# IMPLIED VOLATILITY ON THE ROMANIAN OPTIONS MARKET – DIFFERENCES AND COMMON FEATURES WITH THE DEVELOPED EUROPEAN MARKETS

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*The implied volatility of an option contract is the volatility implied by the market price of the option based on an option pricing model, in this case the Black-Scholes model. The model assumes that the price of an option follows a geometric Brownian motion with constant drift and volatility. By computing the implied volatility for traded options with different strikes and maturities, the Black-Scholes model can be tested. If the Black–Scholes model held, then the implied volatility for a particular stock would be the same for all strikes and maturities. In practice, the volatility surface (the three-dimensional graph of implied volatility against strike and maturity) is not flat, this phenomena being known mostly as the "volatility smile" or "volatility skew" and the term structure of volatility. The article's aim is to show if there are any differences between the implied volatility structures of the options traded on the Sibiu Monetary-Financial and Commodities Exchange and the well known implied volatility characteristics of the developed European option markets and to try to explain any differences that might appear.*

*Keywords: financial options, implied volatility, volatility smile, volatility skew, term structure of volatility, volatility surface, Black-Scholes model*

*JEL codes: G13, G14*

**Introduction and a Brief Review of the Empirical Literature**

From the early '70's the issues regarding option pricing became more and more important this fact being confirmed also by the growth of the literature which parallels the spectacular developments of derivative securities and the rapid expansion of markets for derivatives.

In the last decades, numerous parametric and nonparametric investigations were made, in continuous and discrete time, the empirical option pricing literature revealing a considerable divergence between the risk-neutral distributions estimated from option prices after the 1987 crash and conditional distributions estimated from time series of returns on the underlying index. Three facts clearly stand out. First, the implied volatility extracted from at-the-money options differs substantially from the realized volatility over the lifetime of the option. Second, risk neutral distributions feature substantial negative skewness which is revealed by the asymmetric implied volatility curves when plotted against moneyness. Third, the shape of these volatility curves changes over time and maturities, in other words the skewness and the convexity are time-varying and maturity-dependent.[311] Therefore, our survey's goal is to explore these divergences.

Option pricing has been extensively studied in the mathematical finance literature since the publication of the Black-Scholes formula in 1973[312]. The analysis of Black and Scholes however assumes a perfect market. These assumptions are clearly idealizations. The Black–Scholes option–pricing formula has gained significant popularity for its simplicity and adequate pricing of near–the–money options. However, systematic pricing biases emerge when the formula is applied to options whose strike price differs significantly from the underlying price. MacBeth and

311 Garcia, L., Ghysels, E., Renault, E., 2003

312 Black, F., Scholes, M., 1973

Merville (1979)[313] find that the implied volatilities are high (low) for in–the–money (out–of–the–money) options indicating that the Black–Scholes model underprices in–the–money options and overprices out–of–the–money options. The effect increases with the time to maturity. Similar results are established in Rubinstein (1985)[314] for his pre–1977 sample. The reverse pricing biases are found for Rubinstein's (1985) post–1977 sample.

From the empirical point of view, two different approaches show that the assumption made in the Black-Scholes formula regarding the fact that the underlying asset's volatility would be constant is not valid. Regarding the historical time series of financial assets returns, many studies indicate that volatility is not constant along time (Barndorff-Nielsen and Shephard 2002[315]; Kim et al. 1998[316]). Regarding the pricing measure, if we use market option prices on the same underlying with different maturities and exercise prices, and invert the Black-Scholes formula to obtain implied volatilities, we observe that volatility is not constant. This phenomenon, denominated volatility smile, has been strongly evident on US option market data, especially after the stock market crash of 1987 (Ait-Sahalia and Lo 1998; Dumas et al. 1998)[317]

There is a great variety of option–pricing models that correct the well–known biases in the Black–Scholes prices, nevertheless, the latter remains a widely used model by the practitioners. The simplicity of the model is presumably the primary reason for its popularity. Despite its success, the Black-Scholes formula has become increasingly unreliable over time in the very markets where one would expect it to be most accurate.[318]

Our goal in this article is to identify the main qualitative characteristics of the volatility process that drives the dynamics of the most liquid option contract in the Romanian market.

## Basic review of the implied volatility patterns

### *"Volatility smiles" and "volatility skews"*

If we consider call options on a given underlier, having different strikes but the same expiration and we obtain market (settlement) prices for those options, we can apply the Black-Scholes (1973) model to back-out implied volatilities. Intuitively, we might expect the implied volatilities to be identical. In practice, as shown by the brief review of the empirical literature too, it is likely that they will not be.

