

RGC Ref.:
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<i>(please insert ref. above)</i>

NSFC/RGC Joint Research Scheme
Joint Completion Report

*(Please attach a copy of the completion report submitted to the NSFC
by the Mainland researcher)*

Part A: The Project and Investigator(s)

1. Project Title

Combining Simulation and Optimization with Applications in Financial Risk Management

2. Investigator(s) and Academic Department/Units Involved

	Hong Kong Team	Mainland Team
Name of Principal Investigator <i>(with title)</i>	Jeff Hong	Jianqiang Hu
Post	Professor	Professor
Unit / Department / Institution	Industrial Eng and Logistics Mgt Dept at HKUST	Mgt Sci and Eng Dept at Fudan University
Co-investigator(s) <i>(with title)</i>		Prof. Xiaoling Sun Prof. Shushang Zhu

3. Project Duration

	Original	Revised	Date of RGC/ Institution Approval <i>(must be quoted)</i>
Project Start date	01 Jan 2011		
Project Completion date	31 Dec 2013		
Duration <i>(in month)</i>	36		

Part B: The Completion Report

5. Project Objectives

5.1 Objectives as per original application

- 1. We will develop a sequential approach based on repeatedly using CVaR approximation to solve VaR constrained optimization problems. We will prove that the cluster points of the sequence of solutions found by this algorithm are stationary points of the VaR constrained optimization problem. We will further analyze the efficiency of the Monte Carlo method that realizes this algorithm.*
- 2. We will provide SDP relaxation to VaR constrained mean-variance portfolio selection problems, and develop algorithms that efficiently solve the relaxation. We will also consider an extra constraint on the number of selected stocks (also known as cardinality constraint), and investigate how to incorporate the constraint to the SDP relaxation.*
- 3. We will analyze the structures of portfolio selection problems with marginal risk controls, and develop efficient iterative algorithms that solve the problem. We will also study how marginal risk controls change portfolio selection decisions.*
- 4. We will formulate the two-level loan portfolio management problems faced by a nationwide bank in China, analyze its structures, and propose efficient algorithms to solve the problem. We will investigate the implications of the optimal solutions to practical decisions.*

(Revised 07/09)

5. We will work with the financial industry, in particular Shanghai Pudong Development Bank to apply our algorithms and results to improve their portfolio selection and risk management practices.

5.2 Revised Objectives

Date of approval from the RGC: _____

Reasons for the change: _____

- 1.
- 2.
3.

6. Research Outcome

Major findings and research outcome
(maximum 1 page; please make reference to Part C where necessary)

Simulation and optimization are two widely used operations research tools. However, it is until very recently these two tools have been combined to solve practical problems. In this project, we have demonstrated that the combination of these two tools can solve many seemingly unsolvable problems, and we have applied the methodology to a wide range of problems in financial risk management as well as other important areas.

(Revised 07/09)

The following are the research outcomes and the related findings.

- In Hu, Cao and Hong (2012), we developed the concept of robust simulation and apply it to evaluate various global warming policies. We find that the current environmental simulation models are not robust in terms of evaluating global warming impacts, but they are robust in evaluating the relative orderings of the environmental policies.
- In Hong, Hu and Zhang (2014), we developed a sequential conditional value-at-risk approximation to value-at-risk constrained portfolio selection problems, which are a very important class of problems in financial risk management. We show that, by adding Monte Carlo simulations, the problems may be solved very well.
- In Hu, Hong and Zhang (2013), we combined simulation and optimization to solve a class of difficult stochastic programs, called joint chance-constrained programs. In particular, we proposed a logarithm-sum-exponential smoothing technique to the problem and remove the non-smoothness in the problems.
- In Xu, Nelson and Hong (2013), we developed a new algorithm, called the adaptive hyperbox algorithm, to solve black-box discrete simulation optimization problems. In Chang, Hong and Wan (2013), we developed a new algorithm, called the stochastic trust region response-surface method, to solve black-box continuous simulation optimization problems. In Hong, Juneja and Luo (2014), we developed a simulation-based method to estimate the sensitivities of portfolio credit risk.
- We are invited by the *ACM Transactions on Modeling and Computer Simulation* to write a review paper on the use of simulation method in value-at-risk and conditional value-at-risk related estimation, sensitivity analysis and optimization problems. The paper, Hong, Hu and Liu (2014), is currently under minor revision. This has clearly demonstrated that my research group has become one of the most influential groups in this research area.

Potential for further development of the research and the proposed course of action
(*maximum half a page*)

The combination of simulation and optimization creates a very power tool to solve many practical problems. In this project we focused mainly on financial applications. There are certainly many other important applications that may be considered. In this project, we also considered environmental issues. This is a very promising area that I believe we can do more and have a strong impact.

