Insurance Against Volatility Risk or Negative Skewness as Reflected by Option Returns in Emerging European Markets*

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Abstract

This study examines the risk premia embedded in index option prices using a sample of emerging European Union countries. In contrast to the 'overpriced puts puzzle' in the US market, writing puts in developing European exchanges is found to offer insignificant returns after accounting for risk. However, investors were paying a substantial premium for insurance against volatility risk, especially during the crisis. Insurance against negative skewness also commanded a high premium before the crisis, that disappeared post 2008. The returns of profitable option-selling strategies cannot be explained in an obvious way as compensation for risk across a set of factors.

Keywords: option returns; emerging markets; volatility; insurance premium
JEL Classifications: G01; G11; G13

1 Introduction

Options markets provide a venue for investors to trade on their specific views about the future returns distributions of the underlying assets. This trading among investors with different views on the "correct" prices of options ultimately serves as an essential mechanism for pricing various sources of risk, as well as for dispersing

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risk across all market participants. This paper examines the performance of option trading strategies across four emerging European markets. The strategies under consideration have been examined in the recent finance literature and are commonly used in practice, including positions that trade on the direction of market movements, volatility, and skewness. Under each strategy, a set of performance measures is calculated based on monthly non-overlapping returns and at three different levels of moneyness. The main question that we are trying to answer is whether the observed returns of option strategies are commensurate with the underlying risks of these positions.

The related options literature is characterized by a debate as to whether certain option strategies, particularly those that involve writing index puts, offer abnormal returns that are not justified by their risk exposure. Mis-priced puts constitute a common theme across many previous studies which report that writing puts on the market index is associated with very high average returns and Sharpe ratios, especially in the case of deep out-of-the-money (OTM) contracts, while a similarly high performance has been reported for option positions that go short in the underlying's volatility. For instance, Jackwerth (2000), Coval and Shumway (2001), Jones (2006), Bondarenko (2014) and Chambers et al. (2014) are among a large number of studies arguing that the high returns of put-selling strategies are difficult to explain as compensation for risk within a relative wide class of models. Gabaix (2012) considers mis-priced puts as one of the top ten puzzles in finance.

On the other hand, Broadie et al. (2009) report that deep OTM put returns are consistent with those generated by the simple Black and Scholes (1973) model, while put returns across different strikes are compatible with the stochastic volatility model of Heston (1993) and the returns of volatility-trading strategies (straddles) can be explained by premia for jump risk. Similarly, Bates (2000) demonstrates that a stochastic volatility model with jumps can generate simulated option returns that closely match those observed in the market, providing evidence against the commonly suggested option mis-pricing. Recently, Andersen et al. (2015) show that adding a separate left tail jump factor in a general parametric model for the underlying returns produces OTM puts that are no longer systematically mis-priced. Constantinides et al. (2013) suggest also that, while largely incompatible with standard pricing models, index option returns can be to an extent explained by factors which capture jumps in the market index and its volatility (see also Christoffersen et al., 2013; Hu and Jacobs, 2014).

Another stream of the literature has focused on the dynamics of supply and demand in the options market as a potential explanation for the high returns earned by strategies that write options. Bollen and Whaley (2004) find that net buying pressure is positively related to the implied volatility function of index options, with high net demand for puts bidding up the implied volatilities and, by extension, the prices of all options. Moreover, Garleanu et al. (2009) argue that, in the presence of demand pressure, the inability of market makers to fully hedge their inventory results in high premia for writing options. Santa-Clara and Saretto (2009) further expand the analysis by showing that market frictions, in the form of margin requirements, significantly limit investors from providing additional liquidity in the market by writing options, thereby explaining the high un-margined returns of writing puts that have been reported in previous studies.

The first contribution of this paper is to expand the literature on the performance of option trading strategies by focusing on emerging options exchanges in the EU. Previous studies have traditionally examined developed options markets, predominantly US options written on the S&P 500 index. The handful of papers that investigate option returns in European markets have mainly looked at contracts traded in developed exchanges, such as FTSE 100 index options on LIFFE (Liu, 2007; Cherny and Madan, 2009) and DAX index options traded in Eurex (Goltz and Lai, 2009). However, an analysis of the performance of option trading strategies in emerging European exchanges carries significant implications in the context of international asset allocation and risk management. This paper is the first, to our knowledge, to evaluate the returns of a set of option trading strategies in emerging European exchanges, with particular emphasis on the extent to which expected returns constitute justified compensation for the underlying distributional risks.

This paper also contributes to the literature on international financial markets by providing a direct examination of the impact that the financial crisis of 2008 has had on the risk-return trade-off of option strategies in these EU countries. While previous studies have mainly focused on relatively homogeneous sample periods, this paper evaluates the performance of the above option positions across pre-crisis (2004-2007) and post-crisis (2008-2011) sub-samples separately, in an attempt to detect the potential impact of the crisis on the risk-premia associated with a set of benchmark trading strategies. The pre-crisis sub-sample represents a boom period with appreciating market indices, low volatility and moderate levels of liquidity across the exchanges analyzed. In contrast, the post-crisis period is characterized by deflating equity markets (market premia ranged between -10% and -34% per annum), substantially higher volatility and lower liquidity in the options markets. As a result, options became significantly more expensive after the crisis, in terms of their price-to-spot ratio as well as their implied volatilities, especially with respect to deep OTM contracts. Moreover, the difference in implied volatility embedded in at-the-money (ATM) and deep OTM put contracts increased, suggesting a more negatively skewed risk-neutral distribution post-2008.

During the pre-crisis period (January 2004 to December 2007), the simple strategy of writing uncovered (naked) index puts was found to offer relatively high monthly returns in most cases. In contrast to the results reported by previous studies on S&P options, though, these returns were generally statistically insignificant after accounting for risk, with IBEX puts in Spain being the only exception. Furthermore, hedging this directional strategy, by writing covered or delta-hedged puts, was similarly associated with insignificant returns. On the other hand, strategies that go short in the underlying's future volatility were found to be considerably profitable during 2004-2007, offering statistically significant and very high risk-adjusted returns and Adjusted Sharpe Ratios, particularly in the case of strangles which carry a lower risk than equivalent straddle positions. Finally, trading on the future skewness of index returns by writing risk reversals was also associated with significantly positive performance measures, while buying crash insurance for short directional and volatility strategies (through crash-neutral puts and straddles) was found to have an adverse impact on the strategies' risk-return trade-off.

The empirical results in our paper highlight some differences with respect to the performance of option trading strategies after the financial crisis of 2008. During the deflating and more volatile markets of the post-crisis period (January 2008 to December 2011), hedged directional strategies appear to have offered considerably high risk-adjusted returns and Adjusted Sharpe Ratios. However, this strong performance was likely driven by the significant depreciation of the underlying market indices, particularly in view of the fact that the more efficient delta-hedging resulted in a slightly worse performance compared to naively hedged covered puts (which have a higher exposure to the underlying index). Moreover, the performance of short volatility positions further improved (during highly volatile market conditions), potentially reflecting an increased demand pressure for protection against higher future volatility. In contrast, skewness trading strategies no longer offered returns in excess of their risk exposure, suggesting that the crash premia embedded in risk reversals closely matched the future skewness of the underlying's returns. Buying crash insurance for short put and straddle positions continued to come at a relatively high cost, with crash-neutral puts and straddles offering either negative or statistically insignificant returns after the crisis.

Given that option strategies are evaluated from the perspective of the short side, i.e. the party that is selling options, their performance provides a direct measure of the premia that the market was willing to pay for insurance against specific changes in the underlying index's distribution. The results suggest that protection against downward movements came at a price that was commensurate with the underlying risk, in contrast to the commonly reported premium embedded in US options. Market participants, though, appear to have been paying substantial premia for protection against increases in index volatility, indicating a pronounced aversion to this source of risk or extremely high expectations of future volatility, that did not materialize even in the highly volatile post-crisis European equity market. Premia for insurance against negatively skewed index returns were equally high before the crisis but, in view of the insignificant performance of risk reversals post-2008, this could potentially be attributed to a peso-like problem. The consistently poor performance of crash-neutral strategies implies that investors who take short positions in the options market would be better off without hedging against crash risk, even during the rapidly deflating equity markets after 2008.

The profitable option strategies offer returns that cannot be easily reconciled with a wide set of aggregate sources of risk. Admittedly, the non-linear payoff structures of option strategies and the lack of a comprehensive model for the cross-section of option returns allow for the possibility of omitted risk factors being priced. However, the results from the two-stage regressions serve as evidence that option returns are not linked to typically used risk factors in any obvious way.

The rest of the paper is organized as follows. Section 2 describes the data used in the empirical analysis. Section 3 provides an overall view of market conditions during the sample period in terms of market premia, volatility and options' liquidity, with a particular emphasis on the differences between the pre- and post-crisis sub-samples. Section 4 presents the methodology used to construct option trading strategies, performance measures and confidence intervals. Section 5 discusses the empirical results regarding the performance of trading options in the markets of interest. Finally, Section 6 concludes.

2 Data

The empirical analysis focuses on options traded in four countries of the European Union, namely Greece, Hungary, Poland and Spain. These countries are typically classified as emerging markets, at least from the point of view of their options exchanges.[1] Options in the dataset are European-style, written on the underlying market index for each sample country (on index futures in the case of Spain), they expire on the third Friday of the month and settlement is in cash. The options dataset contains, among other fields, the option price, time-to-maturity, strike price, implied volatility, and greeks. The option prices used in this paper refer to closing prices at the end of the trading day, as these are provided by the

[1] The four sample countries do not represent an exhaustive list of emerging EU options exchanges. Rather, they are intended to serve as a representative sample. In some cases, the lack of data has precluded the extension of the analysis to other EU exchanges that could be considered as emerging. In other cases, options data technically was available but the trading volume in index options was particularly low (below the threshold of 5 traded contracts per day for the majority of trading days), hence these markets were excluded from the sample.

exchanges.[2] For option strategies that require investing in the underlying asset, the closing prices of index futures are used. For the four sample countries, options and futures contracts written on the market index are traded in the same derivatives exchange during the same trading hours, thereby alleviating any potential issues of non-synchronous data. The data on options and futures were obtained directly through the respective derivatives exchanges.

The sample period runs from January 2004 to December 2011, for a total of 2,030 trading days, roughly centered around the financial crisis of 2008. In order to minimize the impact of illiquid trading and recording errors, several filters are applied. First, options with prices that violate standard no-arbitrage conditions or are near-zero are excluded. Second, options that expire within 5 trading days are dropped to avoid any short-maturity effects. Moreover, options with less than 5 traded contracts on a given date are eliminated to avoid illiquidity concerns. The final filter excludes all remaining options with Black and Scholes implied volatilities below 1% or above 200%.

The risk-free rate is proxied by continuously compounded Euribor rates. The risk-free rate of interest that corresponds to a given option maturity is then equal to the 1-month continuously compounded Euribor rate if the respective option maturity is less than a month, otherwise it is obtained by linear interpolation. Euribor rates, along with the spot prices of the underlying market indices, were obtained from DataStream.

Option returns are examined at a monthly frequency, based on the closing price of the first trading day of a given month and the closing price of the first trading day of the subsequent month. The resulting time-series of non-overlapping monthly returns of various option strategies are computed using only options with maturities between 40 and 60 days on the first day of the return window. This constraint ensures that the short-term options considered have around 7 weeks to maturity when the strategy is established and around 2 weeks to maturity when the position is liquidated (see also Driessen and Maenhout, 2007, and Santa-Clara and Saretto, 2009).

[2]Different exchanges use slightly different algorithms to compute closing prices of options (based on best bids and asks, on trades, or on both), which are not usually made publicly available. Nevertheless, exchanges typically state that closing prices are computed in such a way as to provide a meaningful measure of the option's value at the end of the trading day. The returns of option strategies in this paper are based on closing prices of options, without taking into account transaction costs (as is the case with the majority of studies on option returns).

3 Market Conditions and the Crisis

3.1 Market Conditions

The four options exchanges analyzed could be characterized as emerging markets, sharing certain common characteristics. The impact of the financial crisis of 2008 is of particular importance, given that these countries belong to the set of European economies that have been most heavily affected by the economic downturn.

