Summer School of Behavior Modeling, Behavior in Networks Studies Unit, The University of Tokyo
September 19, 2023

Trans/Inter-disciplinary Behavioral Policymaking Research for Future Transportation and Development

(incl., Travel Behavior Modeling in China)

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Travel Behavior Modeling in China

By selecting the top-cited papers published in the recent five years

Jiazhan HU, Yongyi ZHANG, Junyi ZHANG

Travel Behavior Research in China

—— Covid-19 and Pandemic

《交通工程》
Journal of Transportation Engineering

Research on the Choice Model of Travel Mode During the Pandemic Based on Prospect Theory

{CHENG Yuan, XIAN Kai, MA Yilin, SONG Sujuan, CAI Lele}

Coronavirus Pandemic **Travel Mode** **Risk Post** **Prospect Theory**

Main Content

- Initial key factors were identified through a questionnaire and refined using feature selection algorithms.
- Classifiers like MNB, RF, and SVM were used to further screen these factors.
- Multiple logistic regression analyzed the specific impact of each key factor on green travel behavior, with analysis based on significance levels and estimated coefficients.

《交通运输系统工程与信息》
Journal of Transportation Systems Engineering and Information Technology

Residents' Travel Mode Choice Behavior in Post-COVID-19 era Considering Preference Differences

{YANG Yazao, TANG Haodong, PENG yong}

Urban Traffic **travel behavior** **Individual Heterogeneity** **Mixed Logit Model** **Latent Class Conditional Logit Model**

Main Content

- A post-COVID-19 study was conducted on residents' travel choices using questionnaire data.
- Two models, mixed Logit and latent class conditional Logit, were developed and calibrated with Stata.
- The latent class conditional Logit outperformed the mixed Logit, proving more accurate for analyzing travel behavior during health crises.

《北京交通大学学报》
Journal of Beijing Jiaotong University

Travel Mode Choice Analysis with Shared Mobility in Context of COVID-19

{ZHANG Xiaoyu, SHAO Chunfu, WANG Bobin, HUANG Shichen}

Urban Traffic **Shared Mobility** **Travel Mode Choice** **COVID-19** **Mixed Logit Model** **Mode Choice Inertia**

Main Content

- The study evaluated COVID-19's impact on travel choices, including shared mobility, using an SP questionnaire.
- Mixed Logit models analyzed travel behaviors pre and during COVID-19, considering factors like pandemic perception and mode inertia.
- Elasticity analysis predicted travel preferences based on pandemic management policies.

《交通运输系统工程与信息》
Journal of Transportation Systems Engineering and Information Technology

Behavior of Long-distance Travel Mode Choice under the Duration of Public Health Emergencies

{LUO Chen, DONG Qing, YAO Qing, ZHANG Hairong, WANG Qianru}

Integrated Transportation **Travel Mode Selection** **Public Health Emergencies** **Non-aggregate Theory**

Main Content

- This study examined how risk perception affects long-distance travel choices in public health emergencies using a multivariate Logit model.
- Using online questionnaires collected during COVID-19, model parameters were calibrated with SPSS to pinpoint key risk perception factors.
- A sensitivity analysis assessed the influence of each risk perception factor on travel decisions.

Travel Behavior Research in China

—— Environmental and Low-carbon

《交通科技与经济》
Technology & Economy In Areas of Communications

Analysis of Key Influencing Factors of Urban Residents' Green Travel Behavior

{LIU Yun, YANGXinfeng, DANG Haoyang}

Urban Residents | Green Travel Behavior | Feature Selection | Classifier | Multiple Logistic Regression

Main Content

- The study examines the changes in transportation choices of Beijing's residents during the 2020 pandemic.
- Constructs a travel mode choice model, based on prospect theory, that takes risk costs into consideration.
- Uses this model to simulate the travel choices of citizens for a specific scenario during the pandemic.

《中国管理科学》
Chinese Journal of Management Science

Research on Green Travel Behavior Based on Scale-Free Networks

{ZHENG Junjun, ZHANG Bing, CHENG Yi, XU Mingyuan, LI Runfa}

Green Travel | Group Selection | Theory of Planned Behavior | Scale-free Networks | Opinion Dynamics

Main Content

- The study evaluates individuals' tendencies in complex networks to adopt green travel.
- Using the Theory of Planned Behavior, a model was created factoring in individual attitudes, perceived control, norms, and outcomes for green travel intentions.
- Opinion dynamics and scale-free networks shape an interaction model for these choices.

《重庆交通大学学报》
Journal of Chongqing Jiaotong University

Subjective Attitude Identification and Impact Analysis of Residents' Low-Carbon Commuting Travel

{WU Wenjing，SUN Renchao, ZONG Fang，JIA Hongfei}

Traffic Engineering | Low-carbon Travel | Subjective Attitudes Identification | MIMIC Model | IFCM

Main Content

- The study examines the variations in the behavioral willingness formation mechanisms among groups with different subjective attitudes.
- the intuitionistic fuzzy c-means clustering algorithm was applied to categorize residents' subjective attitudes towards low-carbon travel.
- A MIMIC model was developed to analyze the travel intentions of different resident types.

《交通运输系统工程与信息》
Journal of Transportation Systems Engineering and Information Technology

Incorporating Environmental Consciousness into Low-carbon Traveling Behavior

{LIU Jian-rong, HAO Xiao-ni}

Urban Traffic | Environmental Awareness | Multivariate Probit Model | Low-carbon Travel Behavior | Latent Variable | Rasch model

Main Content

- The study examined the influence of travelers' environmental awareness on low-carbon transportation using the Rasch model.
- This environmental awareness was integrated into the multivariate Probit model.
- The influence of this awareness on acceptance of car restrictions and interest in electric vehicles is analyzed.

Travel Behavior Research in China

—— Urban construction and infrastructure

《地理学报》
ACTA GEOGRAPHICA SINICA

The impact of urban rail transit and built environment on residents' walking behavior

{HUANG Xiaoyan, CAO Xiaoshu, YIN Jinagbin, MA Ruiguang}

Urban rail transit
Built environment
Self selection **Self selection**

Main Content

- Explore the impact of Xi'an urban rail transit and built environment on transportation and leisure walking frequency.
- Establishing a Self-Selection model and designing a quasi-experimental study using matched controls
- The respondents' perception of the built environment greatly affects the walking frequency

《公路交通科技》
Journal of Highway and Transportation Research and Development

Study on Relationship between Built Environment and High-Income Group Travel Mode

{HUANG Yong,ZHAO Hang, XU Wang-tu, DUAN Mei-hua, WEI Wei}

Built environment
Multinomial Logit model
High-income groups
Urban traffic **Disaggregate theory**

Main Content

- Explored the differences in the impact of the built environment in Xiamen in 2015 on the travel patterns of high-income groups with or without cars.
- Based on multiple Logit models.
- Impact intensity of individual socio-economic attributes and built environment on travel patterns was explored.

《交通运输工程与信息学报》
Journal of Transportation Engineering and Information

Investigation of Heterogeneous Effects of Built Environment on a Household Member's Travel Mode Choice

{YANG Xi-ning, DENG Qiong-hua, YANG Shuo}

Spatial error model
Travel mode choice
Household members
Built environment **Heterogeneity**

Main Content

- Used classic regression and spatial error models to analyze household members' travel mode choices
- Based on the residents' travel survey, urban planning, and information about transportation in Nanjing
- Indicate the practicability of the park and ride development and demonstrates the importance of improving the quality of pedestrian environments.

