Financial risk management using derivatives

Author: Ionescu Andreea Laura
Coordinator Prof Dr. Univ Ion Stancu

Abstract
Based on the concept of financial risk management through hedging strategies, in this paper we propose to analyze the performance of dynamic hedging strategies with daily and weekly rebalancing of put and call options contracts having as underlying asset - Erste Bank Group from 1 January 2011 - 30 December 2012.

For evaluation we used the methodology options contracts Black - Scholes and for the volatility estimation we used the implied volatility method.

Empirical and practical results, largely confirmed theoretical assumptions drawn from the literature reviewed.

Keywords: risk management, hedging strategies, derivatives

Introduction
Widespread corporate use of derivatives securities is well documented. By the prevalence of derivatives use and impact of ex “bad” transactions has led investors, creditors and regulators to became increasingly concerned about how firms use these derivatives instruments, little empirical evidence documents the effect of derivatives on firm’s risk.

Types of derivative instruments chosen also depend on firm’s exposure risk in ways that are a priori consistent with hedging behavior.

Taking into consideration all the above, the evidence is consistent with firms using derivatives for hedging purposes and not to decrease shareholders’ risk.

Literature review

Financial risk management using derivatives is the subject to numerous case studies on international level that focus on microeconomic sphere. The calculation and estimation vary from author to author, and distribution channels impact financial results.

Presented below are a couple of case studies regarding the results if using derivatives to hedge or not on firm’s risk.

In 1999, Wayne R. Guay examines in his paper derivatives’ roles in firms initiating derivatives use. The results are consistent with firms using derivatives to hedge, and not to increase, entity risk. Firm risk, measured using several methods declines following derivatives use. Realized risk reductions and decisions to initiate derivatives programs vary across firms with the expected benefits from hedging. The findings emphasize the importance of hedge-accounting rules that incorporate the impact of derivatives and hedged items simultaneously.
In 2007, using a sample of 6,888 non-financial firms, Gregory W Brown examined the effect of derivative use on firms’ risk measures and value. A first control for endogeneity was performed by matching users and non-users on the basis of their propensity to hedge. The second one was in order to estimate the effect of omitted variable bias on our inferences. The results are that the use of financial derivatives reduces both total risk and systematic risk. The effect of derivative use on firm value is positive but weak, and is more sensitive to endogeneity and omitted variable concerns.

This increased sensitivity could account for the mixed evidence in the literature on the effect of hedging on firm value.

In 2009, D.Vallière, E. Denis, Y. Kabanov considered a continuous-time model of a financial market with proportional transaction costs. The result is a dual description of the set of initial endowments of self-financing portfolios super-replicating an American-type contingent claim. The latter is a right-continuous adapted vector process describing the number of assets to be delivered at the exercise date. Additional, a specific class of price systems, called coherent, and show that the hedging endowments are those whose “values” are larger than the expected weighted “values” of the payoff process for every coherent price system used for the “evaluation” of the assets.

In 2010, Flavio Angelini and Stefano Herzel explicitly compute closed formulas for the minimal variance hedging strategy in discrete time of a European option and for the variance of the corresponding hedging error under the hypothesis that the underlying asset is a martingale following a geometric Brownian motion. The formulas are easy to implement, hence the optimal hedge ratio can be employed as a valid substitute of the standard Black–Scholes delta, and the knowledge of the variance of the total error can be a useful tool for measuring and managing the hedging risk.

The most recent research belongs to Jitka Hilliard and Wei Li, published in 2013 and developed a new volatility measure: the volatility implied by price changes in option contracts and their underlying, referred to this as price-change implied volatility. In this study, the authors compared moneyness and maturity effects of price-change and implied volatilities, and their performance in delta hedging. They found that delta hedges based on a price-change implied volatility surface outperform hedges based on the traditional implied volatility surface when applied to S&P 500 future options.

**Database**

The data used in the analysis are given in number of intra-day 34 457 spanning a period of 2 years and 1 January 2011 - 30 December 2012. Day exchange is between 10.00-16.30pm, making a simple average we have about 70 transactions per day or transaction 5 minutes.

Options are analyzed in 15 separate categories, namely:

- 5 categories of moneyness, moneyness which represents the ratio between the spot price (S) of the underlying asset and the strike price (K) thereof, we have the following types:
  - DOTM – deep out of the money – moneyness < 0.94
  - OTM – out of the money – moneyness (0.94 – 0.97)
  - ATM – at the money - moneyness (0.97 – 1.03)
  - ITM – Into the money – moneyness (1.03 – 1.06)
  - DITM – deep Into the money – moneyness >1.06
3 categories representing time until due date (t - days):
- On short term  \( t < 60 \)
- On medium term  \( 60 < t < 180 \)
- On long term  \( t > 180 \)

**Research Methodology**

In this section I will present the main methods used in order to determinate the input needed to be used on determine the most efficiency hedging strategy.

