

# SLATT UNDERGRADUATE RESEARCH FELLOWSHIP FINAL REPORT

<b>SCHOLAR NAME:</b>	Sam Gruenler
<b>FACULTY ADVISOR:</b>	Dr. Christiane Baumeister
<b>PROJECT PERIOD:</b>	Fall 2020
<b>PROJECT TITLE:</b>	What can options tell us about oil price risks?
<b>CONNECTION TO ONE OR MORE ENERGY-RELATED RESEARCH AREAS (CHECK ALL THAT APPLY):</b>	<input checked="" type="checkbox"/> Energy Conversion and Efficiency <input type="checkbox"/> Sustainable and Secure Nuclear <input type="checkbox"/> Smart Storage and Distribution <input type="checkbox"/> Transformation Solar <input type="checkbox"/> Sustainable Bio/Fossil Fuels <input type="checkbox"/> Transformative Wind

## MAJOR GOALS AND ACCOMPLISHMENTS

Summarize your research goals and provide a brief statement of your accomplishments (no more than 1-2 sentences). Indicate whether you were able to accomplish your goals by estimating the percentage completed for each one. Use the next page for your written report.

RESEARCH GOALS	ACTUAL PERFORMANCE AND ACCOMPLISHMENTS	% OF GOAL COMPLETED
<b>Compile list of relevant events in the economy and the oil market</b>	Put together a list of major geopolitical events and macroeconomic developments that investors might consider in their trading decisions	80%
<b>Extensive literature study</b>	Explored the literature related to recovering an asset's implied probability density function from option prices with applications to the oil market	100%
<b>Find options data on oil futures</b>	Ran into difficulties, but eventually sourced data over a shorter time period than desired	60%
<b>Generate code to analyze options-implied probability distributions</b>	Prepared generic code to obtain options-implied probability distributions and experimented with example dataset; didn't find relevant dataset in time to generate results	40%
<b>Use distributions to construct and analyze risk assessments</b>	Didn't reach	0%

## RESEARCH OUTPUT

Please provide any output that may have resulted from your research project. You may leave any and all categories blank or check with your faculty advisor if you are unsure how to respond.

CATEGORY	INFORMATION
<b>EXTERNAL PROPOSALS SUBMITTED</b>	(Sponsor, Project Title, PIs, Submission Date, Proposal Amount)
<b>EXTERNAL AWARDS RECEIVED</b>	(Sponsor, Project Title, PIs, Award Date, Award Amount)
<b>JOURNAL ARTICLES IN PROCESS OR PUBLISHED</b>	(Journal Name, Title, Authors, Submission Date, Publication Date, Volume #, Page #s)
<b>BOOKS AND CHAPTERS RELATED TO YOUR RESEARCH</b>	(Book Title, Chapter Title, Authors, Submission Date, Publication Date, Volume #, Page #s)
<b>PUBLIC PRESENTATIONS YOU MADE ABOUT YOUR RESEARCH</b>	(Event, Presentation Title, Presentation Date, Location)
<b>AWARDS OR RECOGNITIONS YOU RECEIVED FOR YOUR RESEARCH PROJECT</b>	(Purpose, Title, Date Received)
<b>INTERNAL COLLABORATIONS FOSTERED</b>	(Name, Organization, Purpose of Affiliation, and Frequency of Interactions)
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<b>WEBSITE(S) FEATURING RESEARCH PROJECT</b>	(URL)
<b>OTHER PRODUCTS AND SERVICES</b> (e.g., media reports, databases, software, models, curricula, instruments, education programs, outreach for ND Energy and other groups)	(Please describe each item in detail)

### **RESEARCH EXPERIENCE**

Please let us know what you thought of your research experience: Did this experience meet your expectations? Were lab personnel helpful and responsive to your needs? What else could have been done to improve your experience or achieve additional results?

**Overall, I really enjoyed working with Dr. Baumeister, and the content of the project itself was very exciting to me. Unfortunately, we ran into some significant difficulties sourcing data, and thus we weren't able to get through as much as we hoped. I did, however, spend a good amount of time working with the business library who were very pleasant and eager to help. A better experience and more progress would basically have hinged on being able to find more data more quickly, which could have theoretically been achieved through smoother communications with the business librarians and Bloomberg support.**

### **FINAL WRITTEN REPORT**

(Please use the space below to describe your research project and objectives, any findings and results you can share, and graphs, charts, and other visuals to help us understand what you achieved as a result of this research experience.)