《北京交通大学学报》
JOURNAL OF BEIJING JIAOTONG UNIVERSITY

Non-linear impact model of community built environment on car usage behavior

{LIU Keliang, CHEN Jian, ZHU Ye, PENG Tao, QIU Zhixuan}

Built environment **Usage behavior**
Parking lot **Non-linear relationship**
Gradient boosting iterative decision tree
Transportation system engineering

Main Content

- Quantitatively analyzes the differences in car usage behavior in the community-built environment
- Gradient Boosting Decision Tree (GBDT) model is built that takes into account the nonlinear effect in Chongqing's main urban.
- all built environmental factors have non-linear relationships with the parking space utilization rate.

Travel Behavior Research in China

—— Elderly and vulnerable groups

《西南交通大学学报》
JOURNAL OF SOUTHWEST JIAOTONG UNIVERSITY

Study on the Characteristics of Activity-travel Behavior of Urban Elderly and the Impact of Related Built Environment

{SONGYAN Liqing, WANG Zhuying}

Older health | **Human environment** | **Community public facilities** | **Travel behavior** | **Urban construction**

Main Content

- Analyze the influence factors of the activity-travel demand and urban built-up environment.
- applying the structural equation model and Logit models.
- The characteristics of daily activities have a significant impact on the characteristics of travel behavior. Personal and family attributes have little impact on travel behavior characteristics

《系统工程》
Systems Engineering

Bus Travel Behavior of the Elderly Based on IC Card Data

{LIU Wusheng, LI Wang, DIE Qian, ZHOU Qing, PAN Zixiang}

Ubern Transit | **Elderly group** | **Public transportation behavior** | **MNL model** | **MNP model** | **IC card**

Main Content

- Based on the IC card swiping data of public transportation in Changsha, the peak travel situation of elderly travelers was analyzed.
- Using MNP and MNL models
- Card type, age, discount level, and consumption amount have a significant impact on departure time and travel frequency, and there are differences in peak travel among different age groups.

《武汉理工大学学报》
Journal of Wuhan University of Technology

Research on Bus Travel Behavior of the Elderly Based on Bayesian Networks

{LIU Jianrong, LIU Zhiwei}

Elderly group | **Bayesian network** | **Public transportation** | **Willingness to use public transportation**

Main Content

- Based on the survey data of public transportation travel in Zhaoqing City.
- Bayesian network model was established to correlate the individual characteristics of the elderly, objective indicators of public transportation, subjective evaluation of travelers, and travel willingness.
- Transfer and punctuality factors greatly affect the willingness to use buses.

《西南交通大学学报》
Journal of Southwest Jiaotong University

Spatial heterogeneity of the impact of built environment on elderly travel behavior

{YANG Linchuan, ZHU Qing}

Built environment | **Older adult** | **Community environment** | **geographically weighted regression model**

Main Content

- Based on the large-scale traffic habits survey data, geographic data, and Google Street View image data organized by the Hong Kong SAR government in 2011.
- A three-level random-intercept binary logistic regression model (level 1: individual, level 2: household, level 3: street block)
- and a geographically weighted binary logistic regression model are developed

Travel Behavior Research in China

—— Autonomous driving and driving behavior

《重庆交通大学学报》
JOURNAL OF CHONGQING JIAOTONG UNIVERSITY

Autonomous Driving Choice Behavior Based on Panel Data Mixed Logit Model

{LIAN Qicai, LI Han, SHI Xiaolin, YAN Zhangcun}

Marginal effect | **Panel Mixed logit** | **Autonomous driving** | **Travel choice behaviou** | **traffic and transportation engineering**

Main Content

- Analyzed the impact mechanism of variables representing the socio-economic attributes of travelers on age, income, and education level.
- panel data Mixed logit model and Marginal effect analysis
- People age increasing, probability of choosing autonomous driving, public transportation, and walking increases, but their probability of choosing ride hailing decreases.

《交通信息与安全》
Journal of Traffic Information and Safety

Impacts of Autonomous Vehicles on Mode Choice Behavior in the Context of Short- and Medium- Distance Intercity Travel

{LIU Zhiwei, SONG Zhengyun, DENG Wei, BAO Danwen}

Mode choice behavior | **The theory of planned behavior** | **Random parameter Logit model** | **Autonomous vehicles**

Main Content

- Studied the impact of Wuhan autonomous vehicles on travel choice behavior between medium and short distance.
- Building a Hybrid Selection Model Based on Planned Behavior Theory and Random Coefficient Logit Model
- Perceived behavioral control and behavioral attitude have a significant positive impact on travelers' choice of autonomous vehicle travel

《系统工程理论与实践》
System Engineering-Theory & Practice

Analysis of morning commuting behavior under mixed driving environment

{ZHU Ling, LU Xiaoshan}

Autonomous vehicle | **Bottleneck model** | **Travel mode** | **Heterogeneity**

Main Content

- Considering the behavior difference between autonomous vehicle and ordinary vehicle in driving
- Studied the morning peak travel behavior of bottleneck traffic corridors when the two coexist
- Late departure modes have lower balanced travel costs. With the increase of traffic capacity and the decrease of VOT, the total cost of the system will decrease.

《交 通 科 技 与 经 济》
Technology & Economy in Areas of Communications

Quantitative analysis model of driver's behavior choice under the influence of traffic events

{PEI Yulong, YU Jian}

Traffic event | **Behavior choice** | **Econometric analysis** | **Binary Logit model** | **Guidance strategy**

Main Content

- Traffic incidents have an impact on driver behavior choices.
- Using the discrete choice analysis method of econometrics, establish a binary Logit model to describe the probability of behavioral choice.
- The gender, age, driving experience, and time delays caused by various traffic events of drivers have a significant impact on their behavioral choices

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Trans/Inter-disciplinary Behavioral Policymaking Research for Future Transportation and Development

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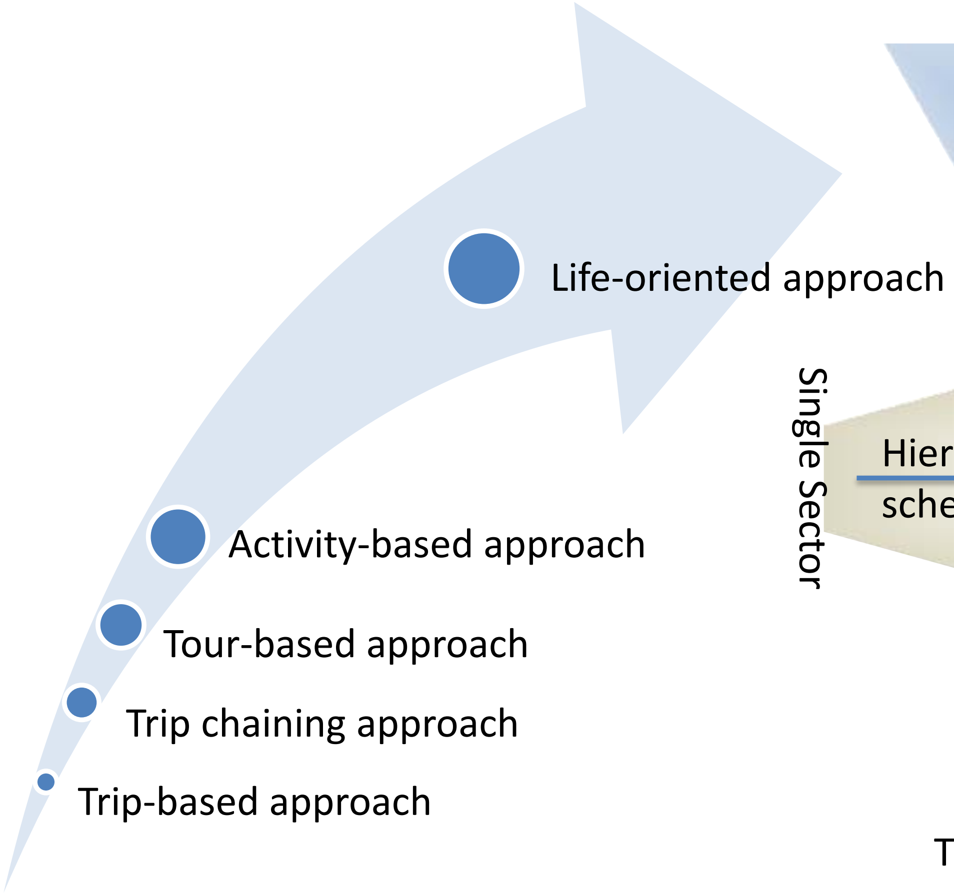
Life-oriented approach

