied distribution is always left-skewed in the period under investigation. Third, the risk-neutral measure of skewness (RN\_Skew, i.e. the measure obtained from option prices) is higher in absolute value than the physical one (R\_Skew, i.e. the measure estimated from historical series of FTSE MIB daily return) for all the maturity windows under investigation, pointing to the existence of a non-negligible risk premium for skewness. This result is in line with previous studies on the US stock market (e.g. Kozhan et al. (2013)), and it will be further investigated in the following section.

#### 4. The skewness risk premium: swap contracts

The results obtained in Section 3 indicate that in the Italian market the risk-neutral measure of skewness (RN\_Skew) is more negative than the physical one (R\_Skew) for all the considered maturities. This suggests that investors expect more negative returns that are subsequently realized, consistently with the existence of skewness a risk premium. A straightforward approach for estimating the skewness risk premium is proposed by Kozhan et al. (2013) and Zhao et al. (2013), who extend the notion of variance swap contract to higher order moments. In a variance swap, at maturity, the long side pays a fixed rate (the variance swap rate) and receives a floating rate (the realized or physical variance). The payoff, at maturity, for the long side is:

$$N(\sigma_R^2 - VRS) \quad (2)$$

where  $N$  is the notional value of the contract,  $\sigma_R^2$  is the realized measure of variance (computed at maturity), and  $VRS$  is the fix variance swap rate, which is equal to the implied variance at the beginning of the contract. The payoff of the swap is equal to the variance risk premium, i.e. the amount that investors are willing to pay in order to hedge against variations in variance.

According to Kozhan et al. (2013) and Zhao et al. (2013), the swap contract could be extended to higher order moments by using the option-implied moment as the fixed leg and the realized moment as the floating one<sup>7</sup>. As a consequence, the skewness risk premium (*SRP*) could be defined as follow:

$$SRP = N(R\_Skew - RN\_skew) \quad (3)$$

The results for the average skewness risk premium, computed by exploiting the skewness swap contract (we use  $N = \text{€}100$ ), are reported in Table 2 for the three different maturities under investigation.

The skewness risk premium (*SRP*) is positive and statistically significant for all the considered maturities (30, 60, 90), in line with Zhao et al. (2013). This result suggests that investors are averse to changes in market skewness and they are willing to pay a premium to hedge against unfavorable and unexpected variations in market skewness. In particular, taking a long position in a skewness swap (i.e. selling physical skewness and buying the risk-neutral one) yields a positive profit, representing an insurance selling strategy, whereas selling risk-neutral skewness represents an insurance buying strategy. As a result, the skewness risk premium (defined as the difference between physical and risk-neutral skewness) is on average positive.

The magnitude of the skewness risk premium is higher for the 30-day maturity (it equals €35) and lower for longer maturities (close to €27 for both 60-day and 90-day maturities) on a €100 of notional. This suggests that investors are more averse to tail risk for short-term horizons than they are for longer term horizons (in line with Zhao et al. (2013)). The result could be addressed to the investors trading activity, which is more focused on options with short-term maturity.

In Figure 1, we show a graphical representation of the skewness risk premium term structure. In order to enhance the readability of the graph, only one skewness estimate per month is depicted (in line with Muzzioli (2010)). We collect the skewness risk premium estimates recorded on the Wednesday following the expiry of the option, i.e. the third Friday of the expiry month) to use for this purpose. We can see that in the period under investigation the skewness risk-premium term structure is highly time-varying and declining with maturity, namely that the skewness risk premium is higher for short-term maturities. This result could be useful for traders, who can set up long skewness trading strategies in the short-term period, in order to profit from the difference between the physical and the risk-neutral moment. An appealing strategy to profit from the existence of a sizable skewness risk premium is provided in the following section.

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<sup>7</sup> It is worth recalling that Zhao et al. (2013) compute the skewness swap contract as the negative difference between the physical and the risk-neutral measure of skewness; however, we prefer to define the skewness risk premium as in Eq. (3) to be consistent with the standard variance swap contract and for ease of comparison.

