Seminar on Case Studies in Operations Research (Mat-2.4177)

The pricing of Asian commodity options

Project plan 6.3.2014

Client: Danske Bank

Reinvall Jaakko (Project manager)
Kilpinen Samu
Kärki Markus
Rintamäki Tuomas

Aalto University
School of Science

Danske Bank

Background and objectives

In this project, we explore pricing methods for Asian options in commodity markets. These options are path dependent in that they are settled against the predetermined strike price and the arithmetic average of spot prices calculated over a given time interval. Hence, the price of the option is determined by the underlying asset's price path upto and including maturity. In many cases, path dependency means that it is not possible to have a closed form solution for the price of an option and therefore simulation, approximate analytical solutions or other methods become essential. We are particularly interested in using Monte Carlo simulation methods for the generation of large number of random price paths.

Asian options are particularly suitable for commodity markets and their share of all options traded in there is considerable. On the one hand they can be used to hedge periodic cash-flows as a less expensive alternative compared to entering into multiple individual option contracts. On the other hand, with Asian options one can hedge against huge momentary volatilities concerning transactions of large exchanged quantities or volumes. [1]

Commodities have special characteristics that distinguish them from other derivatives of interest rates and foreign exchange market. These include amongst other things non-storability (e.g. electricity), seasonality (e.g. agricultural products), jumps and periods of high volatility. Because commodities have their special features in a way that pricing processes are quite unique for each asset class, it is necessary to study them independently.

The purpose of the project is to create pricing models for Asian commodity options. There are three asset classes that are of main interest: electricity, oil and agricultural products. However, the instructions from our client are that we should try to pursue quality over quantity in regards to producing pricing models. Therefore, our team's primary objective is to build models for two of these asset classes so that the client is satisfied with them. Particularly, we were asked to focus on the argumentation of model and parameters selection in the modelling process. The data used in the project is provided by the Danske Bank.

Resources, tasks and schedule

Resources

- The project team has four members: Jaakko Reinvall (project manager), Samu Kilpinen, Markus Kärki and Tuomas Rintamäki. The members study systems and operations research as their major. The team will receive guidance from the client's contact persons: Antti Malava and Svante Laakso. Also, the professor of the course, Ahti Salo, will provide advice on the project.
- The team is well committed to the project. Nonetheless, we will take into account personal preferences of each member about the timing of work in task allocation. For instance, Tuomas will begin his exchange studies in April and hence he will be allocated tasks from the first stages of the project.

Tasks

The tasks include 11 following main phases: project planning, background learning, literature review, data preparation, choosing model structure, implementation, calibration, interim reporting, verification, validation and final reporting. They are specified below. For the most of the tasks, a responsible person or multiple persons are named so that the first one named has the main responsibility.

1. Project planning

- Determining the necessary tasks for the project and allocating tasks to the team members. Also, deciding on the project schedule. Writing the project plan according to these decisions completed with relevant background information. In addition, preparing the presentation slides for the first seminar. Furthermore, providing comments for the selected project team from the course about their project plan.
- Responsible person: Jaakko & the rest of the team members

2. Background learning

- In order to create the pricing models, good understanding of both Monte Carlo methods and commodities is required. Therefore studying thoroughly essential parts of the suggested material – including for example [1] and [2] – is needed. This material will be used throughout the project, but the main part of the learning will occur at the beginning of the project. In addition, we have found some articles e.g. [3] and [4] which are of interest to us.
- Responsible persons: each team member

3. Literature review

- Review solution methods and models presented in the literature.
- Responsible person: Tuomas

4. Data preparation

- Consist of amongst other things of data processing, data subsetting and performing a simple statistical analysis on the data received from the Danske Bank.
- Responsible persons: Markus & Tuomas

5. Choosing model structure

- Identifying the main price drivers and the general structure of a model. Answering questions such as “What variables to include/exclude in the model?” or “What kind of relationships exist between

the variables?" Comparing different model structures. Learning the material will gives us guidance in selection of the basic model structure. The task has high priority in the project.

- Responsible persons: Tuomas & Markus

6. Implementation

- Programming chosen commodity pricing models and their calibration in Matlab. Implementations should be structured in a way that codes generating thousands of price paths can be run efficiently.
- Responsible persons: Markus & Tuomas

7. Estimation

- Estimating parameters so that the prices given by the models are consistent with market data. Studying and experimenting different approaches to parameter estimation.
- Responsible persons: Jaakko & Samu

8. Interim reporting

- Writing the report of the project status and updated project plan. Also, preparing presentation slides and providing comments for the selected project team.
- Responsible persons: Jaakko & the rest of the team members

9. Verification

- Confirming that the implemented models correspond to the conceptual models. Performing fixes to the implementations if needed. The objective is to become confident of the correctness of the models.
- Responsible persons: Samu & Jaakko

10. Validation

- Assessing the accuracy of the model relative to the market reality. The robustness of our models will become clear when they are applied to various options.
- Responsible persons: Samu & Jaakko

11. Final reporting

- Writing the final report which presents the results of the project and includes discussion of the limitations of using the produced pricing models. Additionally, writing a self-assessment of the

project execution and preparing the final presentation slides. And lastly, commenting the final report of the selected project team.

- Responsible persons: Jaakko & the rest of the team members

Schedule

The project schedule is displayed below in Table 1. In addition to it, important dates of the course seminars are separately pointed out. The schedule is intended for two asset classes. However, once we are familiar with the process of commodity price modelling, modelling yet another asset class should not be too much of a problem. Therefore we might be able to work on all three asset classes, but at the moment our goal is to produce models for only two of them.

- Important dates:
    - Project plan presentations: 28.2.
    - Interim report presentations: 4.4.
    - Final report presentations: 16.5.

Table 1. The project schedule.

	Jan.	February				March				April					May
Task	wk 5	wk 6	wk 7	wk 8	wk 9	wk 10	wk 11	wk 12	wk 13	wk 14	wk 15	wk 16	wk 17	wk 18	wk 19
Project planning															
Background learning															
Literature review															
Data preparation															
Choosing model structure															
Implementation															
Estimation															
Interim reporting															
Verification															
Validation															
Final reporting															

Risks

The risks related to the project are presented in Table 2 below. For the assessment of each risk probability and effect, we use qualitative expression of Harvey Balls. Essentially they are five different circles which have none, one, two, three or four quadrants filled with black. Here, the increasing number of black quadrants in a Harvey Ball means greater amount of probability or effect. Apart from estimating the risk probabilities and effects, planning preventive or mitigating actions is also important for managing the risks. These are presented in the last column of Table 2.

Table 2. The project risks.

Risk	Probability	Effect	Preventive action
Delays due to illness and other setbacks			● Taking proper care of one's own health ● Scheduling conservatively ● Readiness to partly re-allocate work to other team members
Individual resources prove to be insufficient for the workload			● Focusing on the essentials ● Readiness to partly re-allocate work to other team members
Results do not meet the client's expectations			● Setting realistic objectives for the project together with the client ● Effective communication with the client

References

[1] Geman, H. (2005). *Commodities and Commodity Derivatives: Modelling and Pricing for Agriculturals, Metals and Energy*. John Wiley & Sons, Chichester.

[2] Glasserman, P. (2003). *Monte Carlo Methods in Financial Engineering*. Springer, New York.

[3] Geman, H. and Roncoroni, A. (2006). *Understanding the fine structure of electricity prices*. Journal of Business, 3(1-2):125–144.

[4] Kemna, A. and Vorst, A. (1990). *A pricing method for options based on average asset values*. Journal of Banking and Finance, 14(1):113–129.