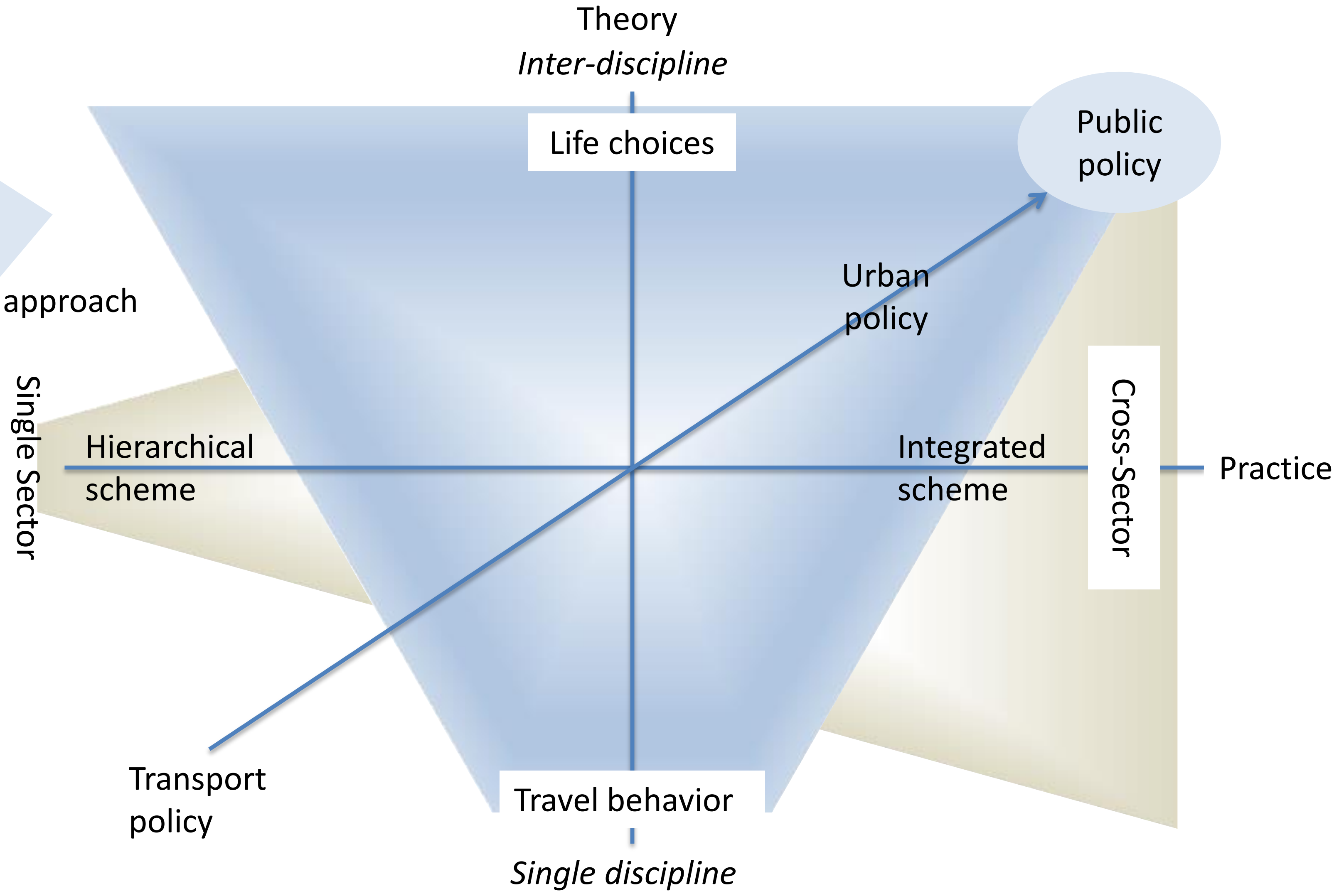
As a scientific system

Junyi Zhang

Transdisciplinary methodologies: Life-oriented approach

Zhang, J. (2017) Life-oriented Behavioral Research for Urban Policy, Springer