## 5. Trading strategies based on skewness

In Section 4 we found evidence of a significant and positive skewness risk premium for all the maturity windows under investigation. The aim of this section is to assess whether investors can profit from the difference between the option-implied and the subsequently realized skewness by means of skewness trades, i.e. strategies based on options that allow investors to profit from an overvalued or undervalued third moment. When the implied third moment is undervalued with respect to the physical skewness, Javaheri (2005) suggests a strategy consisting of buying out-of-the-money calls and selling out-of-the-money puts. This strategy is exploited also in Bali and Murray (2013) where three different skewness assets (they are named skewness assets since their value depends solely on the skewness of the underlying asset) are used to test the pricing of skewness in different portions of the risk-neutral density of returns. Therefore, in order to assess whether it is possible to exploit the difference between risk-neutral and physical skewness, in line with Bali and Murray (2013), we create three different portfolios: a *PUTCALL asset* (a short position in out-of-the-money (OTM) puts and a long position in out-of-the-money (OTM) calls) a *PUT asset* (a short position in out-of-the-money (OTM) puts and a long position in at-the-money (ATM) puts) and a *CALL asset* (a long position in out-of-the-money (OTM) calls and a short position in at-the-money (ATM) calls).

In order to isolate the effect of skewness, the exposure to changes in the underlying asset (delta-neutral) and volatility (vega-neutral) is removed. As a result, each asset represents a long skewness position. A comparison with volatility trading strategies can be useful for a better understanding of these portfolios. Indeed, a long straddle position is considered a long volatility position since it increases (decreases) in value when the volatility of the underlying security increases (decreases). Similarly, skewness assets increase (decrease) in value when the skewness of the underlying security increases (decreases). Portfolio strategies are investigated also in Kozhan et al. (2013): they find that buying low-strike puts and selling high-strike calls generates on average a negative return, and as a result buying risk-neutral skewness is profitable. However, the strategy that aims to capture the skewness risk premium and simultaneously hedge out exposure to the variance risk premium earns insignificant trading profits.

According to Bali and Murray (2013), the *PUTCALL asset*, described by equation (4), is designed to change value if there is a change in the skewness of the risk-neutral return density coming either from a change in the left tail, or from a change in the right tail, or from both:

$$PUTCALL\ asset = C_{OTM} - \frac{V_{C_{OTM}}}{V_{P_{OTM}}} P_{OTM} - \left( \Delta_{C_{OTM}} - \frac{V_{C_{OTM}}}{V_{P_{OTM}}} \Delta_{P_{OTM}} \right) S \quad (4)$$

where  $C_{OTM}$  and  $P_{OTM}$  indicate the price of out-of-the-money call and put, respectively,  $\Delta$  is the delta of the option,  $V$  is the vega of the option, and  $S$  is the position of the investor in the underlying asset. The return on the *PUTCALL asset* is expected to be positive if OTM calls are undervalued relative to OTM puts. This condition is consistent with an implied distribution more negatively-skewed than the physical one.

The *PUT asset*, described by equation (5), is designed to change in value if there is a change in the skewness of the underlying asset coming from a change in the left tail of the risk-neutral density:

$$PUT\ asset = -P_{OTM} + \frac{V_{P_{OTM}}}{V_{P_{ATM}}} P_{ATM} - \left( -\Delta_{P_{OTM}} + \frac{V_{P_{OTM}}}{V_{P_{ATM}}} \Delta_{P_{ATM}} \right) S \quad (5)$$

where  $P_{OTM}$  and  $P_{ATM}$  indicate the price of out-of-the-money put and at-the-money put, respectively,  $\Delta$  is the delta of the option,  $V$  is the vega of the option and  $S$  is the position in the underlying asset. The return of the *PUT asset* is expected to be positive if OTM puts are overvalued relative to ATM puts.