Figure 1 plots the time-series of the underlying market index levels and historical volatilities across the four sample countries from January 2004 to December 2011. As can be seen from the Figure 1, the sample period is characterized by two distinct phases. The underlying equity markets experienced a significant appreciation during the first half of the sample period (2004-2007), offering average annual returns which ranged between 18% (Spain) and 29% (Hungary). Following this initial boom period, the financial crisis of 2008 has had a dramatic impact on the performance of the equity market, with all four indices experiencing a rapid depreciation post-2008. Admittedly the crisis's impact has not been uniform across the four countries, since the Greek FTSE/ASE-20 index has been on a consistently downward trend while the BUX, WIG20 and IBEX indices in Hungary, Poland and Spain, respectively, picked up temporarily during the 2009-2010 period. However, post-2008 all four indices remained substantially depreciated compared to their pre-2008 levels, with average market returns per annum ranging between -10% (Hungary) and -34% (Greece) over the second half of the sample period.

[Figure 1 around here]

In addition to deflating equity markets, the crisis has triggered significantly higher levels of volatility. As reported in Panels A and B of Table 1, the historical volatility HV of daily index returns increased substantially for all four countries after the financial crisis began to unfold, with HV more than doubling in the case of Greece (from 17% to 36%) and Spain (from 13% to 31%). Increased uncertainty is also evident by the significant increase in implied volatility IV during the second half of the sample period. The implied volatility IV refers to the annualized 1-month volatility, estimated as the Britten-Jones and Neuberger (2000) model-free expectation, with Table 1 also presenting the average level of IV for the four market indices of interest. Similarly to HV, implied volatility IV has rapidly increased during the post-2008 period (more than doubling for Greece and Spain), while the volatility of volatility has also experienced a significant increase.

[Table 1 around here]

3.2 Identification of Crisis Moment for Equity Markets

Identifying the exact date of the beginning of the financial crisis represents a notoriously difficult, or close to impossible, task. Changes in market conditions were not perfectly synchronous across different countries, while a similar case can even be made with respect to changes in index level and changes in index volatility within the same market. For instance, Argyrou and Kontonikas (2012) identified a shift in market pricing behavior from a convergence-trade model before the eruption of the subprime crisis in 2007 to one based on macro-fundamentals and international risk including contagion in EMU emerging countries thereafter. However, the choice of January 1st 2008 as the starting point of the post-crisis period can serve as a rough approximation given the significant differences between the resulting two periods.

More specifically, in addition to the clear distinction between the 2004-2007 and 2008-2011 periods, as evidenced by Table 1 and Figure 1, structural breaks in the time series of index levels and volatility can also be detected relatively close to this date. These break points are examined using the Bai and Perron (1998, 2003) test for multiple structural changes and the Iterative Cumulative Sum of Squares (ICSS) procedure (first developed by Inclan and Tiao, 1993) for index levels and volatility, respectively, and the results are presented in Panels C and D of Table 1. Both procedures reject the null of no structural break in the time series of index levels and volatility for all four countries, in favor of the alternative of multiple breaks. The Bai and Perron test detects break dates for index levels during January 2008, with the respective confidence intervals including the first trading day of 2008 across all four countries. The ICSS algorithm detects structural breaks in the time series of index volatility that are not identical to those detected for the respective index levels but are, nevertheless, very close to the beginning of 2008. Furthermore, both procedures fail to detect any additional structural changes within a 3-month period before or after January 2008.

The difference in the sign and magnitude of market returns observed before and after the financial crisis of 2008 is likely to have a direct impact on the expected returns of index options traded in the four countries. Another factor that is expected to affect observed option returns is the substantial loss of liquidity that was experienced by most of these derivatives exchanges after 2008. Obviously, trading volumes differ across the four exchanges. For example, the trading volume in equity derivatives during 2007 (just before the financial crisis began to unfold) was 5.7 million contracts for MEFF in Spain, while the respective volumes were much lower for Greece (0.6), Hungary (0.6) and Poland (0.4). The economic downturn has had a significant impact on the liquidity of the four derivatives exchanges, evidenced by a dramatic loss of liquidity for Greece and Hungary, where the post-2008 trading volumes are roughly half their pre-2008 levels, and to a lesser extent for Spain. Surprisingly, the liquidity of options traded in Poland has been continuously increasing even after the 2008 mark.

Given the above differences in terms of market premia, volatility and liquidity, all subsequent results are reported separately for two distinct sub-samples (pre- and post-crisis), in an attempt to account for the heterogeneity of the sample period, as well as to directly examine the impact of the financial crisis on the performance of option strategies in emerging EU exchanges.

4 Methodology

4.1 Option Strategies

Option returns are constructed at a monthly frequency across a set of intuitive strategies that have attracted academic attention and are often used in practice. The performance of these strategies is examined from the point of view of the investor who is selling options. In this sense, the returns offered by these option trading strategies directly reflect the premia that the market is willing to pay in order to buy insurance against future changes in the distribution of the underlying market index.

Each strategy is established on the first trading day of a given month and its return is calculated up to the first trading day of the subsequent month. The focus is on options that have around 7 weeks to maturity when the position is established and at least 2 weeks to maturity when the position is liquidated, thereby ensuring that only the most liquid short-term options are used. This approach allows for the construction of non-overlapping, equally spaced series of monthly returns that involve short-term options which are not held to maturity. One of the advantages of this procedure is that the resulting returns series of option strategies which are not held to maturity are more sensitive to distributional risks, such as volatility and jump risk (see, for instance, Driessen and Maenhout, 2007). Option strategies are constructed across 3 different levels of moneyness (proxied by the strike-to-spot ratio), namely ATM, 5% OTM and 10% OTM.[3]

The first set of option strategies involves writing put options on the underlying indices. On the first trading day of a given month, a naked put position is established by simply writing the respective option contract. Similarly, a covered put position is formed by writing one put option and going short in one unit of the underlying index. Moreover, a delta-hedged put position combines a short position in one put option and a short position in delta units of the underlying.

[3]The moneyness classification of option strategies does not apply to crash-neutral puts and crash-neutral straddles, since these strategies involve simultaneously buying and writing puts with different moneyness levels. Moreover, ATM straddles are equivalent to ATM strangles.

Naked, covered and delta-hedged puts are standard directional strategies that have been extensively examined in the recent options literature, constituting fairly obvious choices as benchmark strategies (Bakshi and Kapadia, 2003; Santa-Clara and Saretto, 2009). Naked puts provide unhedged directional exposure to the underlying index and have been shown to offer substantially high returns that are difficult to reconcile with existing asset pricing models (Bondarenko, 2014; Coval and Shumway, 2001; Bollen and Whaley, 2004). Covered puts provide a hedge to downward market movements by going short in the underlying index, but this is at best a partial hedge since the strategy does not take into account the relationship between asset and put returns, particularly the fact that expected put returns are a monotonic function of strike price (Coval and Shumway, 2001). In contrast, delta-hedged puts allow for a more efficient hedge by accounting for the option's sensitivity to changes in the underlying's price, although the efficiency of the hedge will depend on how accurately the option's sensitivity is captured by its respective Black and Scholes delta.

The second set of option strategies involves combinations of calls and puts. On the first trading day of a given month, a straddle position is constructed by writing a call and a put option with the same strike price and expiration date. For example, the 5% straddle is formed by writing a 5% OTM put and a call option with the same strike price, which will be 5% in-the-money (ITM). In contrast, a strangle position involves writing a call and a put option with the same moneyness and expiration date, but different strike prices. Similarly to the directional strategies discussed above, strangles are formed using ATM or OTM options, with the 10% OTM strangle, for example, consisting of a short position in a low strike (10% OTM) put and a short position in a (high strike) 10% OTM call. Both straddles and strangles are common volatility trading strategies, with the performance of short positions being negatively related to the volatility of the underlying index, and have been found to offer high average returns which are increasing with the level of moneyness (Coval and Shumway, 2001; Santa-Clara and Saretto, 2009).

In contrast to short volatility strategies, a risk reversal combines opposite positions in a call and a put option with the same moneyness. A risk reversal is constructed by identifying a call and a put option with the same moneyness and expiration date, and then taking a long position in the cheaper option while selling the more expensive one. Given that any difference in the price of calls and puts with the same moneyness is directly related to different levels of implied volatilities, taking opposite positions in the two options through a risk reversal constitutes a typical skewness strategy, intended to profit from high levels of implied skewness in a particular direction that are not associated with subsequent large movements of the underlying index in that direction.

The last set of option strategies refers to option-selling positions that are protected against large market crashes. More specifically, a crash-neutral put is formed by selling a 5% OTM put option and simultaneously buying a cheaper 10% OTM put with the same expiration date, with the short side essentially selling insurance against negative index returns but also insuring herself against an index crash. Similarly, a crash-neutral straddle is constructed to sell insurance against volatility increases while being protected against very large negative index returns, by selling an ATM straddle and buying the 10% OTM put. These crash neutral strategies provide protection against extremely negative returns by establishing a long position in the deep OTM put. However, this protection comes at the cost of lower expected returns given the typically large premia for volatility and jump risk embedded in deep OTM puts.

4.2 Performance Measures

In addition to examining expected returns, the performance of the option strategies discussed above is further evaluated through a set of 9 performance measures. The first two measures, namely the Adjusted Sharpe Ratio and the M-squared, use the returns' standard deviation as a proxy for risk when describing the risk-return trade-off of the option strategies. In contrast, Leland's alpha represents a measure of risk-adjusted returns after accounting for the strategies' systematic risk, as captured by their market betas. Next, the Information Ratio and the Adjusted Treynor Ratio scale a strategy's alpha by its systematic risk and idiosyncratic risk, respectively. The final three performance measures, namely the Omega, the Sortino ratio and the Kappa measure, are based on the Lower Partial Moments of the returns distribution, focusing on the first, second and third order, respectively.

The Sharpe Ratio is arguably the most common performance measure used in the literature. The Adjusted Sharpe Ratio (ASR) explicitly adjusts for the returns' skewness and kurtosis by incorporating penalty factors for negative skewness and excess kurtosis (Pezier, 2008). Further to its intuitive simplicity, the ASR constitutes a risk-adjusted performance measure[4] that is unaffected by the high leverage implicit in put options. The ASR is computed as

$$ASR_i = SR_i \times [1 + \frac{S_i}{6} \times SR_i - \frac{K_i - 3}{24} \times (SR_i)^2] \tag{1}$$

where SR_i is the strategy's Sharpe Ratio (given by $\frac{E[r_i]-r_f}{\sigma(r_i)}$), S_i is the strategy's skewness and K_i is the strategy's kurtosis.