Transdisciplinary methodologies: Life-oriented approach

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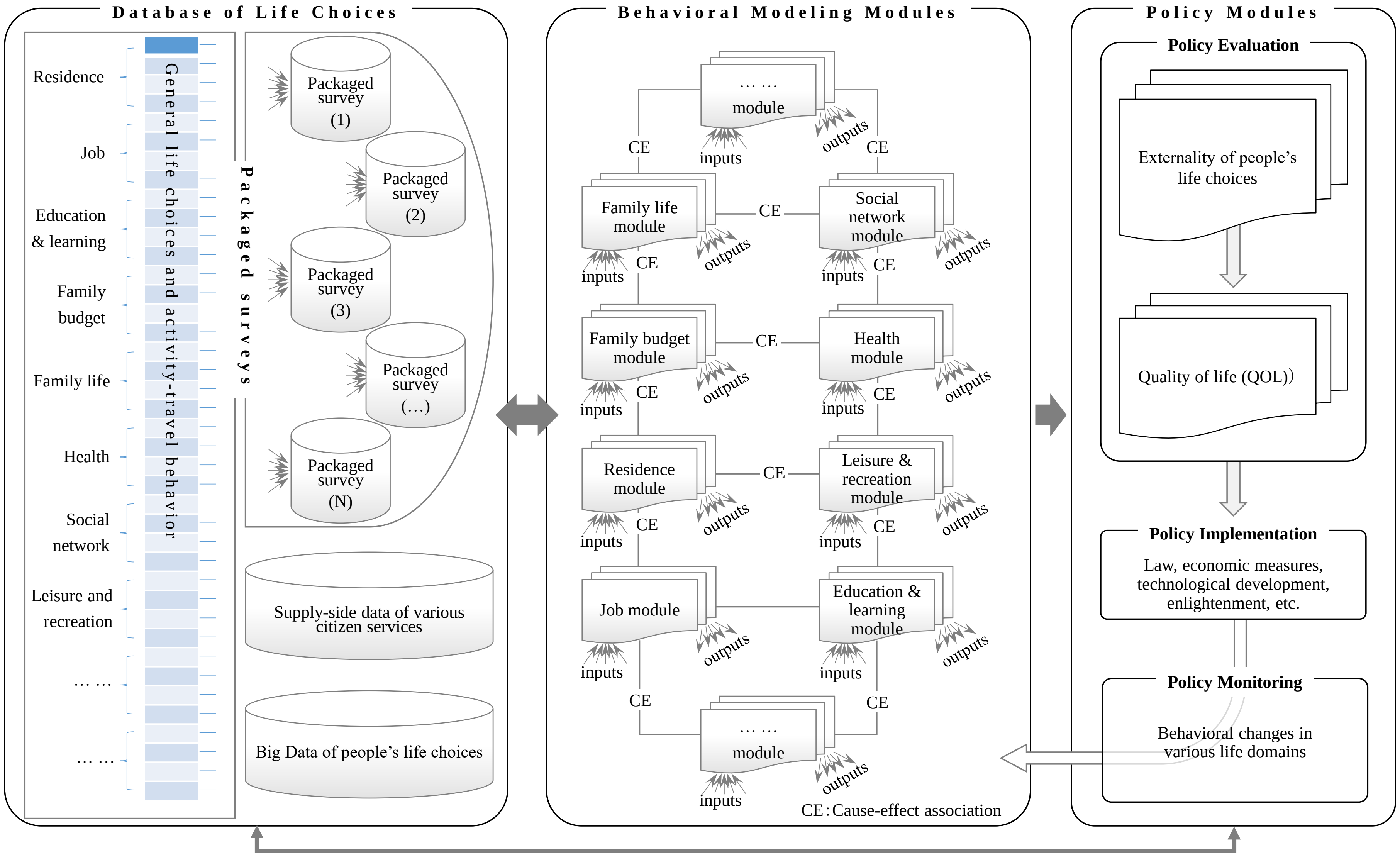
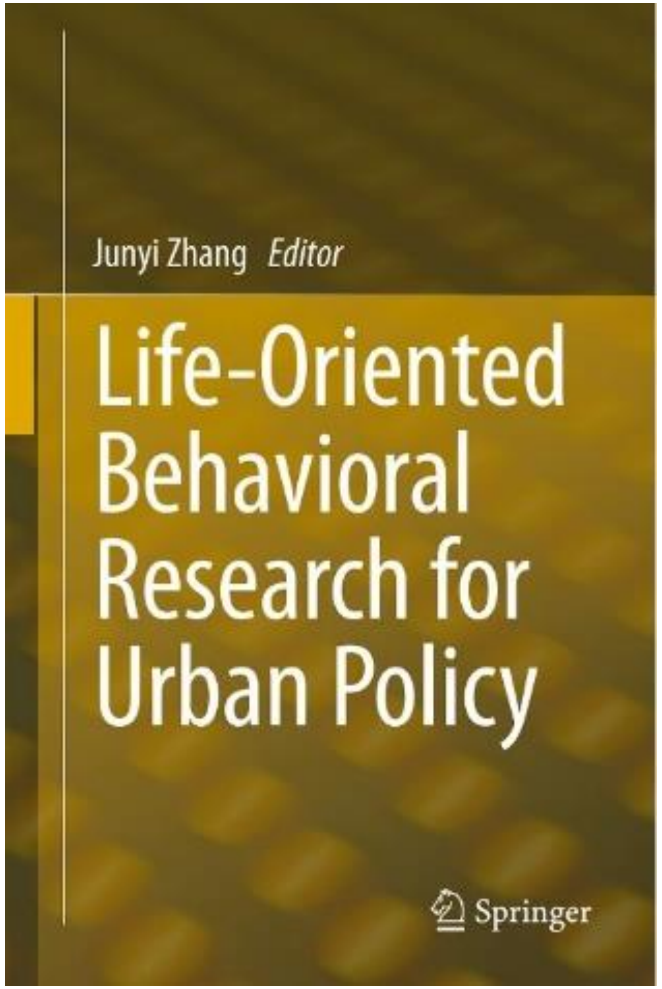
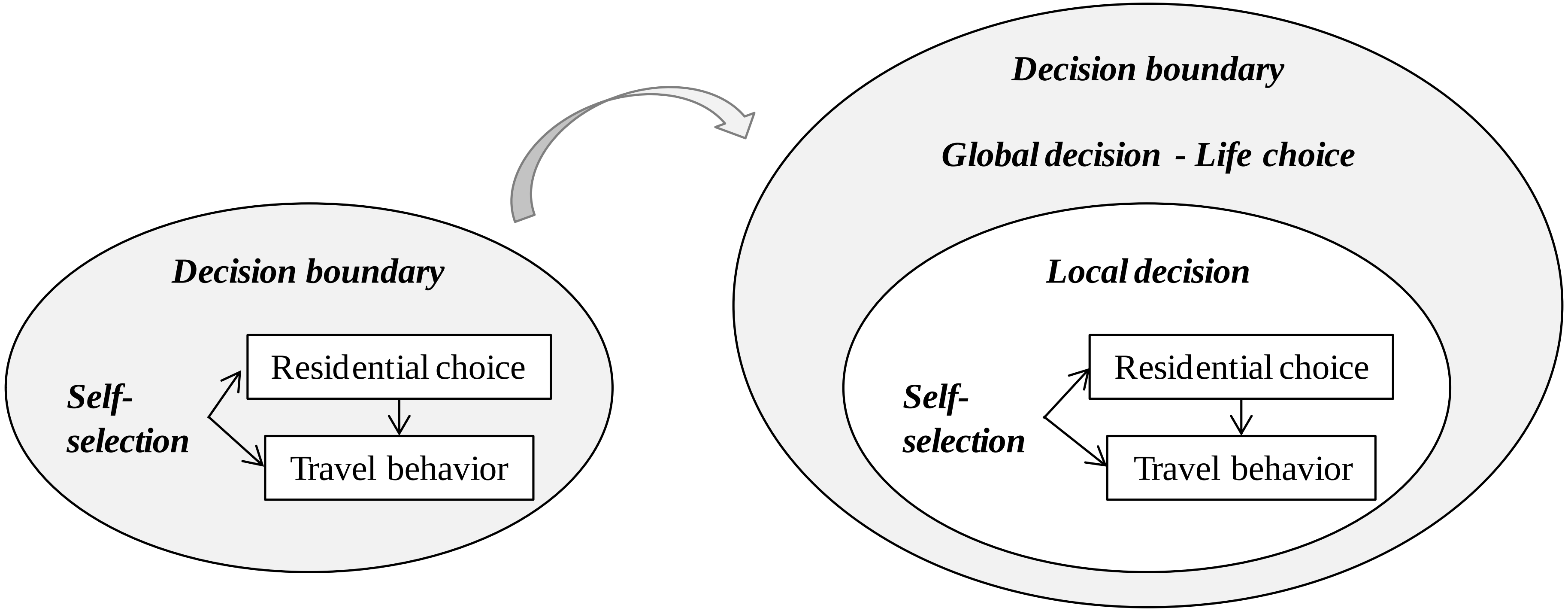