The *CALL asset* described by equation (6), is designed to change value if there is a change in the skewness of the underlying asset arising from a change in the right tail of the risk-neutral density.

$$CALL\ asset = C_{OTM} - \frac{V_{C_{OTM}}}{V_{C_{ATM}}} C_{ATM} - \left( \Delta_{C_{OTM}} - \frac{V_{C_{OTM}}}{V_{C_{ATM}}} \Delta_{C_{ATM}} \right) S \quad (6)$$

where  $C_{OTM}$  and  $C_{ATM}$  indicate the price of out-of-the-money put and at-the-money put, respectively,  $\Delta$  is the delta of the option,  $V$  is the vega of the option and  $S$  is the position in the underlying asset. The return of the *CALL asset* is expected to be positive if OTM calls are undervalued relative to ATM calls.

In order to investigate the profitability of the skewness risk premium for both short and medium-term maturities, we create the skewness assets in equations (4)-(6), by using both near-term option prices (that usually have a maturity between 8 and 30 days) and next-term option prices (with maturity ranging between 30 and 70 days). The choice to use only two option maturities is motivated by the fact that the skewness risk premium has been found to be similar for 60-day and 90-day maturities.

The options with the closest strike price to the underlying asset value are taken to be the at-the-money options. Out-of-the-money options are taken to be the ones whose strike price to underlying asset price ratio is the closest to 0.95 for puts and 1.05 for call options, respectively. In order to have delta and vega neutral portfolios, trades are set at day  $t$  and are closed at day  $t+1$ . Daily profits and losses are

computed as the difference between the value of the portfolios in  $t+1$  and in  $t$  and represent the daily risk premium for being exposed to skewness. Daily return is computed as:

$$r = \frac{P_{t+1} - P_t}{|P_t|} \quad (7)$$

where  $P_{t+1}$  and  $P_t$  are the prices of the skewness asset at day  $t+1$  and  $t$  respectively. In line with Bali and Murray (2013), we use the absolute value of the skewness asset price at time  $t$  because skewness asset prices are not guaranteed to be positive. Moreover, transaction costs are not considered. Differently from Bali and Murray (2013), we use market index option data instead of individual stocks data. In fact, being the implied volatility skew more pronounced for stock index options with respect to individual stock options, we expect attractive profits from the skewness assets. Moreover, we adopt a daily rebalancing procedure ensures the skewness assets to be constantly delta and vega neutral over time. It is worth noting that the sum of the *PUT asset* and *CALL asset* return could be different from the *PUTCALL asset* return. In fact, if we sum the performance of the two portfolios based on a specific part of the distribution (the *PUT asset* and the *CALL asset*, which are meant to capture the difference between the physical and the risk-neutral measure of skewness in the left and in the right tails of the distribution, respectively), the portion of the distribution between at-the-money puts and at-the-money calls is not considered.

The cumulative return of the three skewness assets obtained by using near-term (next-term) option prices is reported in Figure 2, Panel A (Panel B) for a notional amount of 1 million Euro investment. We can observe that the cumulative return of all skewness assets is positive during the sample. The proposed strategies produce an average gross annual return between 7% and 8% for the period 03/01/2005 - 28/11/2014, suggesting that a 1 million Euro capital investment in early 2005 is almost doubled by 2014. The descriptive statistics of the skewness assets' returns for near-term options are reported in Table 3, Panel A. Average daily returns are ascertained to be statistically different from zero, by using the Newey-West adjusted errors. In order to have a comparison in the magnitude of the returns, we report the FTSE MIB index daily returns in the last column of Table 3.

For the near-term options, we can see that both the average annualized return of the *PUTCALL asset* (7.80%) and the return of the *PUT asset* (7.13%) are statistically different from zero over the entire sample (2005-2014), pointing to a significant overvaluation of out-of-the-money put options. On the other hand, the annualized return of the *CALL asset* (4.02%) is not statistically different from zero, suggesting that out-of-the-money call options are not significantly undervalued with respect to at-the-money ones. By comparing the performance achieved by the FTSE MIB market index during the sample

period, with the one obtained by the skewness assets, we can see that the latter are able to provide positive and significant returns also during unfavorable market periods (the FTSE MIB lost more than 50% during the sample period).

