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Engineering

A Network Equilibrium Approach for Simultaneous Estimation of Activity and Travel Choices in Multi-modal Transportation Network

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Principal Investigator
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Funding Scheme
General Research Fund

Amount Awarded
HK$645,500

Project Duration
3.5 years

Project Status
In progress

Research Background

Hong Kong Statistics

- Population: Over 7.25 million
- Total area: 1,104 km^2, about 24% land developed
- Population density *(developed land average)*: 27,700 persons/km^2
  In comparison: Taipei – 9,950 persons/km^2; Tokyo – 6,220 persons/km^2; Bangkok – 5,300 persons/km^2
- Road length = 2,100 km
- No. of licensed vehicles = 750,000 (as at February 2017)
- **14 million** daily trips, in which ~ **90%** is **public transport passenger** trips

Passengers

Multi-modal transit networks

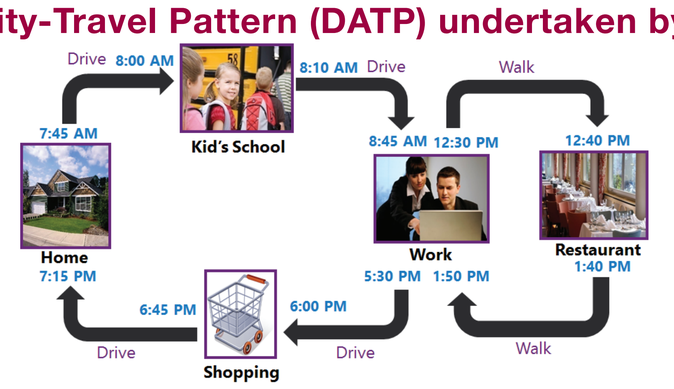
In-vehicle crowding

Activity location crowding

Activity-travel pattern scheduling

Network equilibrium models for modelling activity and travel choice behaviour ***With taking account the congestion effects***

Daily Activity-Travel Pattern (DATP) undertaken by an Individual



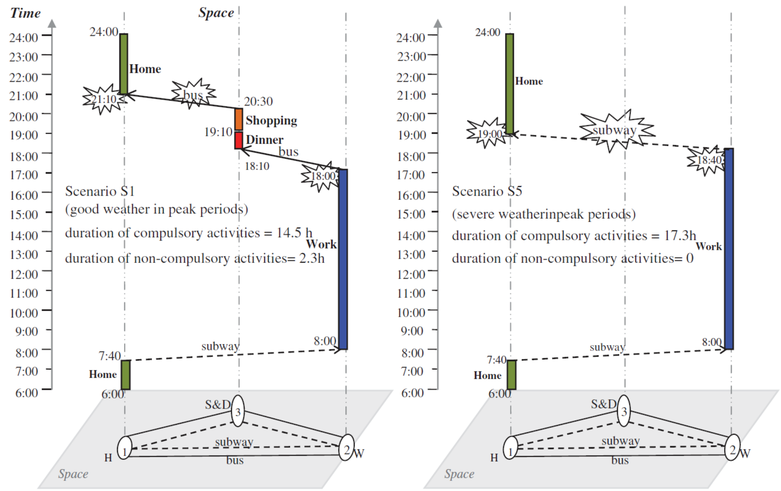


Figure 2. **Daily Activity-Travel Patterns (DATPs)** under different weather scenarios

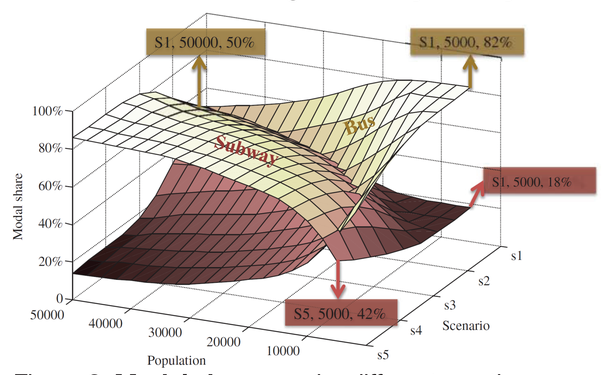


Figure 3. **Modal shares** under different weather scenarios and different population levels

