國立陽明交通大學

運輸與物流管理學系

碩 士 論 文

Department of Transportation and Logistics Management

National Yang Ming Chiao Tung University

Master Thesis

# 考慮低碳交通區之電動與燃油混合計程車車隊排程問題

# The mixed fleet taxi scheduling problem considering low emission zones

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中華民國一一四年六月

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# 考慮低碳交通區之電動與燃油混合計程車車隊排程問題

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## 摘要

本研究針對具有區域及時段限制之低碳交通區域(Low Emission Zones)，以充電式電動計程車及燃油計程車之混合車隊進行運輸與配送服務，並結合共乘概念，允許計程車同時服務乘客及配送貨物。本研究以營運業者成本最小化為目標，於特定之營運時間內，考量混合計程車隊與客貨配送需求之配對問題，並進行車輛排程與電動計程車充電規劃，並在固定且已知的車隊數量及車輛容量限制下，僅服務營運開始前完成預約之乘客與貨物需求。

本研究建構能夠描述人流、物流與車流於時、空維度上移動情形的時空網路(Time-Space Networks)，該時空網路分為需求面及供給面兩個部分，其中需求面涵蓋人流及物流，供給面則包含電動車車流及燃油車車流，其係以每輛車輛作為分層基礎，以有效進行車輛排程及追蹤電動計程車之電量，本研究以此時空網路架構，建立混合整數數學規劃模式，同時為提升大規模問題之求解效率發展模擬退火法(Simulated Annealing)。

為測試及驗證本研究發展之最佳化模式及啟發式演算法之求解績效，本研究以國內某物流業者提供之實際營運資料，整合調整後對不同規模之測試範例進行產出，並應用最佳化軟體 Gurobi 進行模式構建與求解；模擬退火法則係以 Python 語言進行撰寫及求解，測試完成後針對輸出結果進行比較與分析。測試結果顯示本研究所發展的模式與演算法均能有效求解此問題。本研究除了建立數學模式與發展演算法的理論貢獻，研究成果也可以提供計程車業者後續推動混合車隊、客貨共載、低碳交通區之實務參考。

**關鍵詞：**低碳交通區、計程車排程問題、客貨共載、時空網路、最佳化模式、模擬退火法

# The mixed fleet taxi scheduling problem considering low emission zones

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## Abstract

This research introduces transportation and delivery services within Low Emission Zones(LEZ)—areas with spatial and temporal restrictions—by utilizing a mixed fleet of plug-in electric taxis and gasoline taxis. Incorporating the concept of ride-sharing, the model allows taxis to simultaneously serve both passengers and parcel deliveries. From the perspective of a taxi fleet operator, the study addresses the matching of supply and demand, vehicle scheduling, and electric taxi charging planning within operational hours. The objective is to minimize the operator's total cost under constraints of a fixed fleet size and vehicle capacity, serving only pre-scheduled passenger and parcel demands submitted before the start of operations.

The research develops a multi-layer time-space network (TSN) to effectively describe the movements of passengers, parcels and taxis in the spatial and temporal dimensions. This network is divided into a demand side, which includes passenger and freight flows, and a supply side, which includes electric and gasoline vehicle flows. The supply-side network is layered by individual vehicles to enable effective vehicle scheduling and battery tracking for electric taxis. Based on this TSN, the research formulates a Mixed Integer Programming model and further develops a Simulated Annealing(SA) algorithm to enhance solution efficiency for large-scale instances.

To examine the performance of the proposed optimization model and heuristic algorithm, real-world operational data provided by a domestic logistics company is adapted to create test instances of varying scales. The optimization model is implemented and solved using Gurobi, while the SA is developed and executed using Python. Test results indicate that both the mathematical model and the heuristic algorithm are effective in solving the problem.

Beyond its theoretical contributions in model formulation and algorithm development, the findings of this study also offer practical implications for taxi operators, particularly in adopting mixed vehicle fleets, Share-a-Ride Problem, and operating in LEZ.

**Keywords:** Low emission zones, Taxi scheduling problem, Share-a-Ride Problem , Time-space networks, Optimization, Simulated Annealing