The results for the skewness assets obtained using next-term options are reported in Table 3, Panel B. The *PUT asset* achieves the best performance with an average annualized return of 8.10%, the average daily return is statistically different from zero, pointing to a heavy overvaluation of out-of-the-money put options with respect to at-the-money ones. The *PUTCALL asset* achieves an average annualized return of 5.80% and the average daily returns are statistically different from zero. This result suggests an overvaluation of out-of-the-money put options and a symmetrical undervaluation of out-of-the-money call options. Finally, the *CALL asset* realizes an average annualized return of 5.81%, the average daily return is statistically different from zero at the 5% level. Therefore, the undervaluation of next-term out-of-the-money call options with respect to at-the-money ones is marginally significant.

Comparing the results with respect to the maturity of the options (near and next-term) we can see that the *PUTCALL asset* (a short position in out-of-the-money puts and a long position in out-of-the-money calls) achieves a better performance if we use near-term option prices (7.80%) instead of next-term ones (5.80%). This result is consistent with the findings in Section 4: the *PUTCALL asset*, which accounts for the difference between physical and risk-neutral skewness in the entire distribution, achieves a better performance for the short-term maturity (30-day), suggesting that the skewness risk premium is the highest for the short-term maturity. The opposite is true for the *PUT asset* and the *CALL asset* that realize a better performance when next-term option prices are used. The remarkable performance of the *PUT asset* could be explained by the behavior of risk averse investors who prefer medium-term out-of-the-money put options to short-term ones for protection against tail events. On the other hand, the positive performance achieved by the *CALL asset* in the medium-term could be explained by the behavior of investors implementing with next term options a covered call strategy (an options strategy whereby an investor writes a call options and hedges with a long position in the underlying asset).

## **6. A comparison with the results in Bali and Murray (2013)**

Relying on the results in Section 5, we conclude that the implied distribution is in general more negatively-skewed than the physical one and that buying skewness is on average profitable. Therefore, taking a long position in out-of-the-money call and a short position in out-of-the-money put options is a profitable trading strategy. In particular, the profitability of skewness assets is focused in the left tail of the distribution. This evidence is consistent with Kozhan et al. (2013) and the literature that documents

the overvaluation of out-of-the-money put options with respect to out-of-the-money call options (see e.g. Javaheri (2005) and Liu (2007)). However, while Kozhan et al. (2013) find that the skewness risk premium is closely related to the variance risk premium (strategies to capture one and hedge out exposure to the other earn insignificant trading profits), we find the opposite. In fact, the significant positive performance of skewness assets (which are vega neutral by construction) suggests that the skewness risk premium originates from an independent source of risk, namely the risk associated to left tail events.

By using the same strategies, Bali and Murray (2013) find the opposite result. The dissimilarity of our results with the ones in Bali and Murray (2013) might be explained as follows. First, Bali and Murray (2013) do not rebalance the position daily (adjusting for delta and vega), retaining the same portfolios until option expiration. On the other hand, the daily rebalancing procedure adopted in our application ensures the skewness assets to be constantly delta and vega neutral over time. We would like to stress that this procedure is essential in order to isolate the portfolio return component attributable to the skewness risk premium from the other components such as the underlying stock movements and changes in the volatility of the asset price. Second, Bali and Murray (2013) implement skewness assets using stock option data instead of index option data. According to Dennis and Mayhew (2002), who investigate the skewness pattern in the US stock market during the 1986-1996 period, the index option skewness tends to be much more negative (on average equal to -1.6) than the individual stock option measure of skewness (-0.24). Therefore, we may suspect that the difference between physical and risk-neutral skewness for individual stocks is smaller than the one related to the index and, as a consequence, the condition for profitable trading strategies is missing.

The results are of interest for investors and practitioners, who could exploit the difference between physical and risk-neutral skewness settling short-term option strategies or taking profit from the high overvaluation of next-term out-of-the-money put options.