The key goal of this project was to use a market-based risk assessment of oil prices to analyze how market participants' perceptions of the future path of oil prices change in response to various economic and geopolitical shocks. To do this, we planned to use option-implied probability distributions of oil prices and study how these probability distributions are affected by events like the Saudi-Russia oil price war and the current pandemic. The options-implied probability density functions would yield information about how risky oil market participants assess oil prices to be, shown through probabilities of very good or very bad prices to be realized at certain times in the future. This information is valuable as it provides insights into the behavior of key market participants as well as the future demand for oil, both of which have significance economically as well as for the energy space in terms of energy conservation and the efficient use of energy.

While I had a basic understanding of options and option pricing prior to beginning work on the project, I had little familiarity with using them to create a probability distribution for the price of the underlying asset. Through a literature review, I became much more familiar with this process in general as well as the unique challenges posed to it by oil markets in particular. Studying papers that went into depth on issues such as trade-offs related to choice of curve-fitting technique were especially helpful to me as they gave me both important background information on key pieces of our method of which I had little prior knowledge as well as practical exposure to topics I'll deal with again beyond the context of the project. With this more solid conceptual backing, I began to look more closely at the method we planned to use.

Using options to conduct the planned risk assessment works because the variety of strike prices and expiration dates offered gives a comprehensive picture of the market's view of future price risks. Option prices depend on a variety of factors, most importantly the amount of time left until the option expires and volatility (and the price of the underlying asset), and given a set of option prices with a certain expiration date and different strike prices, one can calculate the volatility implied by the price of the option at each strike. Then, one can use interpolation to produce implied volatilities and thus option prices at strikes that aren't offered in reality, yielding a smooth curve of option prices. One can subsequently use other computational finance properties to transform these option price curves into probability density functions, which show the probabilities that market participants assign to different prices of the underlying asset being realized at the time of the options' expiration.

We intended to follow these steps using options data on crude oil futures to obtain probability density functions for oil prices. Given the number of different options expiries, each with a range of strike prices, traded every day, we expected to end up dealing with a large quantity of data and anticipated that finding what we wanted and managing it could pose a challenge. However, we didn't foresee the extent of difficulty we ran into when looking for the data. Having previously used Bloomberg Terminal to locate futures data, we focused our search there, but ran into problems with Bloomberg's naming convention for the oil options tickers which effectively restricts the date range of futures contracts on which option data is available. For help sorting this out, we contacted Bloomberg support through the business librarian who helped us with our data search. At the

same time, we explored other potential sources for the data but made little progress. The communications with both the business library and Bloomberg support slowed down at this point, and frictions from COVID-19-related restrictions inhibited our ability to effectively work with the business library in general. Eventually, we were able to find that Bloomberg did indeed have the data we were looking for, but for a considerably smaller time period than we were hoping. Again, effective collaboration with the library on important points was difficult, so this discovery took longer than it might have in a more normal semester. Given these data limitations, some reworking of the project's scope and focus would be necessary, so since these findings came late in the semester progress effectively stalled.

While the data search was ongoing, I went ahead and used some example data we'd found to begin working on the analysis of options data. Using MATLAB, I was able to work the data into a usable form, calculate implied volatilities, and perform interpolations, but some quirks related to the scope of the example data limited progress past this point. Without having explicit knowledge of the characteristics of a hypothetical full dataset it made little sense to iron out these kinks and tailor our code to the example data, so this was the stage at which we finished the semester with respect to the data analysis.

Despite having to deal with some unexpected difficulties, I enjoyed this research project and consider it a valuable learning experience. Being able to work more with Dr. Baumeister was fantastic, and the project itself was a great blend of my interests across the energy, economics, and financial mathematics fields, and represented a comprehensive use of my skills. It was challenging and rewarding to think about the use of options to learn about energy markets, and it was exciting to apply some of my existing knowledge of options theory to this end. I'll be working with options again this coming summer, so it was valuable to acquire additional skills in dealing with options data and use them from this different angle. Additionally, I ended up doing a fair amount of work in MATLAB (though less than expected, of course), and this ended up being a valuable opportunity to further develop my skills with this programming language and prepare for further coursework and project work using it.

In addition, though ideally the project and data gathering portion in particular would have gone smoother, I feel as though I got a realistic and worthwhile look into the flow of an ambitious research project. I gained experience working closely with librarians and the Bloomberg Terminal, as well as an appreciation for how crucial data is to research projects. As someone who is considering graduate study, these are valuable experiences and lessons for me, and in general I'm very glad to have had the opportunity to work with Dr. Baumeister on this project.