Thus, in order to evaluate the anticipated price of the options we used Black- Scholes Methodology.

Assumptions of the model are:
- The asset pays no dividends during the option time period
- The option used is European type
- Markets are efficient
- There are no commissions
- The interest rate remains constant
- Data used follow a lognormal distribution

The Black Scholes valuation of a call (C) and put (P) is as follows:

\[
C = SN(d_1) - Ke^{r(T-t)}N(d_2) \\
P = Ke^{r(T-t)}N(-d_2) - SN(-d_1)
\]

Where,

\[
d_1 = \frac{\ln(S/K) + (r + \frac{\sigma^2}{2})(T-t)}{\sigma \sqrt{T-t}}
\]

\[
d_2 = d_1 - \sigma \sqrt{T-t}
\]

To use the Black Scholes evaluation we need five parameters of which three are found in the market: the spot price, the exercise price and time to maturity. The other two, the annual interest rate volatility respectively, must be estimated. Interest rate is commonly used yield to maturity of bonds issued by state (zero-coupon bonds), for the same duration (maturity) as the derivative asset.

**Step1**. In order to obtain the 5\textsuperscript{th} parameter, that is volatility, we used the implied volatility method. It has been shown that the use of implied volatility substantially reduce the number of required data and has improved performance models. In our analysis we use implied volatility resulting from the Black Scholes formula by inverting and equalizing with options market price.
Thus we obtained the following results:

<table>
<thead>
<tr>
<th>Moneyness</th>
<th>Optiuni Call</th>
<th>Optiuni Put</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zile pana la scadenta</td>
<td>Zile pana la scadenta</td>
</tr>
<tr>
<td>S/K</td>
<td>&lt;60</td>
<td>60-180</td>
</tr>
<tr>
<td>&lt;0.94</td>
<td>26,52%</td>
<td>22,22%</td>
</tr>
<tr>
<td>0.94 - 0.97</td>
<td>24,82%</td>
<td>21,05%</td>
</tr>
<tr>
<td>0.97 - 1.03</td>
<td>24,05%</td>
<td>21,18%</td>
</tr>
<tr>
<td>1.03 - 1.06</td>
<td>25,29%</td>
<td>20,98%</td>
</tr>
<tr>
<td>&gt;1.06</td>
<td>39,03%</td>
<td>20,84%</td>
</tr>
</tbody>
</table>

Step 2. The following step was to calculate and present a procedure for minimizing errors from the Black Scholes model and then we apply this procedure successively separate on implied volatility for CALL and PUT options. Having the volatility has chosen a single value that minimizes errors in the evaluation of the Black - Scholes. Errors are defined as the difference between the option price calculated theoretically from the model, and the market price of the option.

The procedure to minimize Black Scholes errors:

\[ E = \min \left[ \sum_{j=1}^{n} \sum_{i=1}^{n} \left( C_{BS}(\sigma^e)_i - C_{j\text{obs}} \right)^2 \right] \]

Applying this procedure on all data to get a fairly accurate assessment of the performance evaluation of the chosen model. Per total, the two years of analysis have 462 trading days.

After applying this procedure on the database described above we obtained the following:
Errors average that result from the analysis is SE_{call} = 12326.17 for all call option. The model tends to overestimate OTM options (outside money) and to underestimate the options ITM (in the money).

Chart within the paper shows that valuation errors are quite large especially DITM and ATM options. The best assess OTM options.
Step 3. Test the efficiency of the strategies chosen.

Covered CALL Strategy

Covered Call strategy results:

<table>
<thead>
<tr>
<th>Moneyness</th>
<th>$/K</th>
<th>$t = 1$ zile</th>
<th>$t = 5$ zile</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Zile pana la scadenta</td>
<td>Zile pana la scadenta</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;60</td>
<td>60-180</td>
</tr>
<tr>
<td>&lt;0.94</td>
<td>515.22</td>
<td>1368.70</td>
<td>33.17</td>
</tr>
<tr>
<td>0.94 - 0.97</td>
<td>3635.09</td>
<td>519.02</td>
<td>20.83</td>
</tr>
<tr>
<td>0.97 - 1.03</td>
<td>7250.30</td>
<td>2606.93</td>
<td>9754.21</td>
</tr>
<tr>
<td>1.03 - 1.06</td>
<td>124.20</td>
<td>933.12</td>
<td>2495.25</td>
</tr>
<tr>
<td>&gt;1.06</td>
<td>326.11</td>
<td>76.49</td>
<td>1716.36</td>
</tr>
</tbody>
</table>
Covered Put strategy results:

