General Response to Referee Reports No. 1 and No. 2

First of all, we thank both referees for excellent comments, feedback and suggestions. We are delighted to declare that we have followed your feedback and herewith re-submit our revised paper.

The following response consolidates both referee reports because some feedback was similar and other points were contradictory. Thus, we give a detailed response and explanation to our changes according to the referee.

Note: Our changes in the revised paper and response letter is always highlighted in red text color.

We are looking forward to your response!

Referee:

What is the source of the data? Are the prices used in the study mid prices (i.e. (bid+ask)/2)? Is the data filtered as usually done in this kind of studies (e.g. Bakshi et al., 1997)? - clear in the response, absent in paper. *Should be added to paper.* (done; our first-round response is included in the paper, as you suggest!)

Are you sure that the options you use are European-type and not American-type? – clear in the response that options are American-type, not clear in the paper. *Should be clearly stated in paper*. (done)

From the response, but not from the paper, I understand that, in fact, BS price is not the price of European options computed with the BS formula, but the price of American options computed with a binomial tree method. *This should be also stated in the paper.* (done, cf. footnote 4.)

"Our methodology does not differentiate between American-type and European-type options." - in the response; this should also be stated in the paper. (done, cf. methodological explanation and response below!)

But what eqs 9 and 10 are for? European or American options? I guess that since data on American options is used, eqs 9 and 10 are for American options. *This should be clarified in the paper.* (done)

Response: We are delighted to read that our 1st round response has explained and clarified most issues. We will clarify the remaining points in the paper too!

Yes, we have American-type options. But we also mention European-type options in the paper because the standard BS-approach was first developed for plain vanilla European options. Again, the theory section only motivates option pricing by Black-Scholes in order to demonstrate the restrictions/limitations of BS-theory. We show that pricing without theoretical restrictions (our data driven free-assumption approach with a GA-algorithm) leads to different and new formulas.

Note: our statement that "we do not differentiate between American- and European-types", means that our GA-algorithm does not differentiate! Again, the input variables to our algorithm are all Black-Scholes input variables (no matter of option-type!). And the output are

the option prices. Thereafter, our algorithm searches for the best fit of input vs output. The best functions according to the MAE/RMSE are eqs. (9) and (10) – that is it!

Referee:

The formula for puts (eq. 10) does not depend on volatility and this is very strange. *The paper should discuss why puts are not influenced by volatility*. In this context, how do you compute the sensitivities of put prices with respect to sigma in Table 5 if eq. 10 does not depend on sigma?

If possible, in order to give a better impression on the usefulness of the method, I would suggest to do some out-of-sample analysis also on German data: you could train only on some part of the German data and then use the remaining part for out-of-sample analysis. At the moment, I understand that the entire German data is used for training.

Response: Thank you. The referee asks a good question. There are two answers:

a) We do not tell our GA algorithm to discriminate for volatility data, etc. We simply ask the algorithm to fit all input variables to the output variable and search for the best functional-relationship between input and output. Yet, surprisingly, volatility does not matter in the reverse-engineering formal for put options. But this is the optimal and scientific outcome. We cannot change it. Our GA gives us this formula according to MAE/RMSE.

b) In Table 5, indeed, you see that your question is answered correctly. The put-formula is independent of volatility, as you rightly noted. Hence, the put-option price in Table 5 does not change with the Greek nu/kappa – as you might expect from equ. (10). Indeed, the price computed with the new RE-formula is the same in the benchmark and after any change of volatility. The price is in both cases at 31.43 Euro (Table 5). From an empirical viewpoint this is highly surprising/interesting. Indeed, this issue overlooks an important linkage of option theory. Further research is need. We only have a tentative answer: it might be due to the utilization of German data, where vola is rather low.

Your final thought is not fully correct. Our GA-algorithm always splits the data, as explained in the methodological part, into training and validation data! Consequently, our solution is already tested and evaluated by out-of-sample measures. The finally optimized formula of eqs. (9) and (10) contain the best relationship (lowest MAE/RMSE) after training and validation. In that regard, there is an implicit out-of-sample analysis incorporated in our GA; of course, only for our German data set.

Overall, this paper clearly contributes with a novel approach and first evidence to the literature. Yes, there are new research questions and some results need further research as you indicate. But those critique hold for all empirical approaches in general and AI-approaches or neural networks in particular. In so far, all questions are excellent topics for future research.