Due to the recent financial crisis, there have been many discussions on the use of various risk measures. In this project we considered value-at-risk and conditional value-at-risk. However, there exist other type of risk measures, even multi-dimensional risk measures that can be considered in portfolio selection and financial risk management. This is another direction that we may take in our future research.

7. The Layman's Summary

(describe in layman's language the nature, significance and value of the research project, in no more than 200 words)

How to properly control financial risk has always been a very important issue in portfolio investment and bank supervision. Value-at-risk and conditional value-at-risk are two most widely used risk measures. However, many of the practical financial risk management problems require solving risk-measure related optimization problems that are in general very difficult. In this project we developed various simulation-based methods to solve these optimization problems and the results are very promising.

In addition, we have also applied out simulation-based optimization methods on other important applications. For instance, we used the method to evaluate the robustness of various global warming policies, including the one suggested by Copenhagen Accord and the one proposed by the former US vice president and Nobel Laureate Al Gore. We found that these policies are typically not robust in evaluating environmental and social impacts, but the relative orderings of these policies are quite robust. These findings may help governments and inter-government organizations in evaluating and selecting global warming policies.

Part C: Research Output

8. Peer-reviewed journal publication(s) arising directly from this research project

(Please attach a copy of each publication and/or the letter of acceptance if not yet submitted in the previous progress report(s). All listed publications must acknowledge RGC's funding support by quoting the specific grant reference.)

The Latest Status of Publications				Author(s) <i>(bold the authors belonging to the project teams and denote the corresponding author with an asterisk*)</i>	Title and Journal/Book <i>(with the volume, pages and other necessary publishing details specified)</i>	Submitted to RGC <i>(indicate the year ending of the relevant progress report)</i>	Attached to this report <i>(Yes or No)</i>	Acknowledged the support of this Joint Research Scheme <i>(Yes or No)</i>
Year of publication	Year of Acceptance <i>(For paper accepted but not yet published)</i>	Under Review	Under Preparation <i>(optional)</i>					
2012				Zhaolin Hu, Jing Cao, L. Jeff Hong	Robust simulation of global warming policies using the DICE model. <i>Management Science</i> , 58:2190-2206.	2012	Yes	Yes

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2013				Jie Xu, Barry Nelson, L. Jeff Hong	An adaptive hyperbox algorithm for high dimensional discrete optimization via simulation problems. <i>INFORMS Journal on Computing</i> , 25:133-146.	2012	Yes	Yes
2013				K-H Chang, L. Jeff Hong , Hong Wan	Stochastic trust-region response-surface method (STRONG) – A new response surface framework for simulation optimization. <i>INFORMS Journal on Computing</i> , 25:230-243.	No	Yes	Yes
2013				Zhaolin Hu, L. Jeff Hong , Liwei Zhang	A smooth Monte Carlo approach to joint chance constrained programs. <i>IIE Transactions</i> , 45:716-735.	No	Yes	Yes
2014				L. Jeff Hong , Zhaolin Hu, Liwei Zhang	Conditional value at risk approximation to value-at-risk constrained programs: A remedy via Monte Carlo. <i>INFORMS Journal on Computing</i> , 26:385-400.	No	Yes	Yes
	2014			L. Jeff Hong , S. Juneja, Jun Luo	Estimating sensitivities of portfolio credit risk using Monte Carlo. <i>INFORMS Journal on Computing</i> .	No	Yes	Yes
		Minor revision		L. Jeff Hong , Zhaolin Hu, Guangwu Liu	Monte Carlo methods for value-at-risk and conditional value at risk: A review. <i>ACM Transactions on Modeling and Computer Simulation</i> .	No	Yes	

9. Recognized International conference(s) in which paper(s) related to this research project was/were delivered (Please attach a copy of each delivered paper)

(Revised 07/09)

Month/Year/ Place	Title	Conference Name	Submitted to RGC (indicate the year ending of the relevant progress report)	Attached to this report (Yes or No)	Acknowledged the support of this Joint Research Scheme (Yes or No)
12/2011	Monte Carlo estimation of value at risk, conditional value at risk and their sensitivities	Winter Simulation Conference	No	Yes	Yes

10. Student(s) trained (Please attach a copy of the title page of the thesis.)

Name	Degree registered for	Date of registration	Date of thesis submission/ graduation
Zhaolin Hu	PhD	September 2008	August 2011
Jun Luo	PhD	September 2009	August 2013

11. Other impact (e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, etc.)

Jeff Hong and his former PhD student Guangwu Liu won the Outstanding Simulation Publication Award from the *INFORMS Simulation Society* in 2012

PhD graduate, Dr. Zhaolin Hu, won the third place of the 2012 Prisker Doctoral Dissertation Award from the *Institute of Industrial Engineers*.