RGC Ref. No.:
UGC/FDS14/P02/20
(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)

Submission Deadlines:
1. *Auditor's report with unspent balance, if any: within **six** months of the approved project completion date.*
2. *Completion report: within **12** months of the approved project completion date.*

Part A: The Project and Investigator(s)

1. Project Title

Generalized Sethi Advertising Model and Extensions

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

Research Team	Name / Post	Unit / Department / Institution
Principal Investigator	Chi Chung SIU/Associate Professor	Department of Mathematics, Statistics and Insurance/The Hang Seng University of Hong Kong
Co-Investigator(s)	Suresh SETHI/Eugene McDermott Chair Professor	Naveen Jindal School of Management/ University of Texas at Dallas
Others		

3. Project Duration

	Original	Revised	Date of RGC / Institution Approval *(must be quoted)*
Project Start Date	01/01/2021		

Project Completion Date	31/12/2023	30/06/2024	03/01/2023 (HSUHK)
Duration *(in month)*	36 months	42 months	03/01/2023 (HSUHK)
Deadline for Submission of Completion Report	31/12/2024	30/06/2025	03/01/2023 (HSUHK)

4.4 Please attach photo(s) of acknowledgement of RGC-funded facilities / equipment.

N/A

Part B: The Final Report

5. Project Objectives

5.1 Objectives as per original application

1. Establish a tractable relationship between the general advertising cost function and the general form of the word-of-mouth effect in a model that generalizes the seminal Sethi (1983) model
2. Develop a general form of synergies in the integrated marketing communications (IMC) and apply it to various dynamic advertising problems with competitions.
3. Construct an advertising model on durable goods with innovation and failure rate.

5.2 Revised objectives

Date of approval from the RGC: N/A

Reasons for the change: N/A

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)

1. Establish a tractable relationship between the general advertising cost function and the general form of the word-of-mouth effect in a model that generalizes the seminal Sethi (1983) model.

In "The Generalized Sethi Advertising Model," we developed a tractable model that captures the interplay between advertising costs and word-of-mouth effects. This work was published in ***Operations Research*** in 2024.

2. **Develop a general form of synergies in the integrated marketing communications (IMC) and apply it to various dynamic advertising problems with competitions.**

   In "Co-op Advertising and Pricing in Randomly Fluctuating Markets," we extended the cooperative advertising framework to a regime-switching environment and include both local and national advertisings, demonstrating forward-looking advertising and pricing decisions. This work was published in ***Production and Operations Managemen***t in 2023.

3. **Construct an advertising model on durable goods with innovation and failure rate.**

   In "Optimal Advertising and Product Durability Decisions in New Product Diffusion," we constructed an advertising model for semi-durable goods, focusing on the effects of innovation and failure rates. This work is currently under review in ***Automatica***.

These objectives not only make significant contributions to the dynamic advertising literature but also offer insights for advancing mathematical theories relevant to inventory management, trading strategies in the presence of market frictions, and asset-liability management, which results in the publication of three additional works. Please see Part C: Research Output for details.

5.4 Summary of objectives addressed to date

Objectives *(as per 5.1/5.2 above)*	**Addressed** *(please tick)*	**Percentage Achieved** *(please estimate)*
1. Establish a tractable relationship between the general advertising cost function and the general form of the word-of-mouth effect in a model that generalizes the seminal Sethi (1983) model	✔	100%
2. Develop a general form of synergies in the integrated marketing communications (IMC) and apply it to various dynamic advertising problems with competitions.	✔	100%
3. Construct an advertising model on durable goods with innovation and failure rate.	✔	100%

2. Research Outcome

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

We have published six papers under this research grant, highlighting key findings and outcomes:

1. Han, J., S. P. Sethi, C. C. Siu, and S. C. P. Yam (2023) "Co-op Advertising in Randomly Fluctuating Markets," ***Production and Operations Management***, 32(6), 1617-1635

    - *This paper analyzes a dynamic Stackelberg game between a manufacturer and retailer, focusing on their advertising strategies and cooperative subsidies. It finds that both parties are forward-looking, with advertising influenced by profit margins. Comparative statics indicate that pre-crisis advertising decreases as crisis likelihood rises, while numerical studies reveal risks associated with myopic strategies*.