Junyi Zhang (2017) Life-Oriented Behavioral Research for Urban Policy, Springer

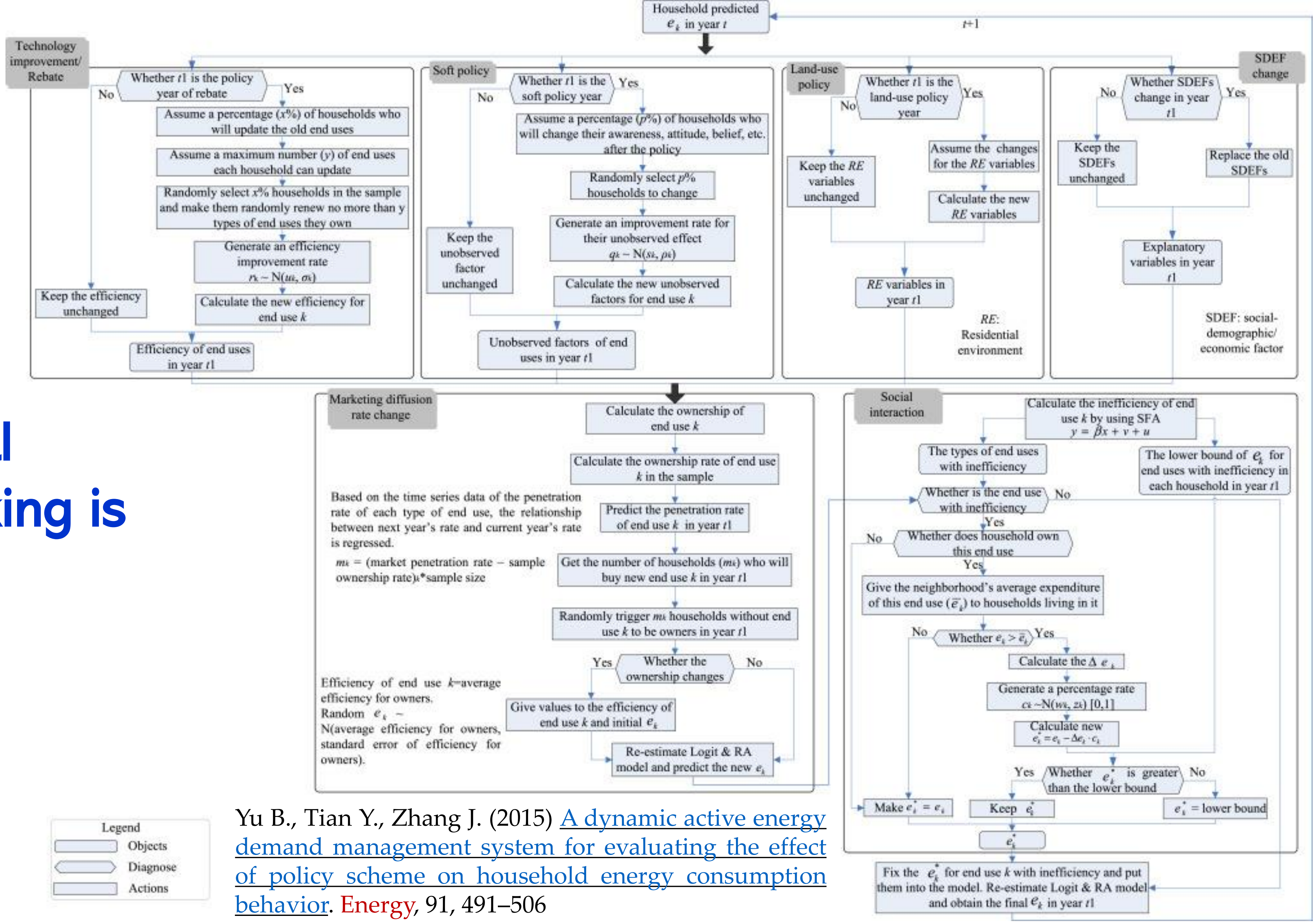
Residential self-selection: Need to be improved!

A decision boundary issue → Another type of context



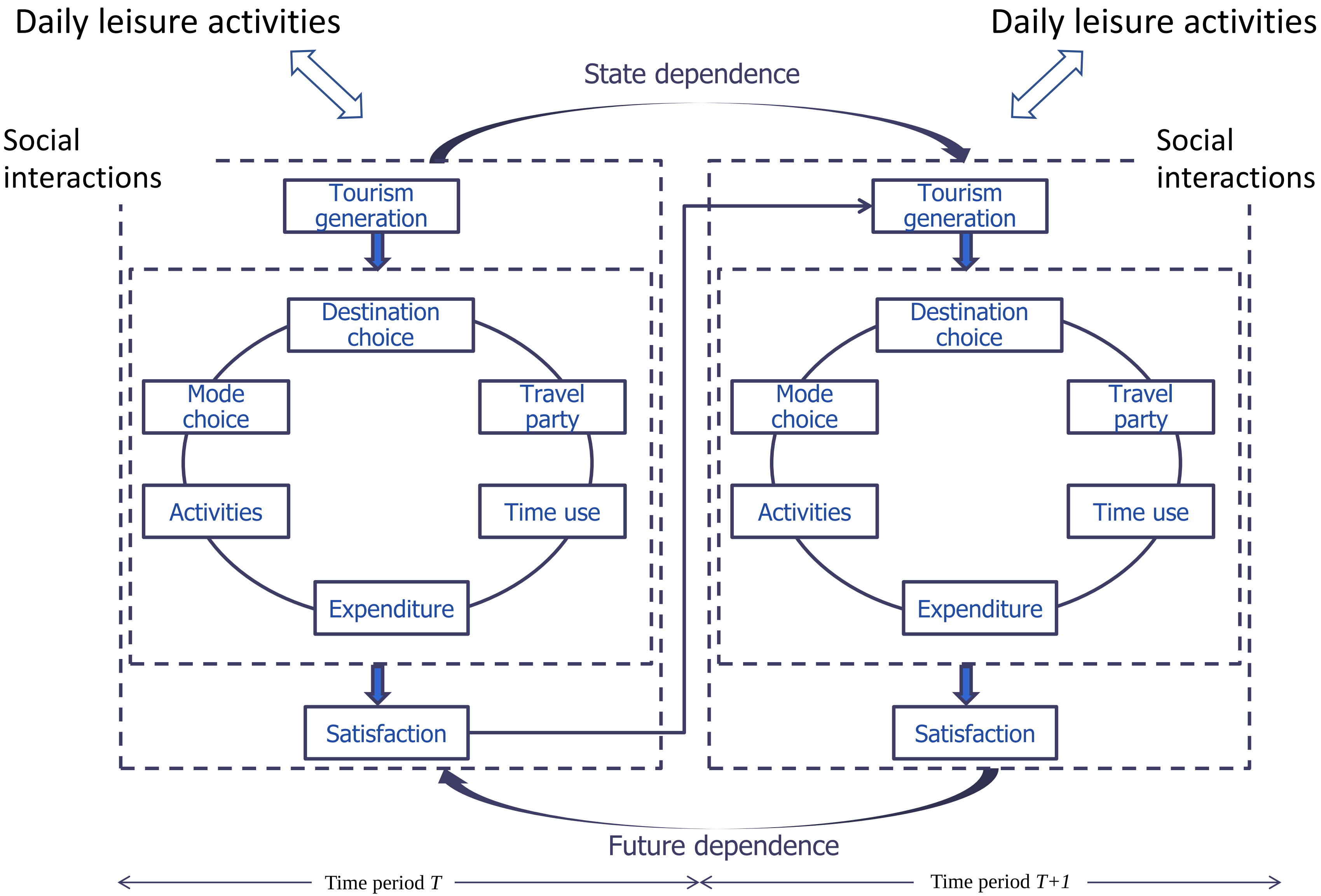
Zhang, J. (2014) Revisiting the residential self-selection issues: A life-oriented approach. Journal of Land Use and Transport, 7 (3), 29-45.

Behavioral policymaking is crucial!



