Semester Report

Author: Gabriel Henrique Souza Cardoso

E-mail: gabrielhsc95@gmail.com / gabrielhsc95@caesar.elte.hu

Ph.D. Program: Doctoral School of Physics - ELTE

Supervisor: Prof. Dr. Gábor Vattay

Ph.D. Thesis Title: Quantum Computing for Finance: Quantum Bond Pricer

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Introduction

Inspired by the new possibilities created by quantum computing and its applications on quantitative finance [1]. A quantum algorithm is being built to understand the fixed income market, mainly on bonds.

For simple bonds, as seen before, the price P is

$$P = \sum_{i=1}^{n} CF(t_i) \cdot D(t_i),$$

where CF is the cash flow (a coupon or the principal) and D is a discount factor, both are time-dependent. The rules about the cash flow and the discount factor are under contract [2]. The program initially tackled only fixed coupons, but there are more complex instruments in the market like zero coupon, float coupon, optionality, amortization [3], such characteristics are now being taken into account to expand the possibilities of the code.

In addition, new statistics such as accrued interest, yield to maturity, duration, convexity, and more detailed output of the cash flows are being considered as well. To not only increase the objects that the program will be able to handle, but also a better analysis of each one of them [2][3].

To increase the quality of the current work the project will also include another program without using quantum algorithms to double check numbers and precision. It is almost a duplicate to make sure the results are valid.

Research Work

Due to changing fields from MSc to PhD, it is still necessary to allocate time to catch up in quantitative finance and quantum computing.

Quantum Computing

To improve my knowledge about quantum computing, I kept studying the book "Quantum Computation and Quantum Information" by Michael A. Nielsen and Isaac L. Chuang [4]. Also, to write a quantum algorithm, I studied the Azure Quantum Documentation [5]. The latter needs more work to improve and understand the current code.

Finance

Besides the book "Options, Futures, and Other Derivatives" by John C. Hull [2], which I started to read last semester, I added "Paul Wilmott Introduces Quantitative Finance" by Paul Wilmott [3] as a main reference to my work.

The internship at MSCI as Quantitative Model Validation had good results and it was extended. It helped improve my knowledge in fixed income and the architecture of development, which is highly connected with my research work.

Studies

FIZ/3/089 - Deep learning and machine learning in natural sciences

Credits: 6
Responsible lecturer: Dr. István Csabai

FIZ/2/057E- Introduction to General Relativity II

Credits: 6
Responsible lecturer: Dr. László Palla

Professional Activities

Quantitative Model Validation Intern

Company: MSCI Inc.
Period: March 2021 - June 2021
Hours: 24 hours a week
Description: Test python library by validating results. Validate bug-fixes and new implementations. Find and report bugs. Develop tools for automated testing. Suggest improvements in the development of the python library.

Mathematics Teacher Volunteer

Company: Colégio Objetivo
Period: May 2021 - December 2021
Hours: 5 hours a week
Description: Teaching mathematics to middle school. It is all done virtually and thought in Portuguese.

References

[1] Orus, Roman, et al. “Quantum Computing for Finance: Overview and Prospects.” Reviews in Physics, vol. 4, Nov. 2019, p. 100028. arXiv.org, doi:10.1016/j.revip.2019.100028.
[2] Hull, John. “Options, Futures, and Other Derivatives”. Ninth edition, Pearson, 2015.
[3] Wilmott, Paul. “Paul Wilmott Introduces Quantitative Finance”. Second edition, John Wiley & Sons Ltd, 2007
[4] Nielsen, Michael A., and Isaac L. Chuang. Quantum Computation and Quantum Information. Cambridge University Press, 2000.
[5] Azure Quantum Documentation. https://docs.microsoft.com/en-us/azure/quantum/