2. Yan, T., J. Han, G. Y. Ma, C. C. Siu (2023) "Dynamic Asset-Liability Management with Frictions," ***Insurance: Mathematics and Economics***, 111, 57-83

    - This study explores asset-liability management under market frictions, using correlated geometric Brownian motions. It identifies optimal trading strategies via coupled Riccati systems, showing that temporary price impacts slow trading, while persistent impacts may lead to more aggressive trading to enhance expected returns.

3. Ma, G., C. C. Siu, S. C. P. Yam, and Z. Zhou (2023) "Dynamic Trading with Markov Liquidity Switching," ***Automatica***, 155, 111156

    - The paper addresses portfolio choice in a Markov jump linear system, focusing on maximizing expected returns while managing risks and trading costs. It reveals that trading behavior shifts based on market liquidity conditions.

4. Kennedy, A., S. P. Sethi, C. C. Siu, and S. C. P. Yam (2024) "The Generalized Sethi Advertising Model," ***Operations Research***, 72(4), 1526 – 1535

    - This paper introduces a dynamic advertising framework that captures varied market penetration rates using a Cobb–Douglas production function. The model allows for closed-form solutions and provides economic insights through sensitivity analysis.

5. Han, J., X. Li, S. P. Sethi, C. C. Siu, and S. C. P. Yam (2024) "Production Management with General Demands and Lost Sales," ***Operations Research***, 72(5), 1751-1764

    - This analysis of continuous-review inventory systems with Lévy demand derives optimal replenishment rates to minimize costs. It employs the renewal theorem for explicit solutions and introduces a Fourier-cosine method for numerical computation, enhancing risk analytics.

6. Kennedy, A., A. Prasad, S. P. Sethi, C. C. Siu, and S. C. P. Yam (2025) "Optimal Advertising and Product Durability Decisions in New Product Diffusion" under review in ***Automatica***

    - This paper explores optimal advertising strategies for semi-durable goods throughout their life cycle, developing a diffusion model with practical guidelines and insights into product durability, while extending the analysis to a competitive context.

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

Based on the completed papers under this research grant, potential avenues for further research include:

3. **Integration of Advertising and Inventory Management**: Develop a unified model that combines advertising strategies with inventory management to examine how advertising influences inventory decisions and demand dynamics in fluctuating markets.

4. **Multi-Channel Advertising Strategies**: Expand the generalized Sethi model to include multi-channel advertising, assessing how different media impact consumer behavior across various industries for empirical validation.

5. **Dynamic Pricing and Advertising Interplay**: Investigate the relationship between dynamic pricing and advertising strategies within competitive, fluctuating environments by extending the Stackelberg game framework to incorporate pricing decisions.

6. **Long-Term Sustainability in Advertising Decisions**: Explore how diverse advertising strategies affect customer retention and market share over time, particularly for semi-durable goods and their durability considerations.

7. **Advanced Risk Analytics in Asset Management**: Enhance dynamic asset-liability management by developing frameworks that incorporate advertising and market resilience factors to gain insights into investor behavior and portfolio strategies.

8. **Collaborative Advertising in Competitive Markets**: Analyze co-op advertising strategies among competing firms using game-theoretic models to evaluate the effects of collective advertising on market outcomes and individual profitability.

9. Layman's Summary

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

This research investigates effective strategies in advertising and inventory management for businesses. A central focus is the generalized Sethi model, which provides insights into how companies can leverage advertising across various media to engage consumers and increase sales. The model also illustrates the impact of advertising on inventory decisions, particularly in dynamic market environments.

Another significant area of exploration is the interaction between pricing and advertising strategies. By understanding how these elements influence each other, businesses can better navigate competitive markets and enhance their profitability. The study further examines the long-term effects of advertising on customer loyalty and market share, especially for semi-durable products that may require replacement.