The Modigliani and Modigliani (1997) M-squared measure is essentially a modified version of the Sharpe ratio, adjusting the strategy's expected return by its riskiness relative to a benchmark level of risk, given by the standard deviation

[4]See also Bondarenko, 2014, for its use in evaluating option returns.

of market returns r_m. Alternatively, MM can be considered as a measure of the return that the investor would have earned if she had leveraged (or diluted) her portfolio in order to obtain the same risk exposure as if investing in the market. The MM_i for a given strategy i is computed as

$$MM_i = \frac{E[r_i]}{\sqrt{var(r_i)}} \sqrt{var(r_m)} = SR_i \sqrt{var(r_m)} \tag{2}$$

In contrast, Leland's alpha replaces the standard deviation with the asset's co-movement with the market as an alternative measure of risk. More specifically, Leland (1999) proposes a modification to the Capital Asset Pricing Model (CAPM) in order to account for observed deviations of asset returns distributions from normality. In the standard CAPM framework, all assets are assumed to offer normally distributed returns and, given the market return r_m, the CAPM's coefficients for the return series r_i of a given option strategy i are computed as

$$\alpha_i = E[r_i] - \beta_i(E[r_m] - r_f) - r_f \tag{3}$$

$$\beta_i = \frac{cov(r_i, r_m)}{var(r_m)}$$

Unlike the CAPM, the Leland (1999) model allows for any arbitrary returns distribution, where the modified risk-adjusted return LEL_i (A_i) for a particular strategy i is computed as

$$LEL_i = A_i = E[r_i] - B_i(E[r_m] - r_f) - r_f \tag{4}$$

with the modified slope B_i given by

$$B_i = \frac{cov(r_i, -(1 + r_m)^{-\beta})}{cov(r_m, -(1 + r_m)^{-\beta})} \tag{5}$$

The Information Ratio (IR) is computed as the strategy's alpha over the standard deviation of the residuals from the market model in (4). Intuitively, the IR can be interpreted as the risk-adjusted (abnormal) return earned by the strategy per unit of idiosyncratic (strategy-specific) risk:

$$IR_i = \frac{\hat{A}_i}{\hat{\sigma}(\epsilon_i)} \tag{6}$$

The Generalized Treynor Ratio (GTR) similarly scales the strategy's alpha by risk. In contrast to the IR, though, the GTR is measured as the strategy's alpha per unit of systematic risk, with the latter measured by the market model's beta in (5). A more detailed discussion of the complimentary information offered by the IR and the GTR regarding a strategy's alpha can be found in Hubner (2005). The GTR equation is

$$GTR_i = \frac{\hat{A}_i}{\hat{B}_i} \tag{7}$$

As an alternative to measuring risk through the returns distribution variance or its co-movement with market returns, the final three measures shift the emphasis to downside risk using the distribution's Lower Partial Moments (LPM), with the n^{th} LPM of r_i defined as

$$LPM_n[r_i] = E[max(0, -r_i)^n] \tag{8}$$

Keating and Shadwick (2002) use the first-order LPM and define the Omega as

$$\Omega[r_i, L] = \frac{\int_L^b [1 - F(r_i)] dr_i}{\int_a^L F(r_i) dr_i} \tag{9}$$

where F is the cumulative distribution function of the returns of asset i, L is a return threshold selected by the investor, while a and b represent the upper and lower bounds of the returns distribution, respectively. Omega is flexible in evaluating the performance of non-normal asset returns, by taking into account the entire returns distribution, and it focuses on the relative probability of returns below a certain threshold as a proxy for risk. In this paper, the returns threshold L is set equal to the risk-free rate of interest.

Similarly, the most common variant of the Sortino ratio focuses on the second-order LPM, with the $SORT_i$ of strategy i defined as

$$SORT_i = \frac{\int_{-\infty}^{\infty} r_i dF(r_i) - L}{\sqrt{\int_{-\infty}^{L} (L - r_i)^2 dF(r_i)}} \tag{10}$$

Finally, Kaplan and Knowles (2004) demonstrate that the Omega and the Sortino ratio represent special cases of a more general performance measure, referred to as Kappa. The n^{th} Kappa measure k_n of the returns distribution r_i is defined as

$$k_n[r_i] = \frac{E[r_i] - L}{\sqrt[n]{LPM_n[r_i]}} \tag{11}$$

and it can be shown that the Omega and the Sortino ratio are essentially equivalent to the Kappa measure for orders 1 and 2, respectively. Given the absence of a universal rule on choosing the appropriate order n for a Kappa measure that best captures the performance of a given returns series (Kaplan and Knowles, 2004), and the fact that such an examination lies outside the scope of this paper, Kappa is chosen to compliment the information provided by the Omega and the Sortino ratio by setting n equal to the immediately next LPM, and it will henceforth refer to the 3^{rd} order measure in equation (11).

4.3 Statistical Inference

The returns distributions of options and option strategies deviate considerably from normality, particularly in terms of pronounced skewness and heavy tails. Therefore, the usual asymptotic standard errors are most likely not valid for statistical inference on the significance of observed returns and their respective performance measures. Due to the non-normality of option returns distributions, the statistical significance of these metrics is evaluated using bootstrapped error bounds on the empirical distribution of returns. Assuming that the observed non-overlapping monthly returns are independent and identically distributed, 1000 non-parametric bootstrapped samples are obtained by sampling with replacement from the returns series. The metrics of interest are then calculated for each bootstrapped set, which can be considered as another sample. Statistical significance at the 5% level is based on the resulting bootstrapped confidence intervals (see also Jackwerth, 2000).

5 Empirical Results

5.1 Option Characteristics

This Section begins with a discussion of the characteristics of calls and puts used in constructing the option strategies described above. Table 2 presents the average Black and Scholes implied volatility, the average option price as a percentage of the underlying's price, and the average Black and Scholes delta of the options. These statistics are tabulated separately for calls and puts, across the 3 moneyness levels, with Panels A and B referring to the pre-crisis (2004-2007) and post-crisis (2008-2011) sub-samples, respectively.

[Table 2 around here]

During the 2004-2007 period, the average ATM implied volatility for calls ranged between 13% (Spain) and 21% (Hungary), while ATM puts were associated with higher implied volatilities that ranged between 16% (Spain) and 25% (Poland). In terms of implied volatility, puts seem to become more expensive the more OTM they are, while a similar pattern is not evident in the case of calls. Similarly to US options (Santa-Clara and Saretto, 2009), the downside protection offered by deep OTM puts generally comes at a higher cost than the upside leverage offered by deep OTM calls.

As has been previously mentioned, the post-crisis period is characterized by substantially higher levels of implied volatility which, as can be seen from Panel B of Table 2, ranged between 29% and 47% for ATM options. Puts are still more expensive (in terms of IV) as they move from ATM to deep OTM levels during 2008-2011, although this is not the case for calls, and puts are generally found to be more expensive compared to similar moneyness calls. Furthermore, the difference in IV between ATM and 10% OTM puts has increased across all four sample countries, indicating more pronounced skewness in the risk neutral distribution. This increase in the implied volatility differential across moneyness could reflect a higher real-world probability attached to a large market crash or more pronounced risk aversion or, most likely, both.

5.2 Directional Strategies

Table 3 reports summary statistics of the performance of directional option strategies across 3 moneyness levels, namely 10% OTM, 5% OTM and ATM. The table is split into 2 Panels, with Panel A referring to the pre-crisis sub-sample (January 2004 to December 2007) and Panel B referring to the post-crisis one (January 2008 to December 2011). For each strategy, the table reports the average monthly return and the values of the 9 performance measures described in the previous section. Statistical significance at the 5% level, based on the respective bootstrapped confidence intervals, is indicated in bold. Furthermore, Figure 2 plots the cumulative monthly returns for the case of covered puts, separately for each moneyness level and sample country.

[Table 3 around here]

[Figure 2 around here]

The first results in Table 3 correspond to the naked put strategy (NP). Prior to the financial crisis of 2008, writing index puts at various levels of moneyness has generally offered positive returns across the four sample countries. However, due to their high levels of risk, the economic benefit of writing put contracts, reflected by all 9 performance measures, is statistically insignificant for Hungary, Poland and (to an extent) for Greece. With the exception of ATM puts on the Greek FTSE/ASE-20, Spain is found to be the only market where writing naked puts during 2004-2007 has offered high average returns which are associated with statistically significant performance measures. For example, selling 5% OTM puts on the Spanish IBEX has earned an average of 48% per month, with an ASR of 0.37. These results for Spain are comparable to those reported by Bondarenko (2014) and Santa-Clara and Saretto (2009) for the US market, as is the finding that naked 5% OTM puts tend to outperform deeper OTM and ATM contracts.

As can be seen from Panel B of Table 3, the performance of NP strategies is substantially different during the post-crisis period, which is characterized by deflating markets and increased volatility. Generally, writing naked puts offers dramatically lower returns compared to the pre-crisis period, with NP performance measures being negative for Poland and positive for Spain, but statistically insignificant for both. Unsurprisingly, losses from selling puts are even more pronounced in the case of Greece, which has been the country most heavily afflicted by the economic downturn, where NP strategies are associated with significantly negative Adjusted Sharpe Ratios across all moneyness levels (reaching -0.36 for deep OTM puts). The only surprising result refers to the exceptionally high profitability of writing index puts in Hungary. Selling naked puts on the BUX index during 2008-2011 has offered very high risk-adjusted returns (between 33% and 44% based on Leland's alpha) with ASRs above 1.7 irrespective of moneyness. Although this result is particularly puzzling given that the Hungarian equity market fell by an average of 10% annually during this period, it could be at least partially related to the dramatic loss of liquidity experienced by the BSE during the financial crisis.

The performance of protective put strategies during the boom 2004-2007 period was considerably worse compared to naked positions. For instance, writing covered puts (CP) has offered monthly returns that are very close to zero and, more importantly, statistically insignificant in most cases. Moreover, the previously reported profitability of writing puts in Greece (ATM) and Spain (all moneyness levels) was lost by incorporating a short position in the appreciating market indices, resulting in negative overall returns for the strategy. Despite their statistical significance, these CP strategies in Greece and Spain are associated with relatively low risk-adjusted returns (roughly -0.1% per month).

In contrast, CP strategies have been particularly profitable after the financial crisis (2008-2011). As can be seen from Panel B of Table 3, going short simultaneously in a put contract and the underlying index has offered positive monthly returns across all four sample countries and all levels of moneyness. These returns are generally statistically significant, with the associated *ASR* in many cases exceeding 1 and the values for all three LPM-based measures being particularly high. However, given the performance of naked puts and the significantly negative market premium during the post-crisis period, this profitability of covered puts is more likely driven by the substantial market deflation experienced after the crisis rather than by the efficiency of what is essentially a fairly naive hedge.

On the other hand, delta-hedged put strategies (DHP) provide more efficient protection of the option position against downward market movements by going short in a fraction of the underlying, determined by the Black and Scholes delta of the put, at the cost of lower expected returns in appreciating markets. During 2004-2007, DHP strategies have offered monthly returns that are indistinguishable from the risk-free rate across all moneyness levels for 3 of the sample countries, with all performance measures also being statistically insignificant. Spain constitutes the only exception, where delta-hedging the put has resulted in significantly positive returns during the boom period. Compared to writing naked puts, DHP strategies in Spain have offered considerably lower monthly returns (from 0.5% to 2%, depending on moneyness), but the *ASR*s have increased substantially due to lower standard deviations and all three LPM measures indicate an improved trade-off between expected returns and downside risk. However, when systematic risk is taken into account, delta-hedged puts represent worse investments than simply writing the option, as evidenced by considerably lower Leland alphas (these results are comparable to those obtained by Bakshi and Kapadia, 2003, and Santa-Clara and Saretto, 2009, for covered and delta-hedged puts written on the S&P 500).

Similarly to covered puts, delta-hedged strategies have offered positive average returns during the post-crisis period, when equity markets depreciated. DHP strategies were associated with lower average returns and performance measures compared to CP strategies for Greece and Poland, though, indicating that the cost of reduced short exposure to the declining underlying index outweighed the benefit of lower risk obtained by more efficient hedging. In contrast, delta-hedging appears to have improved the performance of writing puts in the remaining 2 countries, with *ASR*s exceeding 3 in the case of Hungary. Furthermore, accounting for co-movements with the market, the respective Leland's alphas suggest that these DHP strategies offered statistically significant risk-adjusted returns (around 2.3% and 1.5% for Poland and Spain, respectively). Writing delta-hedged puts after the crisis offered relatively high risk-adjusted returns per unit of strategy specific risk, as evidenced by the relatively high Information Ratios (with the exception of Greece).

5.3 Volatility and Skewness Strategies

The most common volatility trading strategies involve straddles or strangles. Selling a straddle (STD) or a strangle (STG) is equivalent to going short on the volatility of the underlying asset. Table 4 presents summary statistics for the monthly returns of STD and STG strategies across 3 moneyness levels. Figure 3 plots the cumulative monthly returns of strangles, separately for each moneyness level and sample country.

[Table 4 around here]

[Figure 3 around here]

As can be seen from Panel A, going short on volatility by writing straddles during the pre-crisis period has offered significantly positive returns in Spain (all moneyness levels) and, to a lesser extent, in Greece (deep OTM) and Hungary (ATM). The associated performance measures are substantially high and statistically significant, with Greek 10% OTM straddles, for instance, having an *ASR* ratio of 4.7 and risk-adjusted returns (Leland alpha) of 35% per month. Nevertheless, STD strategies for Poland, as well as across alternative levels of moneyness for Greece and Hungary, have resulted in statistically insignificant performances.