The pattern of implied volatilities forms a "smile" shape, which is called a "volatility smile". Such a smile persists over time on the developed European options markets with in-the-money and out-of-the-money volatilities generally higher than at-the-money volatilities.

Most derivatives markets exhibit persistent patterns of volatilities varying by strike. In some markets, those patterns form a smile. In others, such as equity index options markets, it is more of a skewed curve. This has motivated the name volatility skew. In practice, either the term "volatility smile" or "volatility skew" (or simply skew) may be used to refer to the general phenomena of volatilities varying by strike. You may even hear of "volatility smirks" or "volatility sneers".[319]

When implied volatility is plotted against strike price, the resulting graph is typically downward sloping, or downward sloping with an upward bend at either end. For markets where the graph is downward sloping, such as for equity options, the term "volatility skew" is often used. For other

313 MacBeth, J. and L. Merville, 1979 as cited in Savickas, R., 2001
314 Rubinstein, M., 1985 as cited in Savickas, R., 2001
315 Barndorff-Nielsen, O.E. Shephard, N., 2002 as cited in Almeida, C. I. R. de, Dana, S., 2005
316 Kim, S., Shephard, N., Chib, S., 1998 as cited in Almeida, C. I. R. de, Dana, S., 2005
317 Ait-Sahalia, Y., Lo, A., 1998 as cited in Almeida, C. I. R. de, Dana, S., 2005
318 Rubinstein, M.: Implied Binomial Trees, July 1994, Journal of Finance
319 http://www.riskglossary.com/link/volatility_skew.htm

markets, such as equity index options, where the typical graph turns up at either end, the more familiar term “volatility smile” is used.[320]
There are multiple explanations for these phenomena, different explanations applying in different markets. Some explanations relate to the idealized assumptions of the Black-Scholes approach to valuing options. Almost every one of those assumptions - lognormally distributed returns, return homoskedasticity, etc. - could play a role. For example, in most markets, returns appear more leptokurtic than is assumed by a lognormal distribution. Market leptokurtosis would make way out-of-the-money or way in-the-money options more expensive than would be assumed by the Black-Scholes formulation. By increasing prices for such options, volatility smile could be the markets’ indirect way of achieving such higher prices within the imperfect framework of the Black-Scholes model. Other explanations relate to relative supply and demand for options. In equity markets, volatility skew could reflect investors' fear of market crashes - which would cause them to bid up the prices of options at strikes below current market levels.321

***Term Structure of Volatility***
Volatility term structures list the relationship between implied volatilities and time to expiration.
For options of different maturities, we also see characteristic differences in implied volatility. The typical time skew pattern observed is higher implied volatility for options with shorter time to expiration than for longer-time-to-expiration options.
One possible reason is that most speculators are probably more interested in betting on “surprises” that are expected to occur in shorter term than those in longer term.
As such, they would also prefer options with shorter time to expiration, as it carries less time value than longer-time-to-expiration options, and hence can potentially provide higher returns when the extreme price movement does take place as expected.
This would consequently increase demand for shorter time options, and hence push the options’ price up through higher implied volatility.[322]

**Testing Methodologies and Data**
As subject of our empirical research we chose the call option contracts having as underlying asset DESIF5 futures contracts, with maturity in March, June, September and December 2009 with all the strike prices these contracts are made transactions at. The motivation of our choice consist in the fact that the DESIF5 options contracts are the most liquid ones, in January being contracted 1410 DESIF5 call contracts from the total of 1552, in February 1394 DESIF5 call contracts from the total of 1507.
The utilized data covers the January-February 2009 period.
The steps of our research process were as follows:
- using the Black-Scholes model to back-out implied volatilities for all strikes and maturities using actual closing options and futures prices (using Visual Basic Editor);
- calculating the average implied volatilities from options with the same maturity at different strike prices;
- calculating the average implied volatilities from options with the same strike price at different expiration months;
- confront the well-known implied volatility patterns observable on the developed European and American options markets with the Romanian patterns (volatility smile, volatility skew, term structure of volatility) by plotting the implied volatility values of options across various strike prices respectively maturities.

320 http://en.wikipedia.org/wiki/Volatility_smile
321 http://www.riskglossary.com/link/volatility_skew.htm
322 http://www.optionstradingbeginner.blogspot.com/2008/06/volatility-smile-and-volatility-skew_15.html

## Results and Conclusions

The results of the calculations are shown in the next few figures.