## **7. Conclusions**

In this paper we assess the sign and the magnitude of the skewness risk premium in the Italian stock index market based on two methods. First, using the skewness swap contract (i.e. the difference between physical and risk-neutral skewness), we find a positive and statistically significant skewness risk premium for both short and medium-term maturities. Second, using option trading strategies we evaluate whether investors can profit from the difference between the option-implied and the subsequently realized skewness. Several results are obtained. First, the skewness risk premium (i.e. the difference between physical and risk-neutral skewness) is positive and statistically significant for all the considered

maturities (30-day, 60-day, 90-day) in line with Zhao et al. (2013). In particular, the magnitude of the skewness risk-premium is the highest for the 30-day maturity (€35). It is lower (close to €27) for the 60-day and 90-day maturities. Second, the positive returns of the three portfolios constructed (that take profit from the difference between the realized and the implied distribution in the left tail, in the right tail, or in both) confirm that the implied distribution of log-returns is more negatively skewed than the physical one, and the difference is significant also from an economic point of view. Third, the better performance of the portfolios composed of only put options indicates that the profitability of skewness trading comes from the left side of the distribution, suggesting that out-of-the-money put options are highly overvalued compared to other types of options.

This paper contributes to the literature in at least three ways. First, we show the existence of a positive skewness risk premium, and we find that buying risk-neutral skewness yields a positive return. This result is consistent with the findings in Kozhan et al. (2013) but dissimilar to the ones in Bali and Murray (2013). The dissimilarities with respect to Bali and Murray (2013) can be addressed to the use of index option data (instead single stock option data as in Bali and Murray (2013)) and to the daily rebalancing procedure adopted in our application to ensures the skewness assets to be constantly delta and vega neutral over time. Second, given that our strategies are neutral with respect to volatility risk, we find, differently from Kozhan et al. (2013), that the skewness risk premium cannot be explained by the variance risk premium. Last, we find that the amount of the skewness risk premium and its profitability, is greater for the 30-day maturity and smaller for the 60-day and 90-day maturities, suggesting a downward term-structure of skewness risk premia.

The implications for investors can be summarized as follows. Hedging against variance does not protect investors from skewness risk. Second, going long on risk-neutral skewness is profitable. Third, the highest profitability is achievable on the 30-day horizon and decreases for longer horizons (60-day and 90-day).

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## Appendix A. The method used to compute risk-neutral and physical skewness

We provide in this section details about the computational procedure for both the option implied and the risk-neutral measure of skewness. First, the risk-neutral measure of skewness (i.e. the measure of skewness computed by using option prices) is estimated using the model-free formula proposed in Bakshi et al. (2003). The method is called model-free since it does not rely on any option pricing model, being consistent with many underlying asset price dynamics. According to Bakshi et al. (2003), model-free skewness can be obtained from the following equation:

$$SK(t, \tau) \equiv \frac{E_t^q \left\{ \left( R(t, \tau) - E_t^q [R(t, \tau)] \right)^3 \right\}}{\left\{ \left( E_t^q (R(t, \tau) - E_t^q [R(t, \tau)]) \right)^2 \right\}^{3/2}} = \frac{e^{r\tau} W(t, \tau) - 3e^{r\tau} \mu(t, \tau) V(t, \tau) + 2\mu(t, \tau)^3}{\left[ e^{r\tau} V(t, \tau) - \mu(t, \tau)^2 \right]^{3/2}} \quad (\text{A1})$$

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  $\tau$ , based on first, second, third and fourth moment of the distribution, respectively; their value are computed as:

$$\mu(t, \tau) \equiv E^q \ln [S(t+\tau) / S(t)] = e^{r\tau} - 1 - \frac{e^{r\tau}}{2} V(t, \tau) - \frac{e^{r\tau}}{6} W(t, \tau) - \frac{e^{r\tau}}{24} X(t, \tau) \quad (\text{A2})$$

$$V(t, \tau) = \int_{S(t)}^{\infty} \frac{2(1 - \ln [K / S(t)])}{K^2} C(t, \tau; K) dK + \int_0^{S(t)} \frac{2(1 + \ln [S(t) / K])}{K^2} P(t, \tau; K) dK \quad (\text{A3})$$

$$W(t, \tau) = \int_{S(t)}^{\infty} \frac{6 \ln [K / S(t)] - 3 \ln [K / S(t)]^2}{K^2} C(t, \tau; K) dK - \int_0^{S(t)} \frac{6 \ln [S(t) / K] + 3 \ln [S(t) / K]^2}{K^2} P(t, \tau; K) dK \quad (\text{A4})$$

