

RGC Ref. No.: UGC/FDS14/P03/16 <hr/> (please insert ref. above)

**RESEARCH GRANTS COUNCIL
COMPETITIVE RESEARCH FUNDING SCHEMES FOR
THE LOCAL SELF-FINANCING DEGREE SECTOR**

FACULTY DEVELOPMENT SCHEME (FDS)

Completion Report
(for completed projects only)

<p><u>Submission Deadlines:</u></p> <ol style="list-style-type: none"> 1. Auditor's report with unspent balance, if any: within <u>six</u> months of the approved project completion date. 2. Completion report: within <u>12</u> months of the approved project completion date.
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Part A: The Project and Investigator(s)

1. Project Title

Analysis and Application of Bounds in Insolvency Problem

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

Research Team	Name / Post	Unit / Department / Institution
Principal Investigator	LEE Wing Yan Assistant Professor	Department of Mathematics, Statistics and Insurance, The Hang Seng University of Hong Kong
Co-Investigator	WEI Wei Associate Professor	College of Letters & Science, Mathematical Sciences, University of Wisconsin-Milwaukee
Co-Investigator	LI Shu Assistant Professor	Department of Mathematics, University of Illinois at Urbana-Champaign

3. Project Duration

	Original	Revised	Date of RGC / Institution Approval (must be quoted)
Project Start Date	1 st January, 2017		
Project Completion Date	31 st December, 2018	30 th June, 2019	21 st November, 2018
Duration (in month)	24 months	30 months	21 st November, 2018
Deadline for Submission of Completion Report	31 st December, 2019	30 th June, 2020	21 st November, 2018

Part B: The Final Report**5. Project Objectives**

5.1 Objectives as per original application

- 1. To apply the concept of stochastic orders in insolvency problem.*
- 2. To determine bounds on quantities that are related to the time to ruin.*
- 3. To study and suggest possible application of these bounds in real-life situations.*

5.2 Revised objectives

Date of approval from the RGC: N/A

Reasons for the change: N/A

1.

2.

3.

5.3 Realisation of the objectives

(Maximum 1 page; please state how and to what extent the project objectives have been achieved; give reasons for under-achievements and outline attempts to overcome problems, if any)

The project objectives have been achieved in the papers stated in Part C of this report.

In the paper “Analysis of a dynamic premium strategy: from theoretical and marketing perspectives”, a dynamic insurance premium strategy that depends on the past claim experience is studied under the discrete-time risk model. The insolvency problem for insurance companies is investigated through the Gerber-Shiu function which includes the time to ruin as one of the important quantities. The claim sizes and the interclaim times are assumed to be mutually independent. By studying the properties of the Gerber-Shiu function, the second project objective “to determine bounds on quantities that are related to the time to ruin” and part of the first objective “to apply the concept of stochastic orders in insolvency problem” are achieved. Moreover, this paper discussed the real-life implications of the dynamic premium strategy by comparing the constant premium strategy and the dynamic premium strategy from the insurance companies’ marketing point of view. This addressed the third project objective “to study and suggest possible application of these bounds in real-life situations”.

In the paper “A cyclic approach on classical ruin model”, the classical Poisson insurance risk model is revisited by applying the concepts of the cycle lemma. The finite-time ruin quantities are first studied and the result is generalized to the infinite-time horizon by using the weak law of large numbers. The classical results are perceived in a novel and intuitive way by revisiting them with the cycle lemma. Through the studies of the properties of the ruin quantities, the first objective “to apply the concept of stochastic orders in insolvency problem” is achieved.”

5.4 Summary of objectives addressed to date

Objectives <i>(as per 5.1/5.2 above)</i>	Addressed <i>(please tick)</i>	Percentage Achieved <i>(please estimate)</i>
1. To apply the concept of stochastic orders in insolvency problem	✓	100
2. To determine bounds on quantities that are related to the time to ruin	✓	100
3. To study and suggest possible application of these bounds in real-life situations	✓	100

6. Research Outcome

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

The papers published under this project are “Analysis of a dynamic premium strategy: From theoretical and marketing perspectives” and “A cyclic approach on classical ruin model”, respectively. Please refer to Part C of this report for the publication details of these papers.

