

# Modeling Breakpoint Risk–Return Trade-offs in Supplier Development Programs

**Fatemeh Keshavarz-Ghorbani and Guoqing Zhang**

Professor, Department of Mechanical, Automotive and Materials Engineering

Faculty of Engineering

University of Windsor

Windsor, Canada

[Fatemehk@uwindsor.ca](mailto:Fatemehk@uwindsor.ca), [gzhang@uwindsor.ca](mailto:gzhang@uwindsor.ca)

## Abstract

Outsourcing is a common strategy for original equipment manufacturers (OEMs) to reduce costs and enhance service performance, yet it exposes firms to supplier-related risks. A key challenge is how manufacturers can allocate limited resources across multiple suppliers to balance the risk of underperformance against expected returns. While prior studies have applied portfolio theory to supplier development programs, they typically assume linear investment–return relationships. This study introduces a discrete, investment–dependent return function, commonly used in practice, to capture these dynamics and extends the framework to incorporate cooperative strategies among manufacturers. To address computational complexity, we develop a column-generation-based approach that significantly improves solution efficiency. The results provide practical insights for OEMs on optimizing investment decisions under uncertainty in complex outsourcing environments, highlighting trade-offs between engaging in new supplier development programs and maintaining existing contracts. A comparison with the classical Markowitz portfolio model further demonstrates the advantages of the proposed approach.

## Keywords

Manufacturer–Supplier Relationship; Risk–Return Trade-Off; Portfolio Optimization; Column Generation

## Biographies

**Fatemeh Keshavarz-Ghorbani** is a Postdoctoral Fellow at the University of Windsor. She earned her Ph.D. in Industrial Engineering from Kharazmi University, Iran, where she also completed her Master's degree. Her research focuses on supply chain management, optimization, and stochastic modeling. She has published several articles in peer-reviewed journals.

**Guoqing Zhang** is a Professor of Industrial Engineering at the University of Windsor. His research focuses on supply chain management and manufacturing systems modeling. Dr. Zhang received a Master of Science in Engineering from Southeast University, Nanjing, China, and a Ph.D. in Management Sciences from the City University of Hong Kong. His work has been published in numerous peer-reviewed journals and is widely cited by researchers worldwide.