Yu B., Tian Y., Zhang J. (2015) A dynamic active energy demand management system for evaluating the effect of policy scheme on household energy consumption behavior. Energy, 91, 491–506

Integrated modeling of daily life and tourism behaviors



Transdisciplinary methodologies: Life-oriented approach

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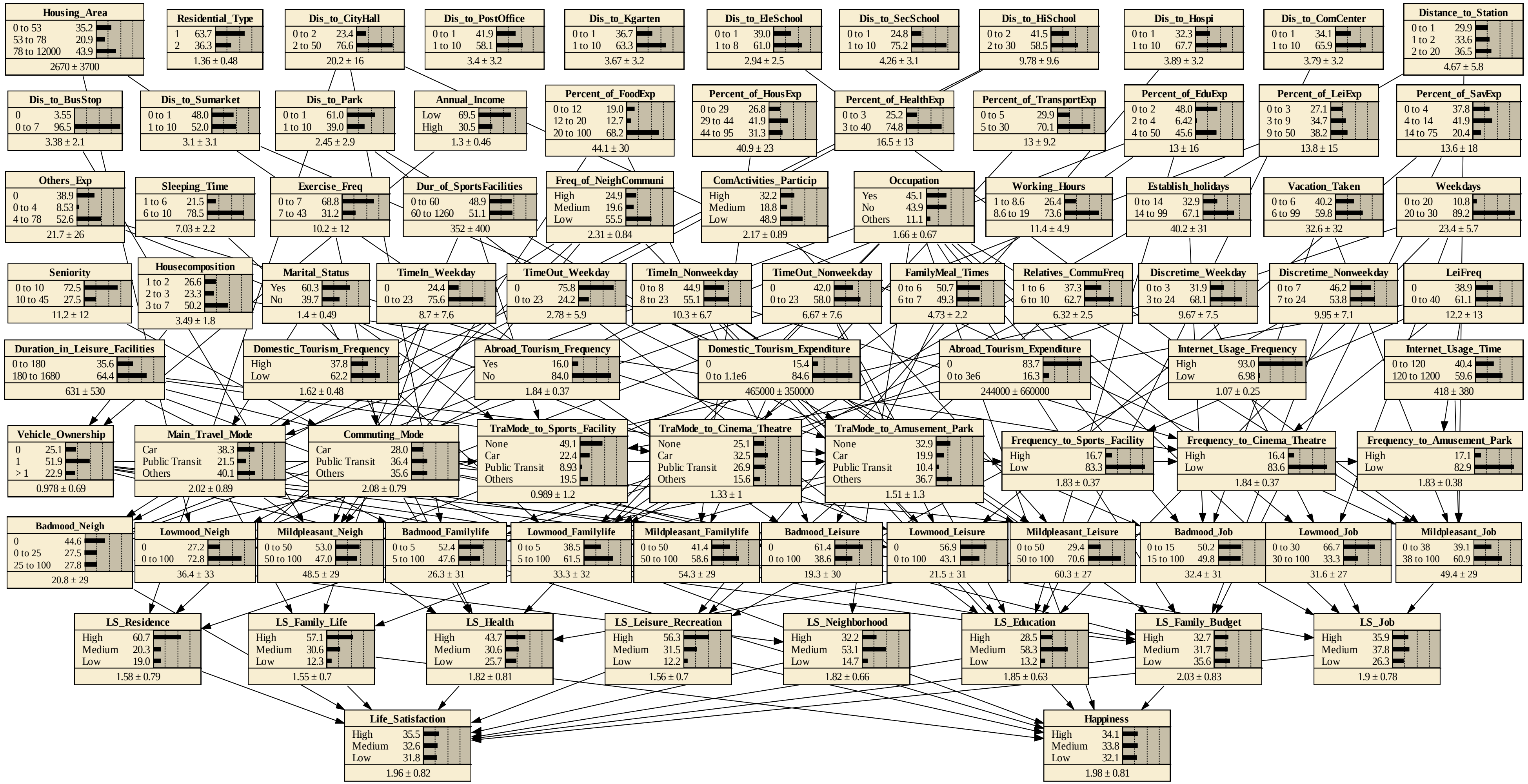
Junyi ZHANG, Yubing XIONG (2015) Effects of multifaceted consumption on happiness in life: A case study in Japan based on an integrated approach. International Review of Economics. 62, 143-162.
(*A special issue edited by Prof. Ruut Veenhoven*)



Junyi Zhang

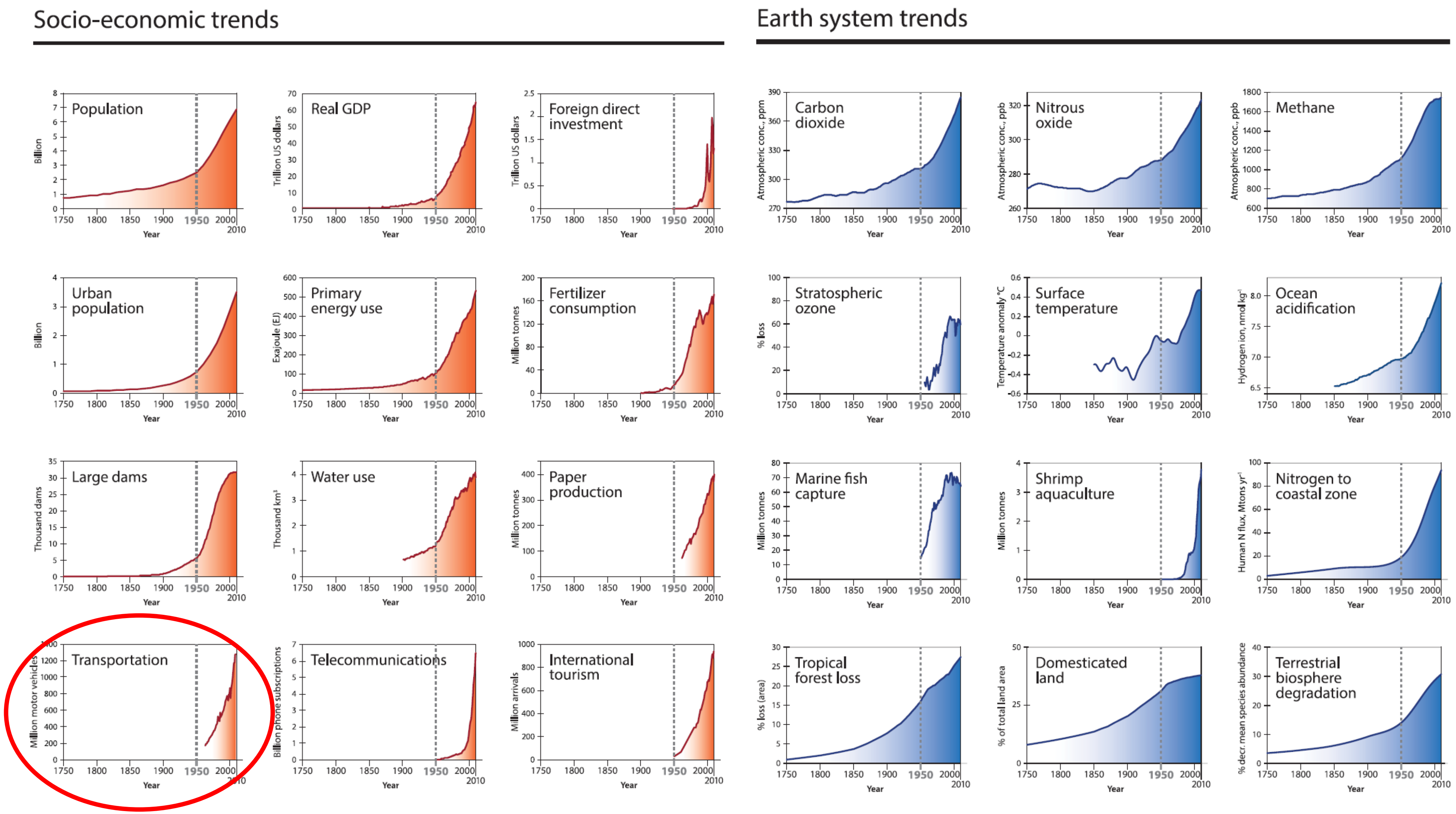
Global challenges

Some personal efforts

Junyi Zhang

Great Acceleration

Development



Climate Change

Transport ≒ 20% of global CO2: about 80% from road

Steffen W. et al. (2015) The trajectory of the Anthropocene: The Great Acceleration. The Anthropocene Review, 2(1), 81-98.