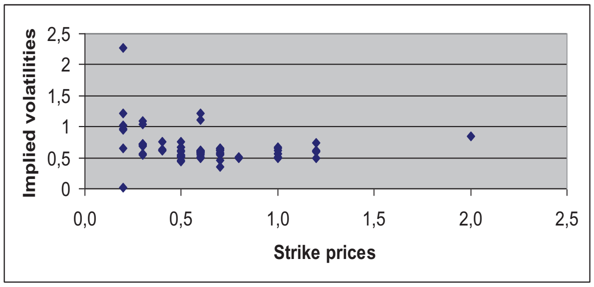



***Figure1:*** *Implied volatility as a function of strike price – DESIF5 options with maturity in December 2009, January-February 2009 data – Testing the "volatility smile" and "volatility skew" effects,* Authors'

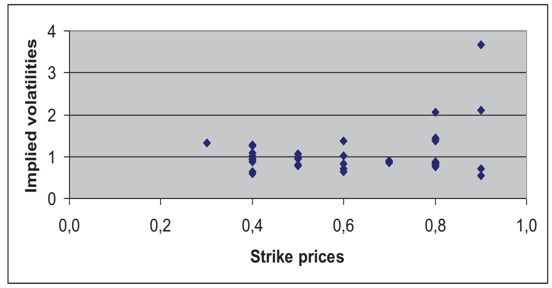



***Figure2:*** *Implied volatility as a function of strike price – DESIF5 options with maturity in March 2009, January-February 2009 data – Testing the "volatility smile" and "volatility skew" effects,* Authors' calculations

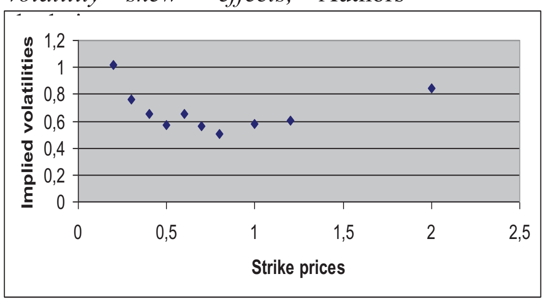



***Figure3:*** *Average implied volatility as a function of strike price – DESIF5 options with maturity in December 2009, January-February 2009 data – Testing the "volatility smile" and "volatility skew" effects,* Authors' calculations

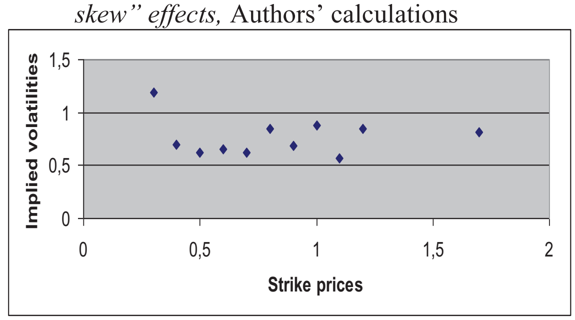
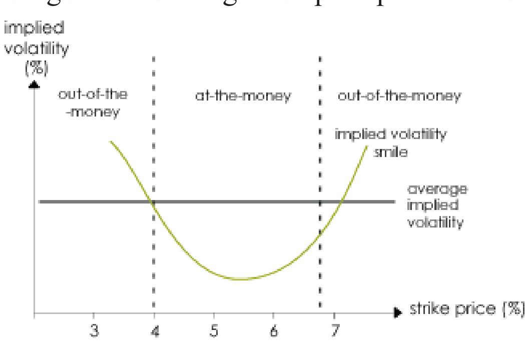



***Figure4:*** *Average implied volatility as a function of strike price – DESIF5 options with maturity in September 2009, January-February 2009 data – Testing the "volatility smile" and "volatility skew" effects,* Authors' calculations

As one can clearly see, the typical volatility patterns observed recently on the well-developed European and American markets are observable also on the Romanian options market: for call options, the implied volatility is the highest for deep in-the-money options and then is decreasing as it moves towards at-the-money options, rising again as it approaches out-the money options, the figures also being an empiric proof of the existence of the "volatility smile" pattern.