<table>
<thead>
<tr>
<th>Moneyness S/K</th>
<th>Δt = 1 zi Zile pana la scadenta</th>
<th>Δt = 5 zile Zile pana la scadenta</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt;60</td>
<td>60-180</td>
</tr>
<tr>
<td>&lt;0.94</td>
<td>42.71</td>
<td>4.56</td>
</tr>
<tr>
<td>0.94 - 0.97</td>
<td>41.77</td>
<td>107.86</td>
</tr>
<tr>
<td>0.97 - 1.03</td>
<td>16.92</td>
<td>144.92</td>
</tr>
<tr>
<td>1.03 - 1.06</td>
<td>5.15</td>
<td>40.16</td>
</tr>
<tr>
<td>&gt;1.06</td>
<td>1.35</td>
<td>8.81</td>
</tr>
</tbody>
</table>

Step 4. The final step of this paper was to evaluate the cost of these 2 types of strategies. In order to do that we calculated the net results: one without the strategy and other with strategy for both Covered Call and Covered Put strategies. The methodology for this cost calculation is more detailed in the paper, thus here will be presented only the results.
Hedging Call Results:

<table>
<thead>
<tr>
<th>Moneyness/ Zile pana la scadenta</th>
<th>Rezultate hedging CALL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Cu strategie</td>
</tr>
<tr>
<td>&lt;0.94</td>
<td>19.24</td>
</tr>
<tr>
<td>0.94 - 0.97</td>
<td>38.29</td>
</tr>
<tr>
<td>0.97 - 1.03</td>
<td>29.98</td>
</tr>
<tr>
<td>1.03 - 1.06</td>
<td>257.86</td>
</tr>
<tr>
<td>&gt;1.06</td>
<td>373.78</td>
</tr>
</tbody>
</table>

As recommended daily share price over the strike price, the net result is negative and less without strategy than using the Covered Call strategy in all 15 cases.

Regarding the effectiveness of the strategy notes that it generated profits in all cases except the ATM option with maturity over 180 days, while confirming the results obtained in our empirical analysis in section 3.

According tunes, the net results were lower than the premiums received initial value generally determined strategies as having the smallest errors preserving the best first initial charging

Hedging Put Results:

<table>
<thead>
<tr>
<th>Moneyness/ Zile pana la scadenta</th>
<th>Rezultate hedging PUT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Cu strategie</td>
</tr>
<tr>
<td>&lt;0.94</td>
<td>189.13</td>
</tr>
<tr>
<td>0.94 - 0.97</td>
<td>137.72</td>
</tr>
<tr>
<td>0.97 - 1.03</td>
<td>86.15</td>
</tr>
<tr>
<td>1.03 - 1.06</td>
<td>48.14</td>
</tr>
<tr>
<td>&gt;1.06</td>
<td>22.37</td>
</tr>
</tbody>
</table>
Recommended daily share price over the strike price, the net result is no greater without strategy than using Covered Put strategy in all 15 cases.

Regarding the effectiveness of the strategy notes that it generated profits in all cases except DOTM type option with maturity over 180 days, while confirming the results obtained in our empirical analysis in section 3.

According to the analysis, the net result was lower than the premiums received initial value generally determined strategies as having the smallest error preserving also received best original first.

The results reflected lower net cost strategy, that is why results without strategy in the case of non-exercise are better.

**Conclusions**

In this paper, we test the performance of dynamic hedging strategies with daily and weekly rebalancing of put and call options contracts having as underlying asset - Erste share for a period of two years using a number of 34457 intra-day data.

For the evaluation methodology was used options contracts Black - Scholes model strategies used to test the performance Covered Call and Covered Put. Necessary to estimate volatility implied volatility method was performed, the results of calculations are presented along the paper.

Based on the analyzed performed I noticed that Black Scholes model tends to overestimate and underestimate OTM options ITM options, and this is very evident in the case of our test call options. Put option valuation errors were significantly higher (almost double), large deviations recorded most DITM and ATM options, which are heavily undervalued.

Regarding the performance of dynamic hedging strategies Covered Call found that the most effective strategies are for DOTM and OTM options with a maturity of 180 days, the biggest errors recorded in general for ATM options. If Covered Put strategy, the most effective strategies were DOTM and OTM with a maturity less than 60 days. The largest error recorded for DOTM and OTM options with maturity greater than 180 days.

Practical assessment strategies largely confirmed the empirical results described above.

**References**


[9] Eviews 6 © User’s guide;


