論 文 の 内 容 の 要 旨

論 文 題 目　　ECONOPHYSICS METHODS FOR EXOTIC OPTION PRICING: FROM THEORY TO IMPLEMENTATION（経済物理学のアプローチによる複雑オプションの価格付け―理論から実装まで―）

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The fast-paced world we live in has faced a transition where the financial system has changed from being relatively self-contained entity with little need for complexity, to a place where interconnection is the rule and sophisticated tools are increasingly present throughout the industry. Those financial instruments among which the exotic derivatives belong have built-in complexity that is a specific answer to an investor very specific need. When investors needed a tool to hedge risk bankruptcy for some risky loans, credit default swap were introduced; weather derivatives were introduced as a way to protect oneself against extreme weather events.

Complexity in the environment of financial derivatives is a side effect of the ongoing adjustment between investors' challenges and industry propositions. In this thesis we are interested in studying the pricing problem for complex derivatives: exotic options. We will tackle this problem from the theoretical ground up to its efficient implementation using an interdisciplinary approach. It is usually the case that theoretical publications do not deal with the implementation of the proposed formula, and alternatively, implementation studies often limit their scope to the straightforward vanilla derivatives as a benchmark.

The contributions of this thesis lie in both the theoretical and implementation space, and pursue this endeavor in an interdisciplinary fashion.

In the theoretical part, we will demonstrate how particularly suitable are quantum mechanics path integrals to study path dependent options. Our first contribution is an improvement and extension on an existing exotic option pricing formula using path integrals. Our second theoretical contribution is the design of a new type of exotic option that we price using path integrals, demonstrating their power and flexibility.

Then the pricing problem in its computational and implementation complexity is studied and two original contributions are made: first a case study of heterogeneous CPU/GPU

designs is done when price is available in a series form. Then, for the studies were new formula are introduced and must be benchmarked, we propose a novel GPU algorithm to speed up Monte Carlo simulations.

The conclusion will summarize the relevance of our contributions to the field of econophysics and more generally to computational finance.