In the paper “Analysis of a dynamic premium strategy: From theoretical and marketing perspectives”, the dynamic premium strategy for an insurance company is investigated instead of the usual constant premium assumption. In the discrete-time risk model studied, the premium rate depends on the past claim experience. The Gerber-Shiu function, including the time to ruin and the penalty function, is analyzed under this model setting. Explicit solution for the Gerber-Shiu function is derived under the special case of geometric claims. This result gives us insight on the form of the Gerber-Shiu function under the dynamic premium strategy. The dynamic premium strategy is further compared to the constant premium strategy through some numerical examples. The marketing implications of the dynamic premium strategy are discussed, which is seldom discussed in detail in the literature.

In the paper “A cyclic approach on classical ruin model”, some of the classical ruin results in the compound Poisson insurance risk model is revisited from a new perspective. The idea of the cycle lemma is applied to study the finite-time ruin probability. The cycle lemma motivates us to study the claim instants retrospectively, which inspires us to perceive the classical results in a novel way. The finite-time result is also linked to the infinite-time result by using the weak law of large numbers. By using this cyclic approach to revisit the elegant classical results, they can be understood in an intuitive way. This gives us insights on the ruin results in more general models.

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

For the dynamic premium strategy, it can be investigated in more general discrete-time risk models. Although the dynamic premium strategy in continuous-time risk model has been widely studied in the literature, it is worth to study dynamic premium strategy in the discrete-time risk model which is more close to real-life situation. The dynamic premium strategy can depend on the policyholder's past claim experiences as well as other related factors such as the policyholder's changing health condition in the case of health insurance.

On the other hand, the cyclic approach can be applied in more general models in order to understand the nature of ruin in an intuitive way. This study can also link the finite-time and infinite-time ruin results. By understanding the nature of ruin, it may be possible to obtain some approximates for the ruin results in complicated models.

More research can be done to explore these topics.

7. Layman's Summary

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

The insolvency problem for insurance companies, also named as the ruin problem, has long been the topic of study in the literature. In this project, some of the usual assumptions in the insurance risk models are revised such that the model is more close to real-life situation. The real-life implications of the results for insurance companies are discussed.

Some of the classical ruin results in the insurance risk model are also revisited and studied with a new approach. By using the new approach, it is easier to understand the nature of ruin in an intuitive way. This gives us insights on ruin problem with more general model settings.

Part C: Research Output**8. Peer-Reviewed Journal Publication(s) Arising Directly From This Research Project**

(Please attach a copy of the 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) (denote the corresponding author with an asterisk*)	Title and Journal / Book (with the volume, pages and other necessary publishing details specified)	Submitted to RGC (indicate the year ending of the relevant progress report)	Attached to this Report (Yes or No)	Acknowledged the Support of RGC (Yes or No)	Accessible from the Institutional Repository (Yes or No)
Year of Publication	Year of Acceptance (For paper accepted but not yet published)	Under Review	Under Preparation (optional)						
2020				Fei Lung Yuen*, <u>Wing Yan Lee</u> , Derrick W. H. Fung	A cyclic approach on classical ruin model, Insurance: Mathematics and Economics, 91 (2020), 104-110		Yes (Annex I)	Yes	Yes
2018				<u>Wing Yan Lee</u> , Fangda Liu*	Analysis of a dynamic premium strategy: From theoretical and marketing perspectives, Journal of Industrial and Management Optimization, 14(4), 1545-1564	2017	Yes (Annex II)	Yes	Yes

9. Recognized International Conference(s) In Which Paper(s) Related To This Research Project Was / Were Delivered

(Please attach a copy of each conference abstract)

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 RGC (Yes or No)	Accessible from the Institutional Repository (Yes or No)
N/A						

10. Whether Research Experience And New Knowledge Has Been Transferred / Has Contributed To Teaching And Learning

(Please elaborate)

The research experience and new knowledge are useful in teaching actuarial and insurance-related courses. Students will be able to understand the insolvency problem for insurance companies in an intuitive way. Real-life implications of the ruin results are also discussed in class.

11. 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
N/A			

12. Other Impact

(e.g. award of patents or prizes, collaboration with other research institutions, technology transfer, teaching enhancement, etc.)

N/A

13. Statistics on Research Outputs

No. of outputs arising directly from this research project	Peer-reviewed Journal Publications	Conference Papers	Scholarly Books, Monographs and Chapters	Patents Awarded	Other Research Outputs (please specify)	
					Type	No.
	2					

14. Public Access Of Completion Report

(Please specify the information, if any, that cannot be provided for public access and give the reasons.)

Information that Cannot Be Provided for Public Access	Reasons
N/A	