The results reported in Panel B of Table 4 suggest that shorting volatility by selling straddles during the financial crisis (2008-2011) has been considerably more profitable compared to its pre-2008 performance. STD strategies have positive and statistically significant monthly returns across all countries and moneyness levels (with the exception of ATM straddles in Poland). Sharpe ratios range from 0.60 to 11.26 and the Omega, Sortino and Kappa measures suggest a higher expected return per unit of downside risk. Moreover, the respective Leland alphas are very high, indicating that short straddle positions offered risk-adjusted returns above 20% per month in all cases, after accounting for systematic risk (these alphas are substantially higher than the one reported by Santa-Clara and Saretto, 2009, for writing ATM straddles on the S&P 500). The strong performance of short volatility strategies during the 2008-2011 period, which was characterized by considerably higher realized volatility compared to 2004-2007, could indicate that index options in emerging EU markets were priced at very high levels of implied volatility that were not followed by equally high realized volatilities. This explanation is also consistent with the results reported in Table 2, which indicate that both calls and puts became more expensive after the crisis, in terms of their price-to-underlying ratio as well as implied volatility. In other words, the market seems to have anticipated a very significant increase in future volatility (or exhibited a very pronounced aversion to volatility risk), which did not quite materialize, thereby offering substantial returns to investors who were willing to provide insurance against volatility risk.

Similarly to writing straddles, a short strangle position will be profitable if the underlying's volatility remains low during the holding period. However, given that the options are written at different strikes, strangles are less sensitive to large volatility changes (exhibiting lower gammas) at the cost of a lower total option premium at inception.[5] The results from Panel A of Table 4 indicate that OTM strangles generally offered significantly positive returns over the pre-crisis period (with the exception of Poland), outperforming the respective STD strategies. Strangles were also associated with high Sharpe ratios and significantly positive and high risk-adjusted returns.

While during 2008-2011 short OTM strangles have offered positive and statistically significant mean returns (except for Poland) in excess of those offered by the corresponding straddles, STG strategies are associated with slightly lower ASR and M-squared measures compared to equivalent STD strategies. Furthermore, the STG risk-adjusted returns LEL are also positive, statistically significant and higher than the respective alphas of comparable STDs. Our results confirm the idea in Xing et al. (2010) that informed traders with negative views may prefer to trade out-of-the-money put options, particularly when the equity market is slow in incorporating the information embedded in volatility smirks.

Finally, a risk reversal is established on the first day of each month by taking opposite positions in a call and a put option with the same moneyness and expiration date. Given that the strategy involves buying the cheaper (low IV) option and selling the more expensive (high IV) one, a RR constitutes a position against the skewness implied by option prices. Furthermore, puts in the four sample countries have typically traded at higher prices (and implied volatilities) compared to same moneyness calls, implying a negative skewness in the risk-neutral distribution, similar to the one documented in Bates (1991) and Doran et al. (2007) for S&P options. In this setting, a risk reversal essentially sells insurance against negatively skewed returns of the underlying index, by selling the put and buying the

[5]The straddles examined involve writing an OTM put and an ITM call with the same strike, effectively doubling the exposure to volatility compared to writing a single option. In contrast, the matching strangle consists of a call and a put that are equally OTM, resulting in a lower total gamma for the position compared to the straddle. However, the total premia received from writing the strangle will be lower compared to those for the straddle, since the OTM call will obviously be cheaper than the ITM one. In the special case of ATM positions, straddles and strangles represent equivalent strategies involving the same pair of option contracts.

call, and it would be profitable if the negative skewness implied by option prices is not followed by subsequent large market declines.

The results reported in Panel A of Table 5 and Figure 4 suggest that, during the pre-crisis period, risk reversals have been profitable mainly in the Greek and Spanish markets, with Leland alphas ranging from 10% to 37%, and high ASRs. Once again, RR strategies in Poland have resulted in statistically insignificant mean returns and performance measures across all moneyness levels. The performance of RR strategies after the financial crisis has not been equally strong. As can be seen from Panel B of Table 5, the mean returns and performance measures of risk reversals during 2008-2011 have been mostly insignificant. Deep OTM risk reversals in Spain are the only exception, earning a risk-adjusted 23% per month. This statistically insignificant performance of risk reversals could indicate that the crash/spike premia embedded in index options during the financial crisis have been relatively accurate predictors of future skewness in the realized returns distribution (Doran et al., 2007), thereby eliminating the opportunity for abnormal profits by betting against the negative skewness implied in the option markets.

[Table 5 around here]

[Figure 4 around here]

5.4 Crash-Neutral Strategies

Given that all the previously discussed strategies involve writing put options, they would be exposed to unlimited downside risk in the event of large market crashes. Therefore, adding a long position in a deep OTM put provides protection against crash risk, at the cost of lower expected returns.[6] To this extent, a crash-neutral put (CNP) allows for a short directional bet, insured against a market crash, by writing a 5% OTM put and simultaneously buying a 10% OTM put with the same expiration date. Similarly, a crash-neutral straddle (CNS) provides crash insurance to a short volatility bet, by writing an ATM straddle and buying a 10% OTM put with the same expiration date. Table 6 reports the performance of CNP and CNS strategies across the four sample countries, with pre-crisis and post-crisis results presented in Panels A and B, respectively.

[Table 6 around here]

[6] The unlimited downside exposure of writing the option strategies is only an approximation, since the positions are not held until maturity. In the same sense, the crash protection offered by buying the deep OTM put is approximate.

While writing 5% OTM puts during the pre-crisis period has been significantly profitable only in the case of Spain, with a mean return of 48% and an ASR of 0.37 (see Table 3), buying crash protection through a CNP comes at a substantial cost, evidenced by lower mean returns of 11% and an ASR of 0.22 reported in Table 6. However, CNP performance remains significantly positive for Spain and statistically insignificant for the remaining 3 sample countries. Adding a long position in deep OTM puts has reduced the average losses of writing 5% OTM puts in Greece and Poland, although it has resulted in more negative ASRs. In addition, the CNP strategies in Hungary and Spain are found to offer negative returns during the period 2008-2011, considerably underperforming relative to the simple strategy of writing the 5% OTM put contract.

A very similar pattern emerges by analyzing the performance of CNS positions. The performance of unprotected short volatility strategies was found to be very strong across the full sample period, particularly during the financial crisis. These results confirm the conclusion of Bollerslev et al. (2015) that future market returns are heavily influenced by the part of the variance risk premium demanded as compensation by investors for bearing jump tail risk. However, insuring these straddles against large market crashes, by buying a deep OTM put, has resulted in CNS strategies offering monthly returns that are either statistically insignificant or, in most cases, significantly negative. Overall, the high cost of crash insurance appears to substantially decrease the appeal of otherwise very profitable volatility strategies for all four sample countries, both before and after the financial crisis.

5.5 Cross-Section of Option Returns

Directional strategies have earned risk-adjusted returns that are in most cases statistically indistinguishable from the risk-free rate, after accounting for their covariance with index returns, suggesting that market participants were not willing to pay over the odds for insurance against downward index movements. However, selling insurance against increases in index volatility was associated with consistently high returns that were significantly higher than the risk-free rate after accounting for systematic risk, while strategies that provided insurance against negative skewness were similarly profitable before the crisis. In order to better understand whether the returns of these option strategies represent compensation for some underlying risk, as opposed to being abnormal, the cross-section of option returns is examined with respect to a set of risk factors that have been shown to explain, to an extent, index option returns in the literature.

Following the literature on capturing risk-premia embedded in asset returns, a two-stage methodology is adopted. The first step involves regressing the time-series of returns for each option strategy against a set of risk factors

$$r_{i,t} = \alpha_i + \sum_{j=1}^{K} \beta_{j,i} F_{j,t} + \epsilon_{i,t} \tag{12}$$

where r_i is the return of strategy i and F_j is the j^{th} risk factor. The time-series regressions in (12) are estimated separately across each option strategy, sample country and level of moneyness. The second step fits a cross-sectional regression of the mean returns of option strategies versus the estimated betas at the first step

$$\overline{r_i} = \eta_0 + \sum_{j=1}^{K} \eta_j \hat{\beta}_{j,i} + u_i \tag{13}$$

where $\overline{r_i}$ is the sample mean of the returns of strategy i, $\hat{\beta}_{j,i}$ is the sensitivity of strategy i with respect to the risk factor j obtained through the time-series regression in (12), and η_j is the price of risk associated with factor j.

In contrast to stocks, for which a number of theoretical asset pricing models have been proposed, no respective models have been derived to describe the cross-section of option returns. The simple continuous-time CAPM of Merton (1971), combined with the Black and Scholes (1973) option pricing framework, represents arguably the only exception, where options earn returns commensurate with their Black and Scholes market betas (see also Jarrow and Rudd, 1983), although this model has not been found to describe realized option returns particularly well (see for instance Coval and Shumway, 2001, and Constantinides et al., 2013). Aside from this exception, the models that have been suggested in the literature to explain the cross-section of option returns essentially comprise various risk factors that are intuitively and empirically linked to option returns, albeit not as a result of a rigorous theoretical framework.

The two-stage methodology in this paper uses the risk factors proposed by Jones (2006) and Constantinides et al. (2013) as potential drivers of index option returns. More specifically, Jones (2006) examines whether the returns of options written on S&P 500 index futures can be explained by the market return, the change in VIX, and the change in the short-term risk-free rate. Constantinides et al. (2013) explore a number of factors, concluding that S&P 500 index option returns are best explained by jumps in market returns, jumps in volatility, changes in implied volatility, and liquidity. We also include in the set of potentially priced risk factors the implied volatility smirk, as defined by Xing et al. (2010).[7]

[7] Constantinides et al. (2013) use the Pastor and Stambaugh (2003) liquidity factor. Computing this measure of liquidity is based on the trading volumes of individual stocks in the equity market, and this data is not readily available for the four emerging markets in this paper. Therefore, only the first three factors of Constantinides et al. (2013) are used to price the cross-section

Table 7 presents the results from the second-stage cross-sectional regressions in (13), separately for the pre- and post-crisis subsamples. The first two columns report the coefficients from estimating the pricing model in Jones (2006), i.e. where the factors refer to the return of the spot market index on a given month, the difference in implied volatility of the market (using index options and computed as the model-free expectation introduced by Britten-Jones and Neuberger, 2000) on the first and last trading day of the month, and the change in the 3-month Euribor during that month. The first two factors refer to the domestic equity market and are, thus, country-specific. The third and fourth columns tabulate the results from regressing option returns on the loadings of jumps in market returns, jumps in volatility and changes in implied volatility, with these factors defined in the same way as in Constantinides et al. (2013). More specifically, *Return Jump* of a given month is defined as the sum of all daily returns of the domestic market index that are lower than -4% during that month (zero if such returns are not observed on that month). Similarly, *Volatility Jump* is defined as the sum of all daily increases of the domestic market's implied volatility index that are greater than 4% during a particular month (zero if no such increases are observed). The final Constantinides et al. (2013) factor (IV changes) is the same as the one used in the Jones (2006) model. All the three latter factors are country-specific. The last two columns of Table 7 report the coefficients of an extended specification that uses the factors from both models plus an implied volatility smirk factor (*Volatility Smirk*). Following Xing et al. (2010), we compute the (country-specific) IV smirk as the difference at the end of the month between the implied volatility of an OTM index put and that of an ATM index call. Statistical significance at the 5% level is indicated in bold, and it is based on Newey and West (1987) heteroscedasticity and autocorrelation consistent standard errors.[8]

The results from the first-stage time-series regressions (unreported for brevity, but available upon request) suggest that market betas are predominantly positive, high and statistically significant for naked puts, which is to be expected given the inherent leverage of short put positions. In contrast, the results from covered and delta-hedged puts are somewhat mixed, consistent with the previous findings of the returns of hedged put-selling strategies CP and DHP being driven to a large extent by the short position in the underlying index, especially in the case of cov-

of option returns in this section.