Global traffic fatalities

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Human being

Figure 1: Number and rate of road traffic death per 100,000 population: 2000–2016

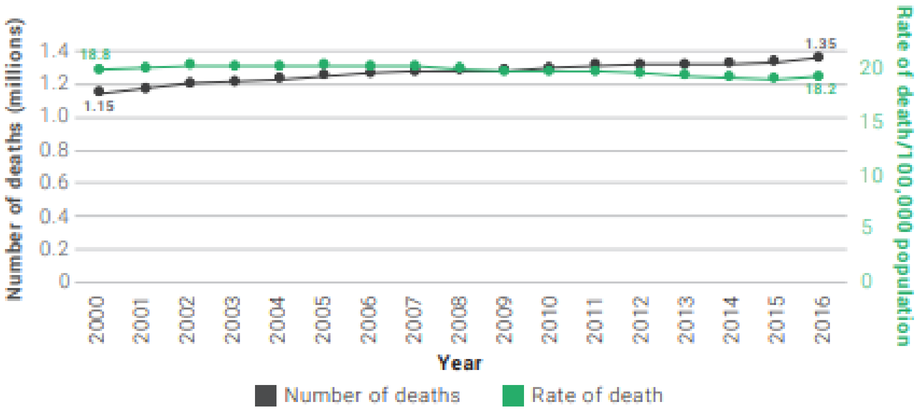
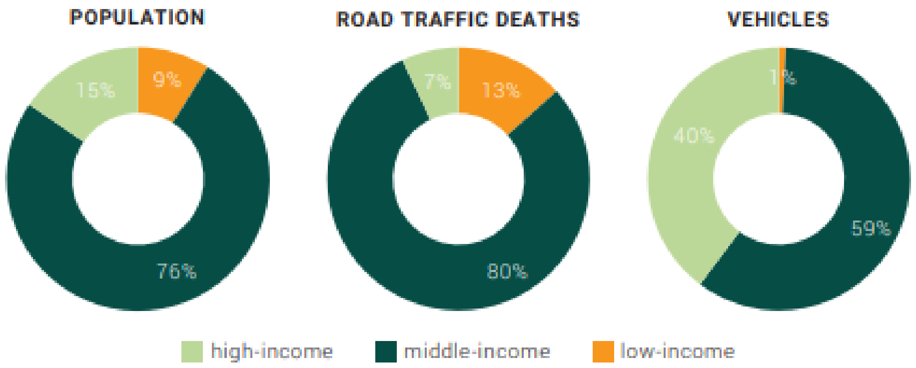


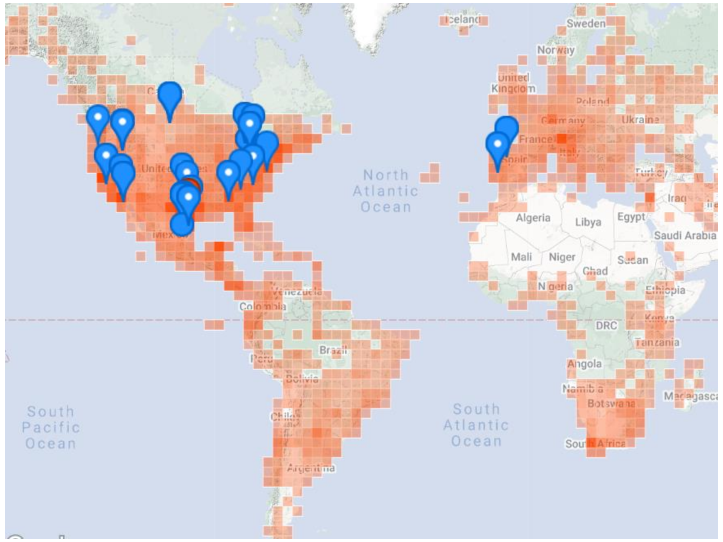
Figure 2: Proportion of population, road traffic deaths, and registered motor vehicles by country income category*, 2016

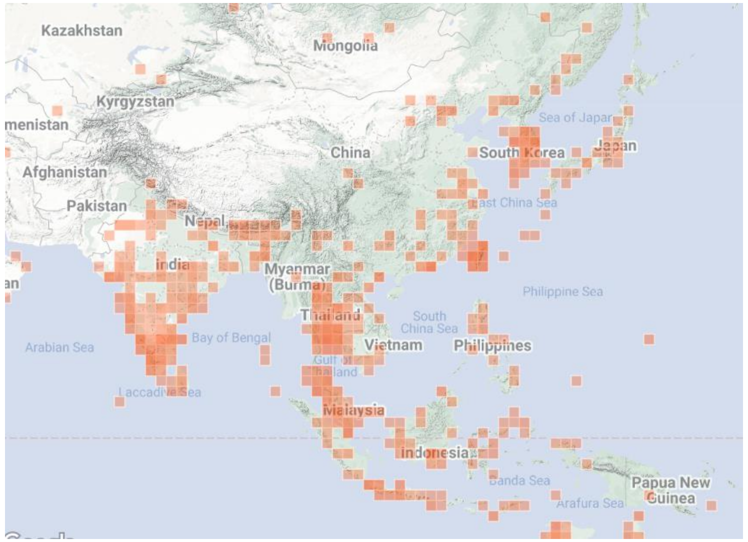


*income levels are based on 2017 World Bank classifications.

http://apps.who.int/iris/bitstream/handle/10665/277370/WHO-NMH-NVI-18.20-eng.pdf?ua=1

Animals





"Globally, there are over 1 billion vehicles driving on almost 6 million miles of paved roads. Every day, millions of mammals, herpetofauna, birds, and insects are killed trying to cross roads, or incidentally as they move around."

Citied from https://www.inaturalist.org/projects/global-roadkill-observations

"An estimated 29 million mammals and 194 million birds are killed annually on European roads. Worldwide, all mortality sources considered, natural or human, vehicle induced mortality was 7% for adult mammals and 1% for adult birds."

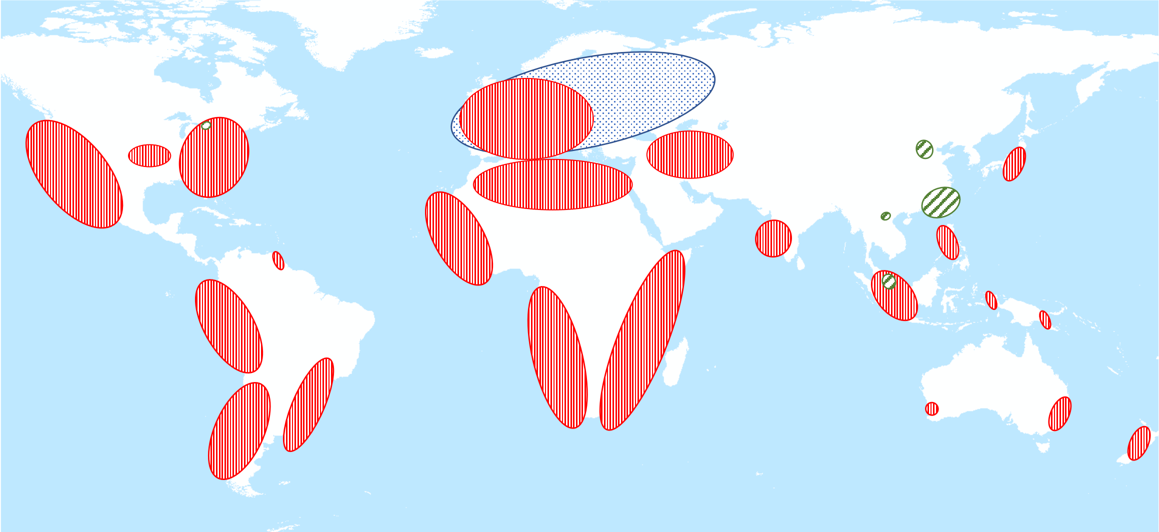
Citied from https://natureconservation.pensoft.net/article/72970/