Additionally, the research explores collaborative advertising efforts among companies in fluctuating markets to improve overall effectiveness. It also advances mathematical techniques that aid in managing investment risks and optimizing inventory management. Ultimately, this work aims to provide practical frameworks and solutions that empower businesses and fund managers to make informed decisions in their advertising, inventory practices, trading strategies, and asset-liability management, leading to improved performance and profitability.

Part C: Research Output

10. 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)*						
2023				Jinhui Han, Suresh P. Sethi, Chi Chung Siu*, Sheung Chi Phillip Yam	Co-op advertising in randomly fluctuating markets, *Production and Operations Management*, 32(6), 1617-1635 *(https://onlinelibrary.wiley.com/doi/abs/10.1111/poms.13929)*	Yes (2022)	Yes (Annex I)	Yes	Yes (https://researchdb.hsu.edu.hk/view/publication/202300050)
2023				Tinjin Yan, Jinhui Han, Guiyuan Ma, Chi Chung Siu*	Dynamic asset-liability management with frictions, *Insurance: Mathematics and Economics*, 111, 57-83 *(https://www.sciencedirect.com/science/article/pii/S016766872300025 2)*	No	Yes (Annex II)	Yes	Yes (https://researchdb.hsu.edu.hk/view/publication/202300051)
2023				Guiyuan Ma, Chi Chung Siu*, Sheung Chi Phillip Yam, Zeyu Zhou	Dynamic trading with Markov liquidity switching, *Automatica*, 155, 111156 *(https://www.sciencedirect.com/science/article/pii/S0005 10982300316*	No	Yes (Annex III)	Yes	Yes (https://researchdb.hsu.edu.hk/view/publication/202300052)

					3)				
2024				Adrian P. Kennedy*, Suresh P. Sethi, Chi Chung Siu, Sheung Chi Phillip Yam	The Generalized Seth Advertising Model, *Operations Research*, 72(4), 1526 - 1535 *(https://pubsonline.informs.org/doi/10.1287/opre.2021.0717*)	Yes (2022)	Yes (Annex IV)	Yes	Yes (https://researchdb.hsu.edu.hk/view/publication/202400126)
2024				Jinhui Han, Xiaolong Li* Suresh P. Sethi, Chi Chung Siu, Sheung Chi Phillip Yam	Production Management with General Demands and Lost Sales, *Operations Research*, 72(5), 1751-1764 *(https://pubsonline.informs.org/doi/10.1287/opre.2022.0191)*	No	Yes (Annex V)	Yes	Yes (https://researchdb.hsu.edu.hk/view/publication/202400127)
2025		Yes		Adrian P. Kennedy, Ashutosh Prasad*, Suresh P. Sethi, Chi Chung Siu, Sheung Chi Phillip Yam	Optimal Advertising and Product Durability Decisions in New Product Diffusion, *Automatica (Under Review)*	No	Yes (Annex VI)	Yes	No

11. 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)*

5-10 April 2024/Kyoto & Osaka, Japan	Optimal investment with return predictability and trading frictions: An asymptotic approach	Universal Academic Cluster International Spring Conference in Kansai (Kyoto & Osaka, Japan) on	No	Yes (Annex VII)	Yes	No

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

(Please elaborate)

Yes, the research from the generalized Sethi advertising models can be applied to undergraduate teaching through graphs that illustrate how word-of-mouth affects advertising spending. There is no need for mathematical results; the emphasis can be on visual representations to aid understanding.

13. 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	N/A	N/A	N/A

14. **Other Impact**

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

N/A

15. **Statistics on Research Outputs**

	Peer-reviewed Journal Publications	**Conference Papers**	**Scholarly Books, Monographs and Chapters**	**Patents Awarded**	**Other Research Outputs (please specify)**	
No. of outputs arising directly from this research project	6 (including one under review)	0	N/A	N/A	Type	No.
					N/A	N/A

16. **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	N/A