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

$$X(t, \tau) = \int_{S(t)}^{\infty} \frac{12 \ln [K / S(t)]^2 - 4 \ln [K / S(t)]^3}{K^2} C(t, \tau; K) dK + \int_0^{S(t)} \frac{12 \ln [S(t) / K]^2 + 4 \ln [S(t) / K]^3}{K^2} P(t, \tau; K) dK \quad (\text{A6})$$

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  $\tau$  and strike  $K$ , respectively,  $S(t)$  is the underlying asset price at time  $t$ .

In order to have a measure of skewness with a fixed time horizon (i.e. 30, 60 and 90 days), we compute risk-neutral skewness by using a linear interpolation procedure between two values of risk-neutral skewness which refer to option series with different times to maturity. In particular, option series that meet the filtering constrain are ordered by time to expiration (the first option series is the one with the shorter maturity) and associated to the different maturities (30, 60 and 90 days). The first and the second option series are used to compute the 30-day measure of skewness. Similarly, we compute the measure of skewness for the 60- (90-) day maturity by using the second (third) and the third (forth) option series:

$$Skew = w Skew_{near} + (1 - w) Skew_{next} \quad (A7)$$

where  $w = (T_{next} - n) / (T_{next} - T_{near})$ ,  $T_{near}$  ( $T_{next}$ ) is the time to expiration of the former (latter) series used in the interpolation procedure,  $Skew_{near}$  ( $Skew_{next}$ ) is the skewness measure which refers to the former (latter) option series, respectively;  $n$  is equal to 30, 60 and 90 days for the 30-day, 60-day and 90-day maturity, respectively. In this way we obtain three different measures of risk-neutral skewness which refer to 30-day, 60-day and 90-day forward looking horizons. This allows us to investigate the term structure and the behavior of the skewness risk premium up to 90 days. The subsequently realized measures of skewness are obtained from daily FTSE MIB log-returns by using a rolling window of 30, 60 and 90 calendar days and are then annualized. In this way the physical measures refer to the same time-period covered by the risk-neutral counterparts.

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Table 1 – Descriptive statistics for the skewness measures of the Italian market return distribution

	R_Skew <sub>30</sub>	R_Skew <sub>60</sub>	R_Skew <sub>90</sub>	RN_Skew <sub>30</sub>	RN_Skew <sub>60</sub>	RN_Skew <sub>90</sub>
	30-day realized skewness	60-day realized skewness	90-day realized skewness	30-day risk- neutral skewness	60-day risk-neutral skewness	90-day risk-neutral skewness
Mean	-0.02883	-0.06907	-0.09727	-0.37998	-0.33747	-0.36330
Median	-0.03012	-0.07594	-0.11094	-0.34191	-0.30831	-0.33229
Maximum	0.57964	0.85460	0.97218	-0.00851	-0.08888	-0.05710
Minimum	-0.60380	-0.78616	-0.77660	-1.76339	-1.28019	-1.40921
Std. Dev.	0.15733	0.19556	0.22778	0.17389	0.13463	0.14475
Skewness	0.05586	0.31778	0.52390	-1.75075	-1.89537	-1.24182
Kurtosis	3.86585	5.09055	4.92561	8.49326	8.56667	5.51489
Jarque-Bera	79.648	487.919	502.214	4434.609	4836.867	1305.527
p-value	0.00000	0.00000	0.00000	0.00000	0.00000	0.00000

Note: the table reports the descriptive statistics of skewness measures estimated from the historical series of daily FTSE MIB returns (realized skewness, R\_Skew) and from MIBO option prices (risk-neutral skewness, RN\_Skew) using the Bakshi et al. (2003) model-free formula. The skewness measures are computed for 30-day, 60-day, 90-day forecast horizons.