[8]A wider set of pricing factors has also been used to explore the cross-section of option returns. This set of factors includes the historical market volatility HV, the difference between implied and historical volatility IV - HV, the skewness and kurtosis of spot market returns, changes in index options' trading volume, and changes in the index's put-call volume ratio (sentiment indicator). None of these factors was found to be associated with statistically significant premia in the cross-section of option returns, therefore the results are omitted for brevity, but they are available from the authors upon request.

ered puts. Volatility trading strategies (especially straddles) tend to be negatively correlated with the implied volatility differential. Furthermore, directional strategies are the only strategies with returns that are strongly negatively correlated with changes in the risk-free rate and with jumps in market returns. Finally, the coefficients of *Volatility Jump* are consistently positive and significant for directional strategies but, somewhat surprisingly, no pattern is evident with respect to volatility strategies.

[Table 7 around here]

In the second-stage cross-sectional regressions, market returns earn positive premia, which is to be expected given that assets that correlate positively with the market are considered to be more risky. Premia for the risk-free rate differential are also positive, implying that assets are considered more risky if they offer higher returns during periods of increasing interest rates, with these periods reflecting "good" states of the economy (to the extent that high rates represent growth). Similarly to Constantinides et al. (2013), ΔIV and *Volatility Jump* are found to earn negative premia, consistent with the hypothesis that assets which offer higher returns during periods of increased market uncertainty act as useful hedges. Jumps in the market returns earn positive (albeit very small) premia, reflecting the fact that assets the prices of which fall when the overall market falls are considered to be more risky. The implied volatility smirk embedded in index options is found to be associated with a negative premium, reflecting investors preference for assets that offer their highest returns during periods when puts become more expensive, potentially as a result of negative market news.

Despite the fact that the signs of observed premia are consistent with theoretical predictions, their magnitude and the associated standard errors do not support the hypothesis of these factors being priced in the cross-section of option returns for this sample. Before the crisis, the IV smirk is the only factor for which the price of risk η is (marginally) statistically significant. After the crisis, the lowest p-values are obtained for jumps in the index's implied volatility. However, all estimated coefficients are insignificant after the crisis, even at the 10% significance level. This finding, combined with the statistically significant intercepts, could potentially suggest that omitted factors are being priced or that, when buying insurance through options, the market was willing to pay a very substantial premium for risks that did not fully materialize during the sample period.

It should be noted that the above empirical results are likely to suffer from a joint hypothesis problem, like any other two-stage approach to determining risk premia in asset returns. The factor loadings that enter into the second-stage cross-sectional regression are model-based, since they are estimated through first-stage time-series regressions. Consequently, rejecting the null of a zero intercept in the second-stage regression should be interpreted as a joint rejection of a zero alpha and of the underlying model. However, the above empirical findings could serve to show that the returns of option strategies in this paper are not linked to commonly examined risk factors in any traditional way.

6 Conclusion

The financial crisis of 2008 has had a dramatic impact on equity markets, which has been even more evident in the case of developing EU countries. The resulting depreciation of market indices and the rapidly increasing uncertainty, in particular, have highlighted the important role of effective options markets in pricing various sources of risk and risk-pooling across market participants. In an attempt to explore options risk-premia in developing exchanges and the impact of the recent crisis, this study has examined the empirical performance of a set of option trading strategies across four emerging option markets of the European Union.

In contrast to previous studies that document abnormally high returns from selling puts on the S&P500 index, our empirical results suggest that similar strategies were not particularly profitable in emerging European exchanges after accounting for their risk exposure. Although hedging short positions in puts by also going short in the underlying index was found to offer significant returns after the crisis began to unfold, improved performance can be more likely attributed to the strong downward trend of the index rather than the efficiency of the hedge.

On the other hand, option strategies that go short in volatility appear to be considerably profitable, offering very high risk-adjusted returns and Sharpe ratios. This finding could potentially be related to market expectations of very high future volatility (which failed to materialize) or increased risk aversion to volatility risk, leading to significant benefits for investors who were willing to provide volatility insurance, particularly during the financial crisis. In addition, it appears that market participants were willing to pay a significant premium for insurance against negatively skewed index returns before the crisis, although skewness premia seem to be commensurate with the underlying risk after the crisis.

Overall, the empirical results indicate that the risk premia embedded in options traded in emerging European exchanges are, to an extent, consistent with the subsequent returns distribution of the underlying indices. However, investors were willing to pay a considerable premium for protection against volatility risk and, to a lesser extent, for insurance against negative skewness. More importantly, the significant returns of these option-selling strategies could potentially be characterized as abnormal, since they cannot be explained in an obvious way as compensation for risk across a wide set of common risk factors. The related literature has yet to formulate a comprehensive model for the cross-section of option returns and, hence, it is possible that the significant alphas that are reported represent compensation for some unknown aggregate risk. Such a task represents an interesting topic for future research.

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Table 1: Summary Statistics of Underlying Indices and Structural Break Tests

Panel A: Index Statistics for 2004-2007				
	GREECE	HUNGARY	POLAND	SPAIN
Mean return	0.082	0.101	0.075	0.065
HV	0.165	0.211	0.206	0.132
IV	0.273	0.241	0.237	0.142
Panel B: Index Statistics for 2008-2011				
	GREECE	HUNGARY	POLAND	SPAIN
Mean return	-0.204	-0.042	-0.046	-0.055
HV	0.360	0.342	0.296	0.308
IV	0.623	0.320	0.328	0.314
Panel C: Bai-Perron Structural Break Test on Index Mean				
	GREECE	HUNGARY	POLAND	SPAIN
supF(21)	0.17	1.13	7.53	13.04*
supF(32)	7.83	4.67	14.74*	16.98*
supF(43)	46.26*	102.48*	16.95*	25.16*
supF(54)	71.36*	102.48*	36.70*	25.16*
supF(65)	35.77*	18.00*	3.74	25.16*
Break Date	11-Jan-08	15-Jan-08	14-Jan-08	18-Jan-08
Conf.Int. (Lower)	05-Sep-07	05-Feb-07	16-Nov-07	17-Dec-07
Conf.Int. (Upper)	15-May-07	29-Feb-08	31-Jan-08	30-Jun-08
Panel D: ICSS Procedure for Structural Break on Index Volatility				
	GREECE	HUNGARY	POLAND	SPAIN
no of breaks	12	13	6	12
Break Date	15-Jan-08	28-Nov-07	22-Dec-07	21-Jan-08

NOTE: The sample runs from January 2004 to December 2011. Panel A presents summary statistics for the pre-crisis period (January 2004 to December 2007) and Panel B refers to the post-crisis period (January 2008 to December 2011). Mean daily returns are tabulated in percentages. HV is the historical volatility of realized daily index returns. IV is the (annualized) implied volatility over the next month calculated as the model-free expectation (Britten-Jones and Neuberger, 2000). Panel C presents the results of the Bai and Perron (1998, 2003) test for detecting multiple structural breaks in the time series of index levels. The test allows for heteroscedasticity and autocorrelation in the residuals, sets the maximum number of allowed breaks to 10, and selects the number of breaks using the sequential procedure and the Bayesian Information Criterion (BIC). Panel C tabulates the respective supF test-statistics, the estimated break date that is closest to January 2008, and the 95% confidence interval around that date. Statistical significance at the 5% level is denoted by *. Panel D presents the results of the Iterative Cumulative Sum of Squares (ICSS) procedure (Inclan and Tiao, 1993) for detecting multiple structural breaks in the time series of index volatility. Panel D tabulates the number of structural changes detected, and the break date that is closest to January 2008.

Table 2: Summary Statistics of Options data

Panel A: 2004-2007													
		GREECE			HUNGARY			POLAND			SPAIN		
		10%	5%	ATM	10%	5%	ATM	10%	5%	ATM	10%	5%	ATM
Calls	*IV*	0.221	0.214	0.206	0.210	0.215	0.213	0.213	0.210	0.210	0.116	0.122	0.133
	C/S	0.005	0.008	0.022	0.008	0.018	0.038	0.010	0.018	0.034	0.009	0.009	0.024
	delta	0.135	0.218	0.524	0.155	0.304	0.547	0.183	0.305	0.527	0.168	0.210	0.547
Puts	*IV*	0.278	0.255	0.234	0.207	0.211	0.204	0.278	0.263	0.249	0.207	0.181	0.160
	P/S	0.006	0.011	0.024	0.013	0.017	0.031	0.010	0.019	0.035	0.009	0.010	0.023
	delta	-0.10	-0.18	-0.46	-0.15	-0.23	-0.45	-0.14	-0.26	-0.45	-0.11	-0.18	-0.46
Panel B: 2008-2011													
		GREECE			HUNGARY			POLAND			SPAIN		
		10%	5%	ATM	10%	5%	ATM	10%	5%	ATM	10%	5%	ATM
Calls	*IV*	0.494	0.486	0.460	0.206	0.283	0.295	0.280	0.282	0.288	0.253	0.273	0.295
	C/S	0.020	0.030	0.045	0.024	0.034	0.054	0.018	0.029	0.046	0.012	0.027	0.046
	delta	0.243	0.351	0.520	0.260	0.466	0.563	0.216	0.342	0.528	0.163	0.325	0.535
Puts	*IV*	0.573	0.504	0.467	0.286	0.289	0.444	0.335	0.314	0.298	0.368	0.340	0.314
	P/S	0.022	0.030	0.045	0.043	0.053	0.064	0.020	0.030	0.046	0.014	0.026	0.048
	delta	-0.20	-0.29	-0.46	-0.32	-0.40	-0.44	-0.18	-0.29	-0.47	-0.15	-0.28	-0.46

NOTE: This table presents summary statistics for index calls and puts. *IV* is the Black and Scholes implied volatility, $price/S$ is the ratio of the option price to the spot price of the underlying index, and delta is the first derivative of the Black and Scholes price function with respect to changes in the value of the underlying. Both calls and puts are classified into 3 moneyness groups according to their strike-to-spot ratio, namely 10% OTM, 5% OTM and ATM. Panel A refers to the pre-crisis sub-sample (January 2004 to December 2007), while Panel B refers to the post-crisis sub-sample (January 2008 to December 2011).

Table 3: Performance of Directional Strategies

Panel A: 2004-2007													
		GREECE			HUNGARY			POLAND			SPAIN		
		10%	5%	ATM	10%	5%	ATM	10%	5%	ATM	10%	5%	ATM
NP	Mean	-0.82	0.24	**0.35**	-0.01	-0.13	0.21	0.36	-0.09	0.02	**0.45**	**0.48**	**0.30**
	ASR	-0.14	0.12	0.29	-0.04	-0.06	0.15	0.33	-0.06	0.02	**0.21**	**0.37**	**0.38**
	MM	-0.01	0.01	**0.02**	0.00	0.00	0.01	0.02	0.00	0.00	**0.01**	**0.02**	**0.01**
	LEL	-0.82	0.24	**0.36**	0.00	-0.12	0.22	0.36	-0.10	0.02	**0.45**	**0.49**	**0.30**
	IR	-0.17	0.19	**0.72**	-0.06	-0.10	0.31	0.62	-0.13	0.04	**0.58**	**1.08**	**0.86**
	GTR	-0.85	1.02	7.20	-0.21	-0.35	2.83	1.63	-0.22	0.08	**3.23**	**6.71**	**9.14**
	Omega	-1.29	0.36	**0.64**	-0.15	-0.22	0.42	0.59	-0.17	0.06	**0.72**	**0.80**	**0.61**
	Sortino	-1.14	0.32	**0.54**	-0.13	-0.18	0.34	0.49	-0.14	0.04	**0.63**	**0.69**	**0.49**
	Kappa	-1.04	0.30	**0.47**	-0.11	-0.16	0.29	0.44	-0.12	0.04	**0.57**	**0.62**	**0.42**
CP	Mean	0.01	0.00	0.00	-0.01	-0.01	-0.01	0.01	0.01	0.01	0.01	**-0.00**	**-0.00**
	ASR	0.03	-0.20	-0.35	-0.09	-0.18	-0.21	0.05	0.10	0.17	0.13	**-0.10**	**-0.26**
	MM	0.01	0.00	**-0.01**	0.00	-0.01	-0.01	0.01	0.01	0.02	0.01	**0.00**	0.00
	LEL	0.00	**-0.00**	**-0.00**	-0.01	-0.01	**0.00**	0.00	0.00	0.00	0.00	**-0.00**	**-0.00**
	IR	0.03	-0.24	-0.40	-0.25	-0.48	-0.51	0.32	0.24	0.39	1.26	**-0.68**	**-0.77**
	GTR	3.42	2.87	2.64	20.03	8.90	1.42	0.44	0.85	2.07	1.94	**2.15**	**1.743**
	Omega	0.10	-0.41	**-0.60**	-0.19	-0.34	-0.41	0.13	0.26	0.58	0.36	-0.23	**-0.50**
	Sortino	0.05	-0.22	**-0.35**	-0.12	-0.23	-0.26	0.08	0.15	0.28	0.20	-0.14	**-0.28**
	Kappa	0.03	-0.14	**-0.23**	-0.08	-0.18	-0.19	0.05	0.09	0.16	0.13	-0.09	**-0.18**
DHP	Mean	-0.01	0.01	0.00	-0.01	-0.01	0.00	0.02	0.00	0.01	**0.02**	**0.01**	**0.001**
	ASR	-0.07	0.08	0.07	-0.11	-0.21	-0.04	0.39	-0.02	0.12	**0.66**	**0.59**	**0.17**
	MM	0.00	0.01	0.01	0.00	-0.01	0.00	0.03	0.00	0.01	**0.03**	**0.02**	**0.01**
	LEL	-0.01	0.00	0.00	-0.01	-0.01	0.00	0.02	0.00	0.00	**0.02**	**0.01**	**0.00**
	IR	-0.08	0.09	0.08	-0.12	-0.22	-0.03	0.43	-0.02	0.14	**1.00**	**0.83**	**0.18**
	GTR	0.43	-0.50	-0.48	0.46	0.89	0.14	-3.63	0.08	-0.48	**-14.2**	**-3.93**	**-0.67**
	Omega	-0.28	0.33	0.24	-0.30	-0.50	-0.11	2.09	-0.05	0.40	**7.49**	**3.70**	**0.52**
	Sortino	-0.07	0.10	0.09	-0.12	-0.21	-0.05	0.75	-0.02	0.16	**1.84**	**1.29**	**0.25**
	Kappa	-0.03	0.04	0.04	-0.06	-0.10	-0.02	0.41	-0.02	0.08	**0.76**	**0.69**	**0.15**