		Activity duration (hours)	
		S1 (Good weather)	S5 (Severe weather)
Activity	Home	4.50	6.67
	Work	10.00	10.66
	Dinner	1.00	**0**
	Shopping	1.33	**0**
Travel		1.17	0.67
Total time		18.00	18.00

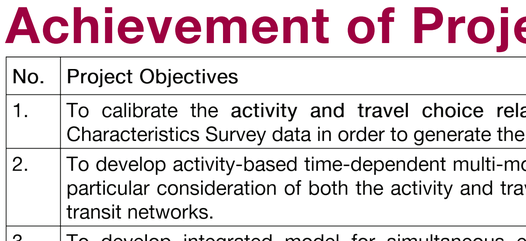
Table 1. Equilibrium results under different weather scenarios

Achievement of Project Objectives

No.	Project Objectives	Research Outputs
1.	To calibrate the **activity and travel choice relationships** with the use of the 2011 Travel Characteristics Survey data in order to generate the travelers' activity and travel choice patterns.	4, 5, 6, 7, 11
2.	To develop activity-based time-dependent multi-modal transport network equilibrium models with particular consideration of both the activity and travel choices of travelers in congested road and transit networks.	1, 2, 3, 6, 7, 8, 9, 10
3.	To develop integrated model for simultaneous estimation of travel demands by modes and parameter estimation of the activity/travel choice model with and without updated vehicle occupancy counts in the Hong Kong Annual Traffic Census.	4, 5

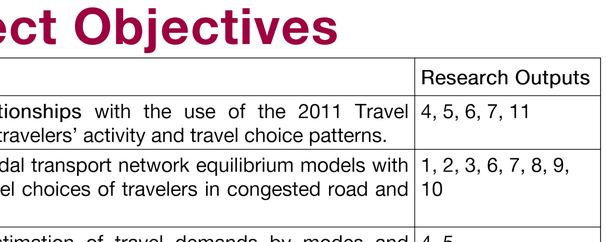
Research Activities in the Project

In relation to the project objectives 1 and 3, the relationships among **home-work-home and home-school-home activity durations and travel times of workers and students** were investigated using the 2011 Travel Characteristics Survey (TCS) data in Hong Kong for developing the activity-based models (see Figure 1). In addition, a maximum-likelihood method that uses multiple sources of roadside observations (link counts and/or plate scanning data) was proposed for **parameter estimation of activity/travel choice models**. Another maximum-likelihood method was also proposed for calibrating individual's and household's activity-travel scheduling models.



t_{home1}: Time stay at home in the morning before work
t_{home2}: Time stay at home in the evening after work
$t_{h\text{-}w}$: Overall time window of home-work travel
$t_{w\text{-}h}$: Overall time window of work-home travel
t_w: Time duration for work

(a) **home-work-home** activity patterns



(b) **home-school-home** activity patterns

Figure 1. Profiles of **activity patterns** for Hong Kong workers and students by time of day

In connection to the project objective 2, several **network equilibrium models were proposed with consideration of both the activity and travel choices of travelers in congested transport networks**. An activity-based network equilibrium model for scheduling daily activity-travel patterns (DATPs) in multi-modal transit networks under adverse weather conditions with different rainfall intensities was proposed (see Figure 2). In the proposed model, weather forecast information was incorporated for solving the individuals' DATP scheduling problem. The DATP choice problem under adverse weather conditions was transformed into an equivalent static transit assignment problem by constructing a novel super-network platform. The equilibrium results are shown in Figure 3 and Table 1.

With respect to the project objectives 1 and 2, an activity-based network equilibrium model was proposed for scheduling two-individual **joint activity-travel patterns (JATP) in multi-modal transit networks**. The proposed model can be used to comprehensively investigate the individuals' activity choices and travel choices in multi-modal transit networks, including both independent ones and joint ones. The joint-activity-time-space super-network for two-individual JATP scheduling is illustrated in Figure 4. The equilibrium results are presented in Figure 5.