Table 2 – Skewness risk premium computed by using the skewness swap contract

	<i>t = 30 days</i>	<i>t = 60 days</i>	<i>t = 90 days</i>
R_Skew <sub>t</sub>	-0.02883*** (-3.399)	-0.06907*** (-6.274)	-0.09727*** (-7.441)
RN_Skew <sub>t</sub>	-0.37998*** (-43.358)	-0.33747*** (-46.037)	-0.36330*** (-47.090)
SRP <sub>t</sub>	€35.115*** (30.613)	€26.840*** (21.065)	€26.603*** (17.829)

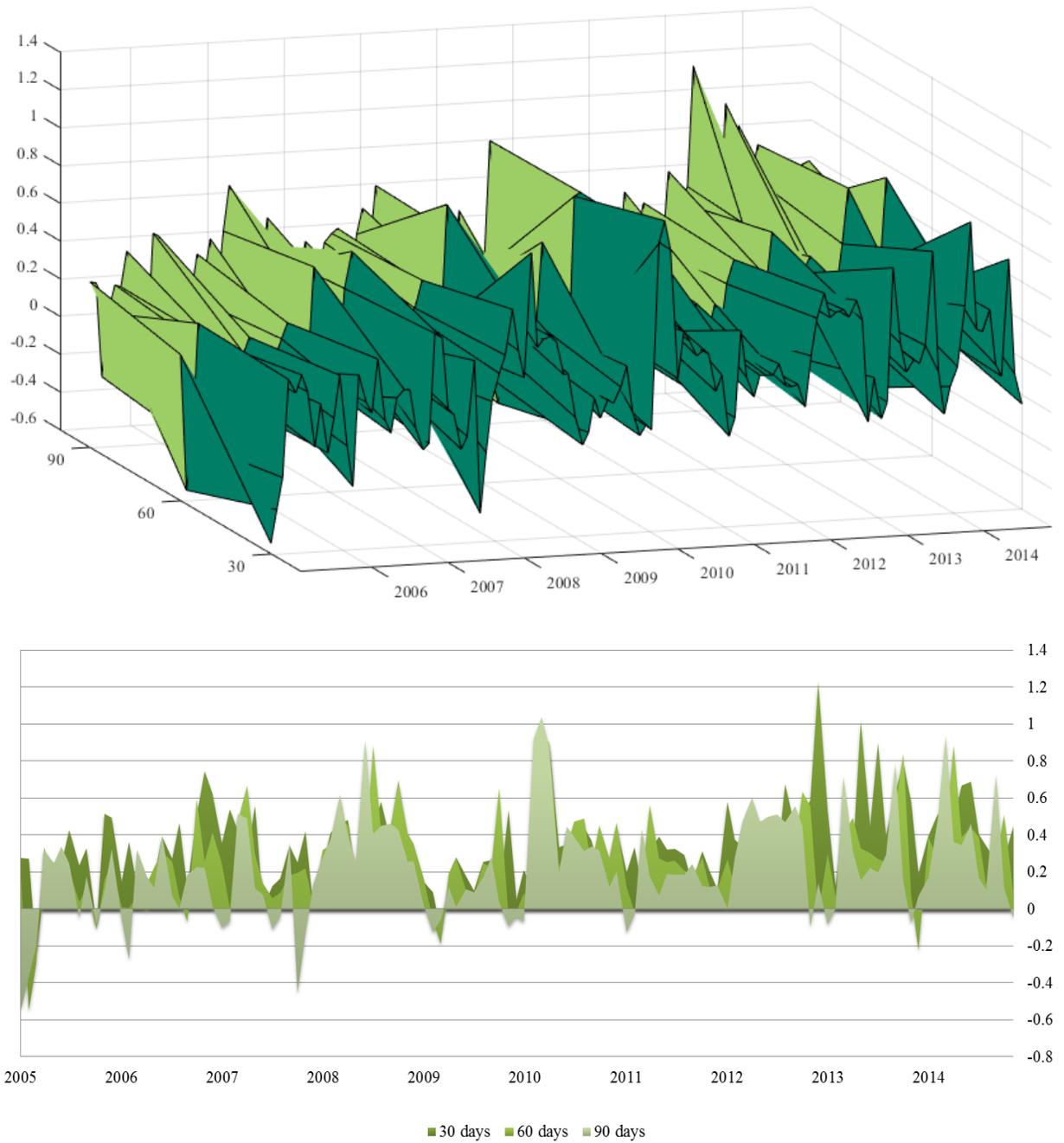
Note: The table reports the average daily measures of skewness (realized and risk-neutral) and the average daily estimates for the skewness risk premium (SRP). R\_Skew<sub>t</sub> is the skewness estimated using the historical series of daily FTSE MIB returns. RN\_Skew<sub>t</sub> is the Bakshi et al. (2003) model-free measure of skewness obtained using the option prices listed on the FTSE MIB index.  $SRP_t = N(R\_Skew_t - RN\_Skew_t)$ , where  $N$  is the notional of the contract (equal to €100),  $t = 30, 60, 90$  days. The series under investigation are ascertained to be statistically different from zero by using the Newey West adjusted errors; t-stats are in parenthesis. Significance at the 1% level is denoted by \*\*\*, at the 5% level by \*\*, and at the 10% level by \*. For the definition of the measures see Table 1.