Panel B: 2008-2011													
		GREECE			HUNGARY			POLAND			SPAIN		
		10%	5%	ATM	10%	5%	ATM	10%	5%	ATM	10%	5%	ATM
NP	Mean	**-0.43**	**-0.40**	-0.32	**0.33**	**0.36**	**0.44**	-0.37	-0.27	-0.37	0.21	0.13	0.07
	ASR	**-0.36**	**-0.33**	**-0.23**	**1.74**	**1.80**	**1.96**	-0.13	**-0.17**	-0.36	0.15	0.10	0.06
	MM	**-0.02**	**-0.02**	-0.02	**0.03**	**0.03**	**0.05**	-0.01	-0.01	-0.01	0.01	0.01	0.00
	LEL	**-0.44**	**-0.42**	-0.33	**0.33**	**0.36**	**0.44**	-0.38	-0.27	-0.38	0.21	0.14	0.07
	IR	**-0.63**	**-0.58**	**-0.38**	**3.24**	**3.36**	**4.01**	-0.14	-0.21	-0.47	0.26	0.18	0.11
	GTR	**-1.57**	**-1.24**	-0.90	**5.32**	**-23.4**	**-8.18**	-0.82	-0.93	-1.67	0.80	0.56	0.43
	Omega	**-1.95**	**-1.56**	-0.98	**1.00**	**1.00**	**1.00**	-0.89	-1.11	-2.21	0.34	0.25	0.17
	Sortino	**-1.05**	**-0.92**	-0.66	**0.89**	**0.87**	**0.89**	-0.67	-0.67	-1.31	0.29	0.20	0.13
	Kappa	**-0.73**	**-0.68**	-0.51	**0.81**	**0.76**	**0.79**	-0.55	-0.49	-0.94	0.26	0.18	0.11
CP	Mean	**0.04**	**0.03**	**0.02**	**0.02**	**0.01**	0.00	**0.03**	**0.03**	**0.02**	0.01	0.01	**0.01**
	ASR	**0.82**	**0.44**	**0.07**	**1.69**	**1.25**	0.64	**0.83**	**1.16**	**1.18**	0.08	0.09	**0.13**
	MM	**0.04**	**0.03**	0.01	**0.02**	**0.02**	**0.02**	**0.04**	**0.05**	**0.04**	0.01	0.01	**0.01**
	LEL	**0.02**	**0.01**	**0.01**	**0.01**	**0.01**	0.01	**0.01**	**0.01**	**0.01**	0.00	0.00	**0.01**
	IR	**0.76**	**0.46**	**0.07**	**4.61**	**3.14**	1.47	**2.90**	**3.15**	**1.80**	0.39	0.29	**0.29**
	GTR	**-15.9**	**42.41**	**-1.11**	**4.38**	**51.29**	-2.93	**4.66**	**4.96**	**6.14**	3.10	-2.80	**-1.56**
	Omega	**7.01**	**2.15**	0.22	**5.93**	**29.89**	4.18	**6.86**	**21.13**	**56.47**	0.23	0.26	0.48
	Sortino	**2.97**	**0.92**	0.10	**3.22**	**8.63**	1.89	**3.02**	**7.13**	**16.99**	0.12	0.12	0.19
	Kappa	**1.77**	**0.45**	0.06	**1.94**	**4.64**	1.18	**1.82**	**3.78**	**8.78**	0.07	0.07	0.10
DHP	Mean	0.02	0.00	0.00	**0.03**	**0.02**	**0.02**	0.02	0.02	0.01	**0.02**	**0.02**	**0.01**
	ASR	0.15	-0.01	-0.08	**4.47**	**3.15**	**3.66**	0.23	0.37	0.32	**0.38**	**0.32**	**0.22**
	MM	0.01	0.00	0.00	**0.045**	**0.05**	**0.09**	0.01	0.02	0.02	**0.03**	**0.03**	**0.02**
	LEL	0.01	0.00	-0.01	**0.02**	**0.02**	**0.02**	0.02	0.02	0.01	**0.02**	**0.02**	**0.01**
	IR	0.22	-0.03	-0.11	**3.85**	**3.42**	**3.65**	0.30	0.55	0.37	**0.44**	**0.37**	**0.30**
	GTR	-0.66	0.09	0.38	**16.68**	**44.44**	**20.53**	-2.66	-5.06	-2.49	**-1.79**	**-1.30**	**-1.19**
	Omega	0.50	-0.03	-0.20	**1.42**	**1.78**	**0.04**	1.33	2.75	1.30	**1.88**	**1.32**	**1.17**
	Sortino	0.22	-0.01	-0.10	**0.70**	**0.79**	**0.02**	0.33	0.71	0.55	**0.68**	**0.53**	**0.36**
	Kappa	0.12	-0.01	-0.05	**0.38**	**0.43**	**0.01**	0.17	0.36	0.32	**0.33**	**0.28**	**0.15**

NOTE: Summary statistics of writing Naked Puts (NP), Covered Puts (CP) and Delta-Hedged Puts (DHP). The table reports the mean monthly return, Adjusted Sharpe Ratio (ASR), Modigliani and Modigliani M-squared (MM), Leland's alpha (LEL), Information Ratio (IR), Generalized Treynor Ratio (GTR), Omega ratio (Omega), Sortino ratio (Sortino), and the Kappa measure (Kappa). All strategies are classified into 3 moneyness groups according to the strike-to-spot ratio of the corresponding put, namely 10% OTM, 5% OTM and ATM. Panel A refers to the pre-crisis sub-sample (January 2004 to December 2007), while Panel B refers to the post-crisis sub-sample (January 2008 to December 2011). Statistical significance at the 5% level is indicated in bold.

Table 4: Performance of Volatility Strategies

Panel A: 2004-2007													
		GREECE			HUNGARY			POLAND			SPAIN		
		10%	5%	ATM	10%	5%	ATM	10%	5%	ATM	10%	5%	ATM
STD	Mean	**0.35**	0.05	0.08	-0.01	-0.01	**0.15**	0.10	-0.05	0.09	**0.29**	**0.14**	**0.16**
	ASR	**4.65**	0.08	0.17	0.03	-0.02	**0.46**	0.10	-0.10	0.19	**0.77**	**0.40**	0.46
	MM	**0.11**	0.00	0.01	0.00	0.00	**0.02**	0.01	-0.01	0.01	**0.02**	**0.01**	**0.012**
	LEL	**0.35**	0.04	0.08	-0.01	-0.01	**0.15**	0.10	-0.06	0.09	**0.29**	**0.14**	**0.16**
	IR	**0.29**	0.09	0.19	0.04	-0.03	**0.53**	0.46	-0.13	0.20	**2.10**	**0.54**	0.55
	GTR	**5.13**	-0.45	-1.07	-0.35	0.17	**-2.61**	6.36	1.22	-0.85	**2.41**	**-7.98**	-3.05
	Omega	**0.70**	0.27	0.67	0.09	-0.05	**2.15**	0.30	-0.24	0.59	**6.61**	**1.75**	**2.53**
	Sortino	**0.35**	0.11	0.24	0.05	-0.03	**0.88**	0.15	-0.13	0.27	**2.39**	**0.75**	**0.88**
	Kappa	**0.25**	0.06	0.11	0.03	-0.02	**0.51**	0.11	-0.08	0.17	**1.34**	**0.41**	**0.45**
STG	Mean	**0.69**	**0.33**	0.08	**0.47**	**0.18**	**0.15**	0.21	-0.26	0.09	**0.59**	**0.34**	**0.16**
	ASR	**0.55**	**0.64**	0.30	**0.49**	**0.36**	**0.28**	0.17	-0.24	0.01	**-0.22**	**0.53**	0.33
	MM	**0.09**	**0.01**	0.01	**0.02**	**0.01**	**0.02**	0.00	-0.01	0.01	**0.03**	**0.01**	**0.02**
	LEL	**0.69**	**0.33**	0.08	**0.47**	**0.18**	**0.15**	0.21	-0.27	0.09	**0.59**	**0.34**	**0.16**
	IR	**4.48**	**0.88**	0.32	**0.59**	**0.40**	**0.30**	0.25	-0.24	0.01	**1.51**	**0.73**	**0.35**
	GTR	**3.79**	**5.75**	2.94	**3.32**	**3.32**	**-2.69**	11.95	2.50	-0.65	**199**	**10.87**	**4.09**
	Omega	**8.84**	**3.92**	**1.10**	**2.37**	1.50	1.10	0.60	-0.53	0.03	**15.84**	**4.00**	**1.38**
	Sortino	**3.25**	**1.54**	**0.50**	**0.99**	**0.65**	0.49	0.22	-0.24	0.01	**3.51**	**1.23**	**0.57**
	Kappa	**1.89**	**0.86**	**0.30**	**0.56**	**0.36**	0.29	0.13	-0.15	0.01	**1.42**	**0.58**	**0.31**
Panel B: 2008-2011													
		GREECE			HUNGARY			POLAND			SPAIN		
		10%	5%	ATM	10%	5%	ATM	10%	5%	ATM	10%	5%	ATM
STD	Mean	**0.22**	**0.23**	**0.22**	**0.36**	**0.36**	**0.34**	**0.28**	**0.28**	0.11	**0.20**	**0.20**	**0.23**
	ASR	**1.53**	**1.11**	**0.89**	**7.98**	**11.15**	**11.26**	**1.29**	**0.88**	0.19	**0.81**	**0.60**	**0.62**
	MM	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**	**0.12**	**0.05**	**0.05**	0.01	**0.04**	**0.04**	**0.04**
	LEL	**0.22**	**0.23**	**0.22**	**0.36**	**0.36**	**0.34**	**0.28**	**0.27**	0.10	**0.20**	**0.20**	**0.23**
	IR	**1.65**	**1.65**	**1.45**	**3.88**	**4.81**	**5.02**	**1.54**	**1.32**	0.24	**0.87**	**0.74**	0.91
	GTR	**-80.1**	**-3.60**	**-3.27**	**-67.6**	**-50.1**	**-36.9**	**10.35**	**-29.8**	-1.08	**10.77**	**-4.15**	-3.47
	Omega	**2.01**	**20.98**	**9.12**	**1.65**	**6.99**	**2.04**	**30.78**	**14.70**	0.77	**6.18**	**3.82**	**5.20**
	Sortino	**1.15**	**8.69**	**3.03**	**1.05**	**3.73**	**7.31**	**8.54**	**3.93**	0.26	**2.50**	**1.41**	**1.68**
	Kappa	**0.83**	**5.33**	**1.51**	**0.76**	**2.44**	**4.11**	**4.50**	**2.03**	0.14	**1.47**	**0.73**	**0.83**
STG	Mean	**0.34**	**0.32**	**0.22**	**0.38**	**0.36**	**0.34**	0.22	0.17	0.11	**0.47**	**0.32**	**0.23**
	ASR	**0.77**	**0.89**	**0.95**	**6.04**	**10.47**	**10.16**	0.07	0.18	0.23	**0.38**	**0.53**	**0.39**
	MM	**0.02**	**0.03**	**0.05**	**0.01**	**0.02**	**0.12**	0.00	0.00	0.01	**0.02**	**0.01**	**0.04**
	LEL	**0.34**	**0.32**	**0.22**	**0.38**	**0.36**	**0.34**	0.22	0.17	0.10	**0.47**	**0.32**	**0.23**
	IR	**0.86**	**1.01**	**1.01**	**4.22**	**4.50**	**4.82**	0.07	0.21	0.26	**0.78**	**0.67**	**0.45**
	GTR	**-219**	**-10.5**	**-20.6**	**22.43**	**-70.1**	**-281**	95.24	195.75	3.74	**822.2**	**7.62**	**-6.55**
	Omega	**6.12**	**8.75**	**9.49**	**1.67**	**1.15**	**0.53**	0.29	0.93	1.22	**4.25**	**2.78**	**1.76**
	Sortino	**2.24**	**2.92**	**3.40**	**0.64**	**0.41**	**0.24**	0.07	0.24	0.33	**1.23**	**1.09**	**0.69**
	Kappa	**1.31**	**1.50**	**1.88**	**0.38**	**0.22**	**0.15**	0.04	0.12	0.17	**0.53**	**0.61**	**0.38**