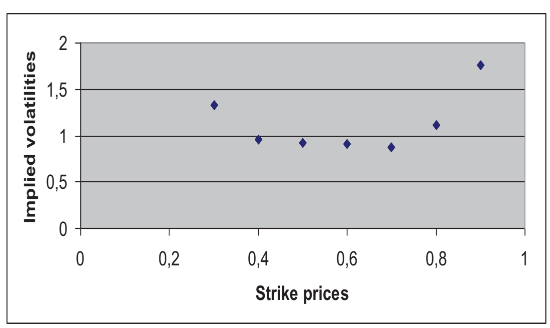




***Figure1:*** *Volatility smile,* www.erisk.com

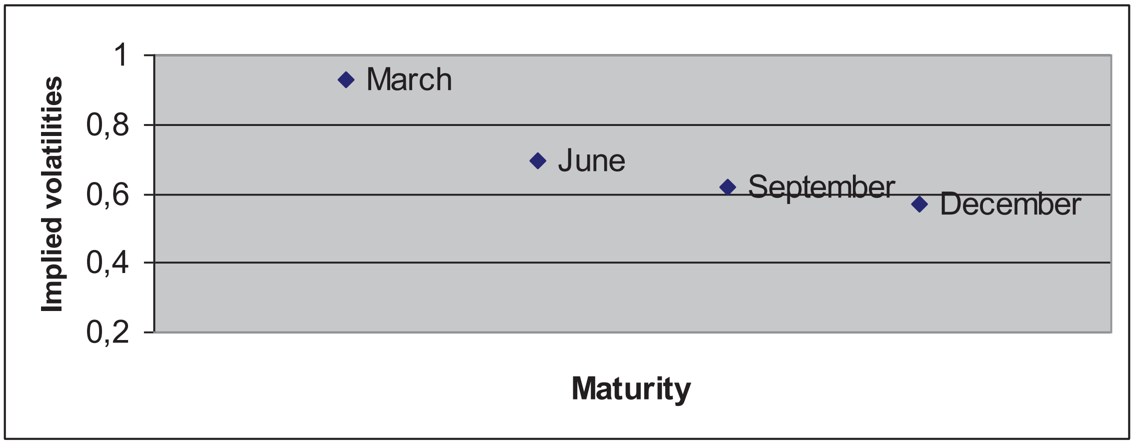



*Figure5: Average implied volatility as a function of strike price – DESIF5 options with maturity in March 2009, January-February 2009 data – Testing the "volatility smile" and "volatility skew" effects,* Authors' calculations

*Figure7: Average implied volatility as a function of maturity – DESIF5 options at 0,5 lei strike price, January-February 2009 data – Testing the volatility term structure,* Authors' calculations

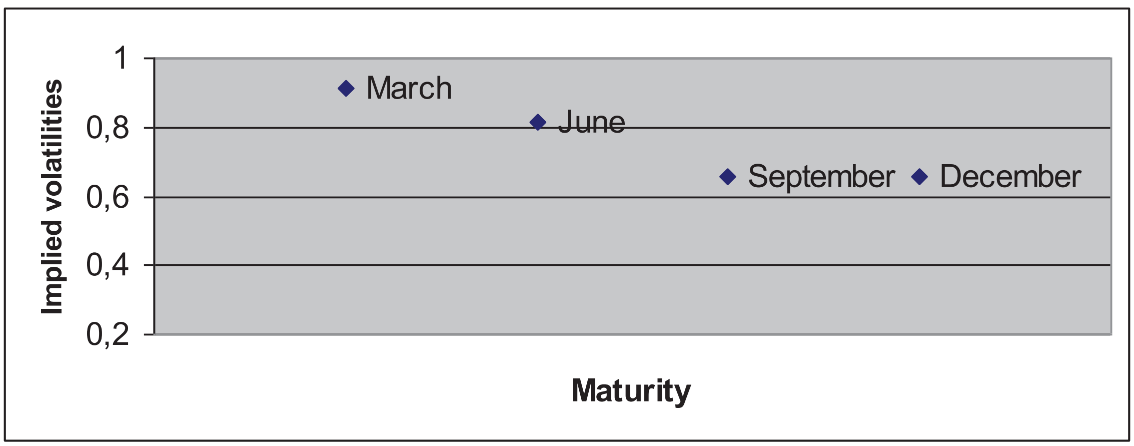



*Figure8: Average implied volatility as a function of maturity – DESIF5 options at 0,6 lei strike price, January-February 2009 data – Testing the volatility term structure,* Authors' calculations

As looking at Figures 7 and 8, it becomes evident that the volatility term structure of the most liquid Romanian option's implied volatility has the same behavior as the ones observable on the developed markets.

In general, financial institutions in emerging markets are aware that illiquidity plays an important role on their daily trading game. In particular, illiquidity in the primary stock market directly propagates illiquidity to the option market, generating more pronounced smile patterns. On the Romanian equity market, although an acceptable level of liquidity exists in the primary market, it is the option market that is affected by the illiquidity phenomenon. For instance, even for the most liquid options, the moneyness pattern for a single stock is very sparse. Even though, this article proves the similitude between the emerging and developed markets regarding the patterns of the implied volatilities op financial options.

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