Table 3 - Skewness assets returns for the entire sample period

<b>Panel A: near-term options</b>	<i>PUTCALL asset</i>	<i>PUT asset</i>	<i>CALL asset</i>	FTSE MIB
Average daily return	0.03%	0.03%	0.02%	-0.02%
t-statistic	5.35	4.05	1.52	-0.54
p-value	0.00	0.00	0.13	0.59
Average ann. Return	7.80%	7.13%	4.02%	-4.04%
Annualized volatility	5.34%	6.81%	9.94%	25.31%
Cumulative return (notional 1 M. Euro investment)	2.10 M	2.00 M	1.40 M	0.49 M
Cumulative return (2005-2014)	110.27%	100.29%	39.57%	-51.39 %
<b>Panel B: next-term options</b>	<i>PUTCALL asset</i>	<i>PUT asset</i>	<i>CALL asset</i>	FTSE MIB
Average daily return	0.02%	0.03%	0.02%	-0.02%
t-statistic	5.73	4.54	2.13	-0.54
p-value	0.00	0.00	0.03	0.59
Average ann. Return	5.80%	8.10%	5.81%	-4.04%
Annualized volatility	4.04%	6.95%	8.91%	25.31%
Cumulative return (notional 1 M. Euro investment)	1.75 M	2.16 M	1.70 M	0.49 M
Cumulative return (2005-2014)	75.43%	116.44%	70.30%	-51.39 %

Note: The table reports the descriptive statistics for the skewness asset returns used in the study (*PUT asset*, *CALL asset* and *PUTCALL asset*). In the last column, the descriptive statistics of the FTSE MIB index daily return are reported in order to have a comparison. The average daily return is ascertained to be statistically different from zero by using the Newey West adjusted errors; t-statistic and p-value are reported in rows 2-3. The *PUT asset* and the *CALL asset* are meant to capture the difference between the physical and the risk-neutral measure of skewness in the left and in the right tails of the distribution, respectively. The *PUTCALL asset* is designed to profit from the difference between the option-implied and the physical distribution in both the tails.

Figure 1 – Term structure of the skewness risk premium in the Italian stock market.



Note: the figure proposes a graphical representation of the term structure of the skewness risk premium for the FTSE MIB index return distribution. In the upper panel, we report the term-structure in a tridimensional graph. In the lower panel, we report the term-structure in a bidimensional graph, in order to highlight the comparison among the different maturities (30-day, 60-day, 90-day), which are represented by different shades of green.

Figure 2 – Skewness assets returns (notional 1 M. Euro investment) obtained using near-term (top panel) and next-term (bottom panel) option prices.