NOTE: Summary statistics of writing Straddles (STD) and Strangles (STG). The table reports the mean monthly return, Adjusted Sharpe Ratio (ASR), Modigliani and Modigliani M-squared (MM), Leland's alpha (LEL), Information Ratio (IR), Generalized Treynor Ratio (GTR), Omega ratio (Omega), Sortino ratio (Sortino), and the Kappa measure (Kappa). All strategies are classified into 3 moneyness groups according to the strike-to-spot ratio of the corresponding put, namely 10% OTM, 5% OTM and ATM. Panel A refers to the pre-crisis sub-sample (January 2004 to December 2007), while Panel B refers to the post-crisis sub-sample (January 2008 to December 2011). Statistical significance at the 5% level is indicated in bold.

Table 5: Performance of Skewness Strategies

Panel A: 2004-2007													
		GREECE			HUNGARY			POLAND			SPAIN		
		10%	5%	ATM	10%	5%	ATM	10%	5%	ATM	10%	5%	ATM
RR	Mean	**0.24**	0.14	**0.20**	**0.43**	0.10	0.03	0.42	-0.18	0.11	**0.37**	**0.34**	0.10
	ASR	**0.75**	0.19	**0.25**	**0.25**	0.12	0.04	0.32	-0.12	0.11	**0.65**	**0.45**	0.13
	MM	**0.02**	0.00	**0.01**	**0.02**	0.00	0.00	0.01	0.00	0.00	**0.01**	**0.01**	0.00
	LEL	**0.24**	0.14	**0.19**	**0.43**	0.10	0.03	0.41	-0.19	0.10	**0.37**	**0.34**	**0.10**
	IR	**0.85**	0.20	**0.26**	**0.30**	0.14	0.05	0.32	-0.12	0.12	**0.65**	**0.46**	0.13
	GTR	**-63.5**	1.81	**6.06**	**1.48**	0.66	0.33	-21.9	16.56	-1.06	**-73.4**	**9.29**	3.03
	Omega	**7.94**	0.65	**0.92**	0.10	0.36	0.11	1.87	-0.30	0.33	**5.12**	**2.51**	0.38
	Sortino	**2.18**	0.29	**0.46**	0.44	0.19	0.07	0.78	-0.18	0.18	**1.75**	**0.95**	0.21
	Kappa	**1.08**	0.18	**0.27**	0.26	0.12	0.05	0.45	-0.12	0.11	**0.91**	**0.45**	0.13
Panel B: 2008-2011													
		GREECE			HUNGARY			POLAND			SPAIN		
		10%	5%	ATM	10%	5%	ATM	10%	5%	ATM	10%	5%	ATM
RR	Mean	0.20	0.13	**-0.00**	0.02	0.01	0.12	-0.44	-0.29	0.18	**0.23**	0.08	0.01
	ASR	0.30	0.22	**-0.01**	0.29	0.03	0.50	-0.16	-0.33	0.24	**0.29**	0.10	0.01
	MM	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	**0.01**	0.00	0.00
	LEL	0.20	0.12	**-0.01**	0.02	0.01	0.12	-0.45	-0.29	0.18	**0.23**	0.08	0.01
	IR	0.32	0.22	**-0.01**	0.39	0.03	0.61	-0.15	-0.30	0.25	**0.29**	0.10	0.01
	GTR	-20.4	23.91	**0.38**	3.41	0.29	9.58	119.01	321.18	-1.47	**59.2**	8.26	-0.61
	Omega	1.33	0.81	-0.03	1.22	0.09	2.81	-0.58	-0.69	0.95	**1.41**	0.34	0.03
	Sortino	0.52	0.37	-0.02	0.66	0.04	1.11	-0.16	-0.30	0.55	**0.51**	0.15	0.01
	Kappa	0.28	0.21	-0.01	0.47	0.03	0.65	-0.08	-0.16	0.39	**0.26**	0.08	0.01

NOTE: Summary statistics of writing Risk Reversals (RR). The table reports the mean monthly return, Adjusted Sharpe Ratio (ASR), Modigliani and Modigliani M-squared (MM), Leland's alpha (LEL), Information Ratio (IR), Generalized Treynor Ratio (GTR), Omega ratio (Omega), Sortino ratio (Sortino), and the Kappa measure (Kappa). All strategies are classified into 3 moneyness groups according to the strike-to-spot ratio of the corresponding put, namely 10% OTM, 5% OTM and ATM. Panel A refers to the pre-crisis sub-sample (January 2004 to December 2007), while Panel B refers to the post-crisis sub-sample (January 2008 to December 2011). Statistical significance at the 5% level is indicated in bold.

Table 6: Performance of Crash-Neutral Strategies

		Panel A: 2004-2007			
		GREECE	HUNGARY	POLAND	SPAIN
CNP	Mean	-0.03	0.08	0.03	**0.11**
	ASR	-0.07	0.13	0.04	**0.22**
	MM	0.00	0.01	0.00	**0.01**
	LEL	-0.03	0.08	0.03	**0.11**
	IR	-0.11	0.23	0.10	**0.34**
	GTR	0.38	-1.93	-0.19	**-1.73**
	Omega	-0.17	0.41	0.12	**0.91**
	Sortino	-0.08	0.19	0.05	**0.34**
	Kappa	-0.05	0.11	0.03	**0.15**
CNS	Mean	**-0.33**	**-0.19**	0.06	**-0.17**
	ASR	-2.17	**-0.66**	0.08	**-0.48**
	MM	**-0.07**	**-0.02**	0.01	**-0.02**
	LEL	-0.33	**-0.19**	0.05	**-0.17**
	IR	-2.19	**-0.75**	0.08	**-0.61**
	GTR	-6.02	**-3.07**	0.24	**-2.69**
	Omega	**-1.00**	**-0.81**	0.22	**-0.75**
	Sortino	**-0.90**	**-0.64**	0.17	**-0.61**
	Kappa	**-0.81**	**-0.54**	0.15	**-0.52**
		Panel B: 2008-2011			
		GREECE	HUNGARY	POLAND	SPAIN
CNP	Mean	**-0.16**	-0.02	-0.22	-0.06
	ASR	**-0.74**	-0.20	-0.29	-0.14
	MM	**-0.03**	0.00	-0.01	-0.01
	LEL	**-0.16**	-0.02	-0.23	-0.06
	IR	-1.06	-0.87	-0.32	-0.20
	GTR	2.77	1.46	1.46	0.68
	Omega	**-0.91**	-0.19	-0.74	-0.33
	Sortino	**-0.58**	-0.24	-0.26	-0.14
	Kappa	**-0.37**	-0.25	-0.14	-0.08
CNS	Mean	0.04	**-0.20**	-0.09	**-0.32**
	ASR	0.06	**-2.89**	-0.14	**-0.37**
	MM	0.00	**-0.07**	-0.01	**-0.04**
	LEL	0.05	**-0.20**	-0.09	**-0.32**
	IR	0.40	**-1.45**	-0.19	**-1.16**
	GTR	0.23	**-2.13**	-0.77	**-4.23**
	Omega	0.18	-0.51	-0.37	**-0.89**
	Sortino	0.11	-0.39	-0.30	**-0.79**
	Kappa	0.08	-0.33	-0.25	**-0.72**

NOTE: Summary statistics of writing Crash-Neutral OTM Puts (CNP) and Crash-Neutral ATM Straddles (CNS). The table reports the mean monthly return, Adjusted Sharpe Ratio (ASR), Modigliani and Modigliani M-squared (MM), Leland's alpha (LEL), Information Ratio (IR), Generalized Treynor Ratio (GTR), Omega ratio (Omega), Sortino ratio (Sortino), and the Kappa measure (Kappa). Panel A refers to the pre-crisis sub-sample (January 2004 to December 2007), while Panel B refers to the post-crisis sub-sample (January 2008 to December 2011). Statistical significance at the 5% level is indicated in bold.

Table 7: Regressions of Option Returns

	BC	AC	BC	AC	BC	AC
intercept	**0.08**	0.11	**0.10**	**0.09**	**0.10**	0.07
r_m	0.47	0.02			0.67	0.05
Δr_f	0.01	0.00			0.01	0.00
ΔIV	0.00	0.11	0.00	0.00	0.00	0.00
Return Jump			0.00	0.00	0.00	0.00
Volatility Jump			0.00	-0.01	0.00	-0.03
Volatility Smirk					**-0.04**	-0.03
$Adj.R^2$	0.03	0.17	0.29	0.25	0.28	0.31

NOTE: This Table reports the results from two-stage regressions of monthly option returns on a set of risk factors. The risk factors examined consist of the monthly return of the spot market index r_m, the change in the risk-free rate Δr_f, the change in the index's implied volatility ΔIV, the total (downward) jumps in index returns *Return Jump*, the total (upward) jumps in the index's implied volatility *Volatility Jump*, and the difference in implied volatility between an OTM index put and an ATM index call *Volatility Smirk*. The first-stage time-series regressions are given as