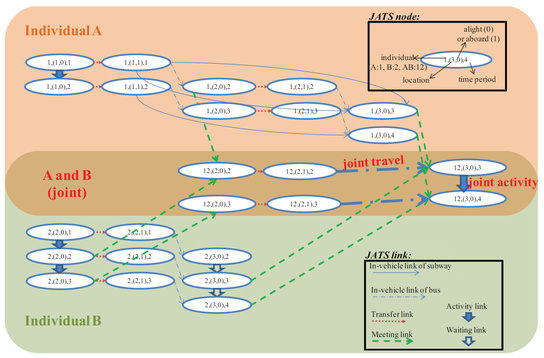
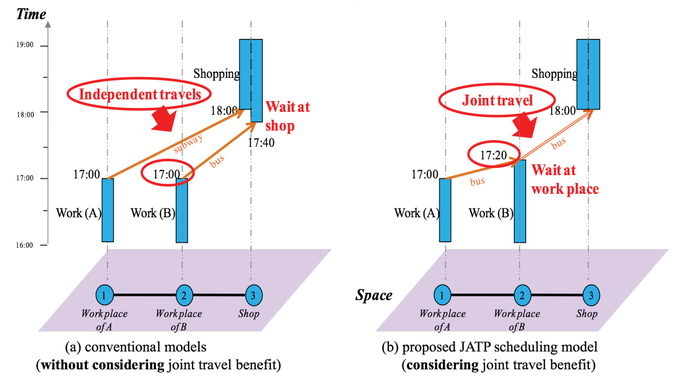


Figure 4. A joint-activity-time-space **super-network**



(a) conventional models (**without considering** joint travel benefit)

(b) proposed JATP scheduling model (**considering** joint travel benefit)

Figure 5. Comparison of JATP choice with and without considering joint travel benefit

Research Outputs

1. Fu, X., Lam, W.H.K. and Meng, Q. (2014) Modelling impacts of adverse weather conditions on activity-travel pattern scheduling in multi-modal transit networks, *Transportmetrica B: Transport Dynamics*, 2(2), 151-165.
2. Li, Z.C., Lam, W.H.K. and Wong, S.C. (2014) Bottleneck model revisited: An activity-based perspective, *Transportation Research Part B*, 68, 262-287.
3. Yin, Y., Li, Z.C. and Lam, W.H.K. (2014) Braess-like paradox in transit network: Activity approach, *Proceedings of the 19th International Conference of Hong Kong Society for Transportation Studies*, Hong Kong, 409-414.
4. Fu, X. Lam, W.H.K. and Xiong, Y. (2015) Calibration methods and results for activity-travel scheduling models, *Journal of Eastern Asia Society for Transportation Studies*, 11, 640-652.
5. Siripirote, T., Sumalee, A., Ho, H.W. and Lam, W.H.K. (2015) Statistical approach for activity-based model calibration based on plate scanning and traffic counts data, *Transportation Research Part B*, 78, 280-300.
6. Fu, X., Lam, W.H.K. and Xiong, Y. (2016) Modelling intra-household interactions in household's activity-travel scheduling behavior, *Transportmetrica A: Transport Science*, 12(7), 612-628.
7. Fu, X. and Lam, W.H.K. (2016) Modelling joint activity-travel pattern scheduling problem in multi-modal transit networks, *Transportation*, On-line available, DOI:10.1007/s11116-016-9720-8.
8. Lam, W.H.K. and Li, Z.C. (2016) Optimal schedules for multimodal transit services: An activity-based approach, In: A. Nuzzolo and W.H.K. Lam (ed.) *Modelling Intelligent Multi-modal Transit Systems*, CRC Press, 253-285.
9. Li, Z.C., Yin, Y., Lam, W.H.K. and Sumalee, A. (2016) Simultaneous optimization of fuel surcharges and transit service runs in a multimodal transport network: A time-dependent activity-based approach, *Transportation Letters: The International Journal of Transportation Research*, 8(1), 35-46.
10. Xu, M., Lam, W.H.K., Gao, Z.Y. and Grant-Muller, S. (2016) An activity-based approach for optimisation of land use and transportation network development, *Transportmetrica B: Transport Dynamics*, 4(2), 111-134.
11. Su, J., Lam, W.H.K., Lai, X.J., Tam, M.L. and Cheng, L. (2017) Modeling the relationships among home-work-home activity durations and travel times of workers in Hong Kong, *Journal of Eastern Asia Society for Transportation Studies*, Under review.

Collaboration with other Universities

The University of Hong Kong

Research Student Trained

WEPULANON Piyanit (Degree registered: PhD)