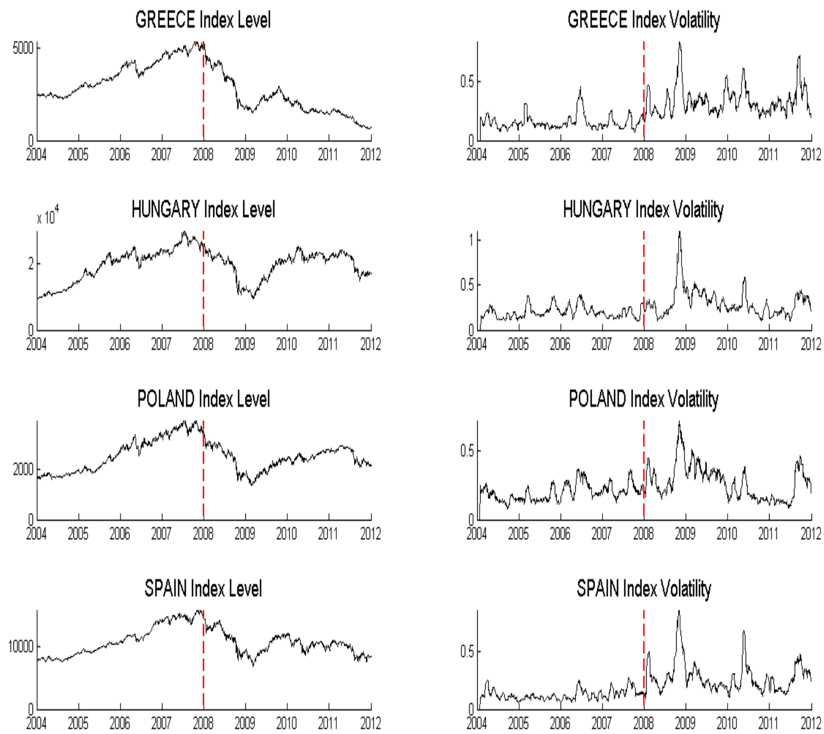
$$r_{i,t} = \alpha_i + \sum_{j=1}^{K} \beta_{j,i} F_{j,t} + \epsilon_{i,t}$$

where F_j is the j^{th} risk factor. This time-series regression is estimated separately across each option strategy, sample country and level of moneyness. The option strategies examined are Naked Puts (NP), Cover Puts (CP), Delta-Hedged Puts (DHP), Straddles (STD), Strangles (STG), Risk Reversals (RR), Crash-Neutral Puts (CNP) and Crash-Neutral Straddles (CNS). The countries are Greece, Hungary, Poland and Spain. The second-stage regressions are given as

$$\overline{r_i} = \eta_0 + \sum_{j=1}^{K} \eta_j \hat{\beta}_{j,i} + u_i$$

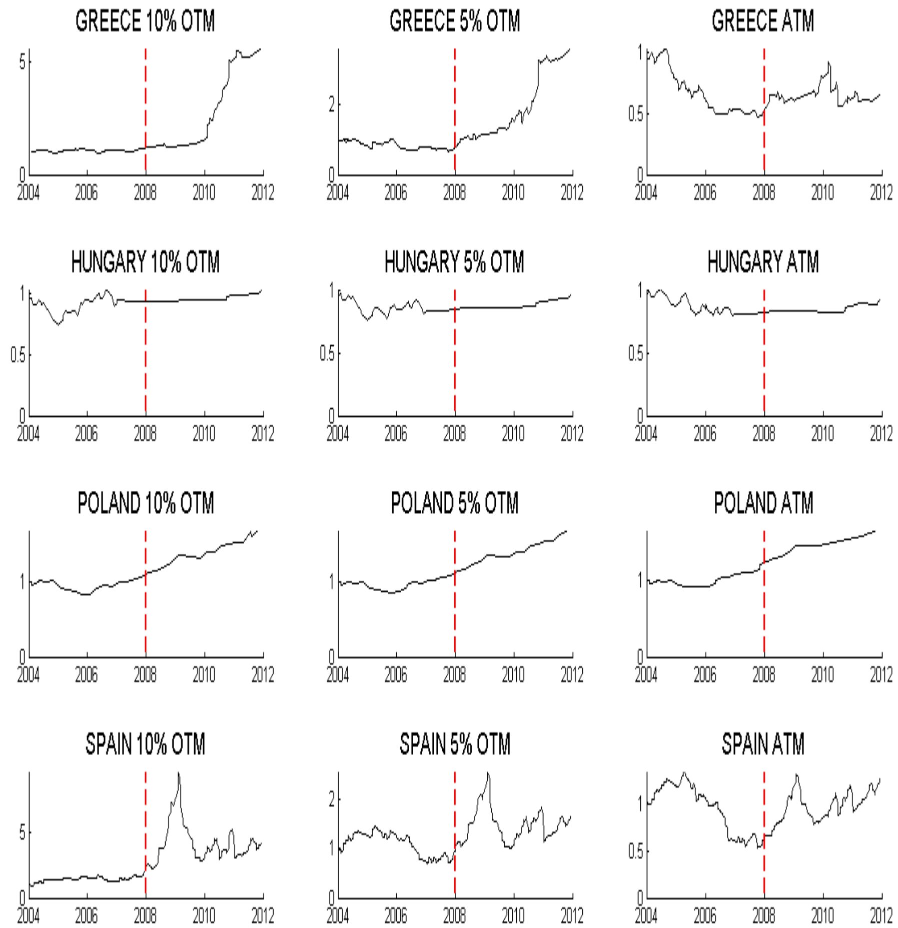
where $\overline{r_i}$ is the mean monthly return of strategy i and $\hat{\beta}_{j,i}$ is the sensitivity of strategy i with respect to the risk factor j. The Table reports the estimated coefficients and the $Adj.R^2$ of the second-stage cross-sectional regressions. *BC* and *AC* refer to the pre-crisis (2004-2007) and post-crisis (2008-2011) subsamples, respectively. Statistical significance at the 5% significance level is based on Newey and West (1987) heteroscedasticity and autocorrelation consistent standard errors, and it is denoted in bold.

Figure 1: Time-Series of Daily Index Levels and Realized Volatility



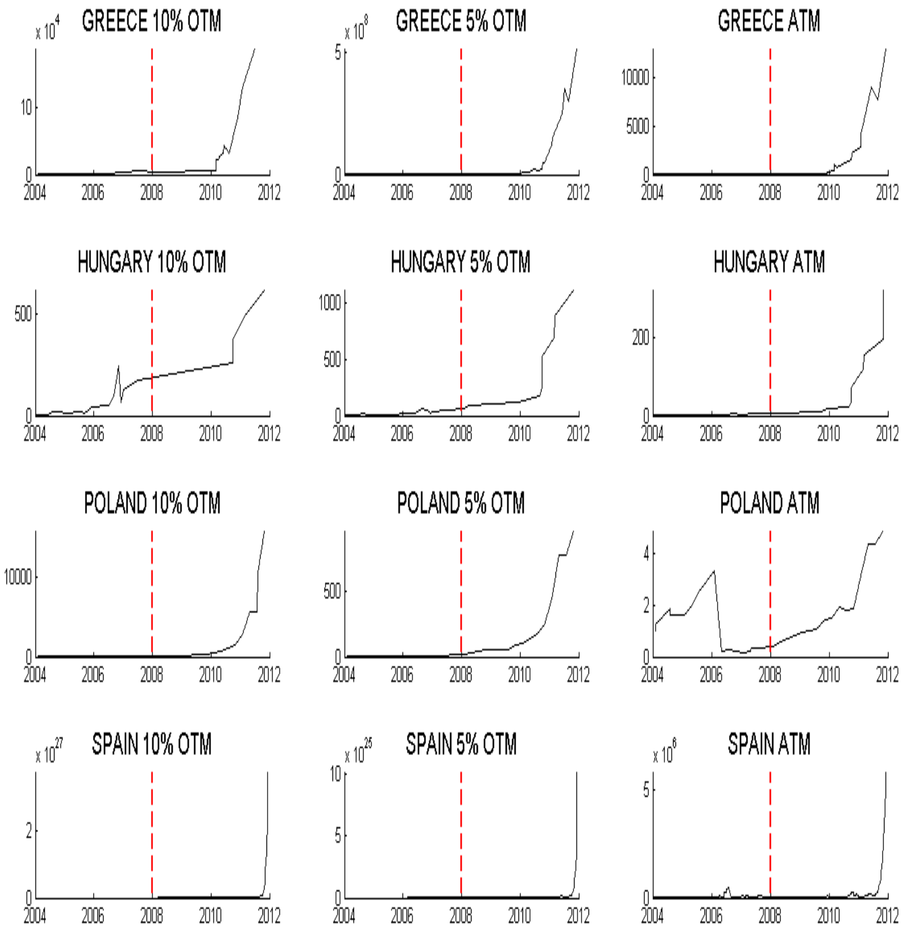
NOTE: This Figure plots the time-series of underlying index levels and realized volatility across the 4 sample countries. The sample runs from January 2004 to December 2011. The vertical red line corresponds to January 1st 2008.

Figure 2: Time-Series of Cumulative Monthly Returns of Covered Puts



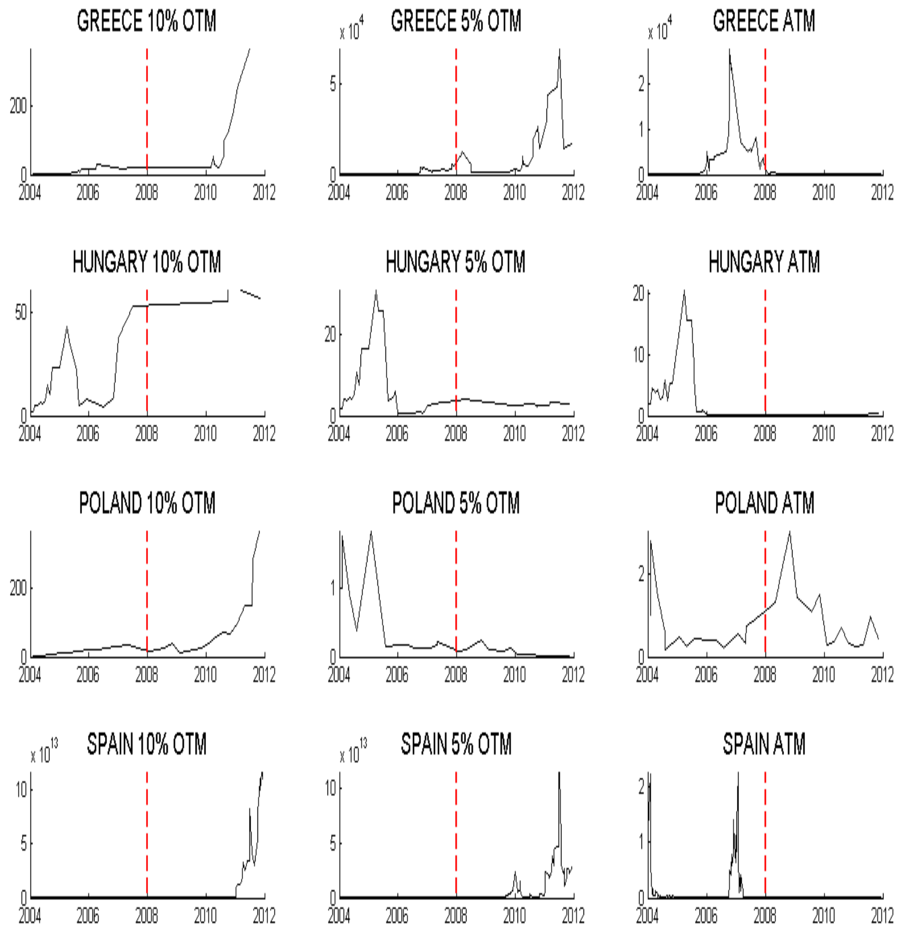
NOTE: This Figure plots the time-series of cumulative monthly returns of *Covered Puts*. All strategies are classified into 3 moneyness groups according to the strike-to-spot ratio of the corresponding put, namely 10% OTM, 5% OTM and ATM. The sample countries consist of Greece (GRE), Hungary (HUN), Poland (POL) and Spain (SPA). The sample runs from January 2004 to December 2011. The vertical red line corresponds to January 1^{st} 2008.

Figure 3: Time-Series of Cumulative Monthly Returns of Strangles



NOTE: This Figure plots the time-series of cumulative monthly returns of *Strangles*. All strategies are classified into 3 moneyness groups according to the strike-to-spot ratio of the corresponding put, namely 10% OTM, 5% OTM and ATM. The sample countries consist of Greece (GRE), Hungary (HUN), Poland (POL) and Spain (SPA). The sample runs from January 2004 to December 2011. The vertical red line corresponds to January 1st 2008.

Figure 4: Time-Series of Cumulative Monthly Returns of Risk Reversals



NOTE: This Figure plots the time-series of cumulative monthly returns of *Risk Reversals*. All strategies are classified into 3 moneyness groups according to the strike-to-spot ratio of the corresponding put, namely 10% OTM, 5% OTM and ATM. The sample countries consist of Greece (GRE), Hungary (HUN), Poland (POL) and Spain (SPA). The sample runs from January 2004 to December 2011. The vertical red line corresponds to January 1st 2008.