Pandemics and transport

Risk of pandemics =

Pr(Viruses) * Pr(Intensity|Viruses)* Pr(*Transmission*|Intensity) * Pr(*Exposure* | *Transmission*)
* Pr(*Consequency*|*Exposure***Transmission*)
** Consequence (infection+death, economic/social impacts)*

Pr (*Tripmaking*|*Activities*)
* Pr (*Activities*|*Needs in life*)

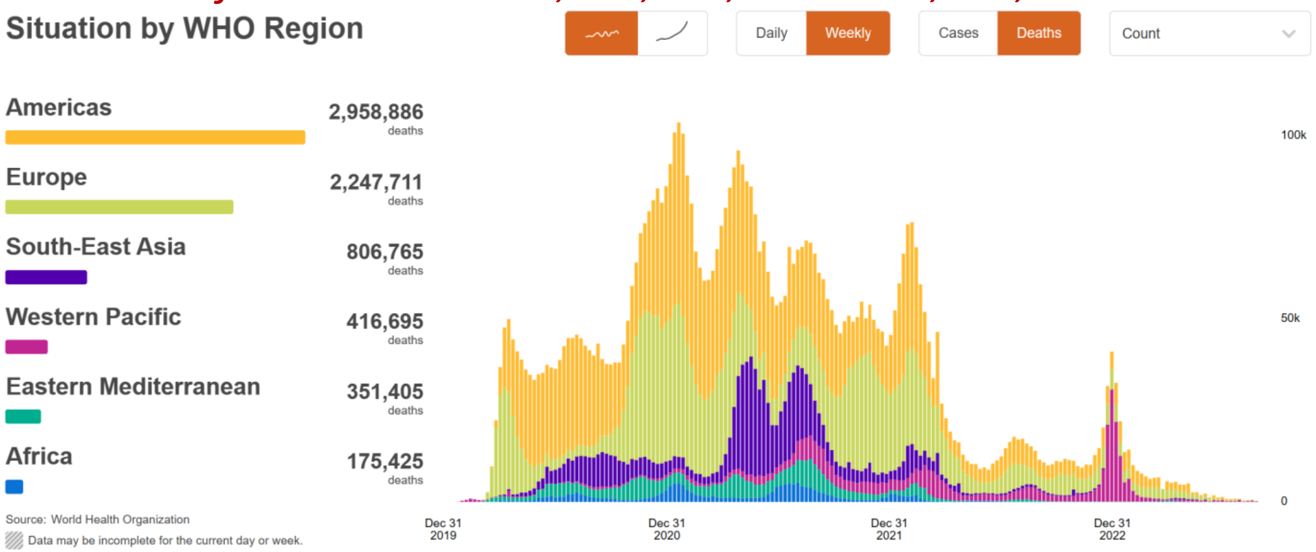


Plague (land and river transport)
Spanish flu (marine transport)
SARS (air transport)

Nakanishi H and Kobayashi YH (2022) Historical overview of pandemics. In: Zhang H and Hayashi Y (eds), [Transportation Amid Pandemics: Lessons Learned from COVID-19](), Chapter 2, Elsevier.

The COVID-19 Pandemic

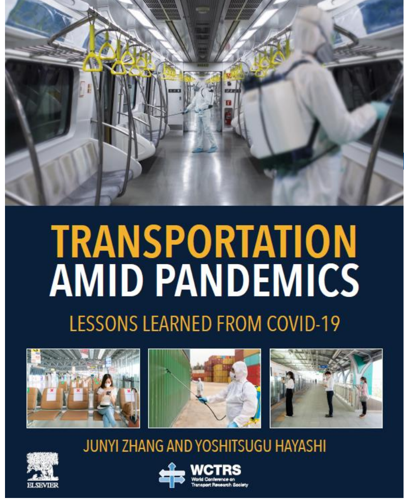
Global confirmed cases=770,437,327; deaths=6,956,900



https://covid19.who.int/ (accessed on Sept 13, 2023)

Junyi Zhang, Yoshitsugu Hayashi (2022) Transportation Amid Pandemics: Lessons Learned From COVID-19, Elsevier

https://www.elsevier.com/books/transportation-amid-pandemics/zhang/978-0-323-99770-6



Pandemic & crisis policymaking: PASS Approach

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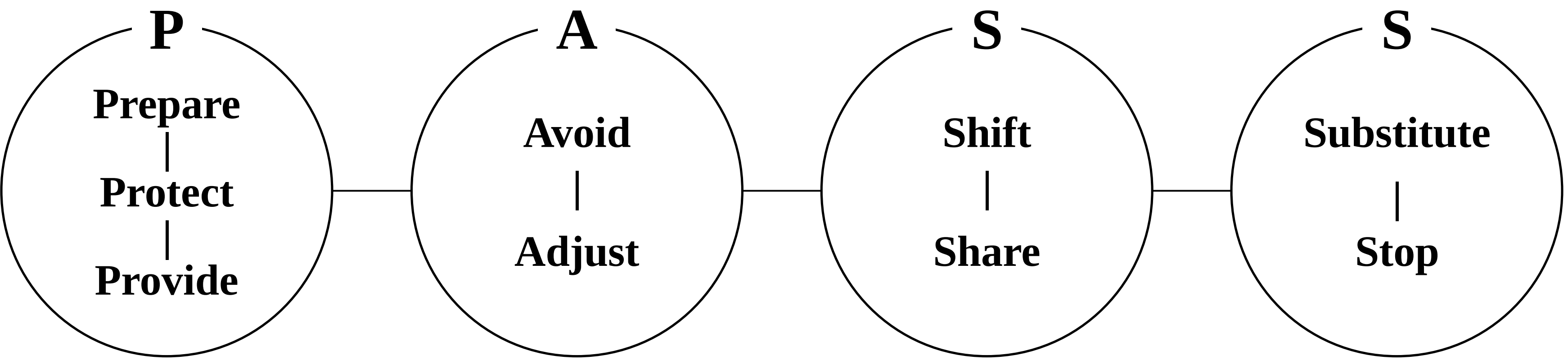

Junyi Zhang (2020) Transport policymaking that accounts for COVID-19 and future public health threats: A PASS approach. Transport Policy, 99, 405-418

In total, more than 100 policy measures are proposed. *Some examples* are as follows:

- **P**: Preparing emergency plans, transport capacity of health services, inventory holding for increasing resilience, public participation, and capacity building; Protecting transport service staff and users as well as vulnerable population groups; Providing guidance and information, financial support, and anti-virus services.
- **A**: Avoiding inconsistent and less scientific policy decisions, crowded platforms and vehicles, and unnecessary and non-urgent trips; Adjusting policymaking processes, service operations and demand management, activity-travel schedules, logistic supply chains and so on for minimizing transport.
- **S**: Modal shifts (esp. for encouraging sustainable transport), shared mobility, shared operational resources (e.g., using public transport and taxi vehicles to transport both passengers and goods), and information sharing.
- **S**: Substitution of transport activity by virtual communication, substitution of face-to-face procedures by online procedures to minimize transport, stop of services with close face-to-face contacts, lockdown, and stay at home.

Pandemic & crisis policymaking: LASTING Approach

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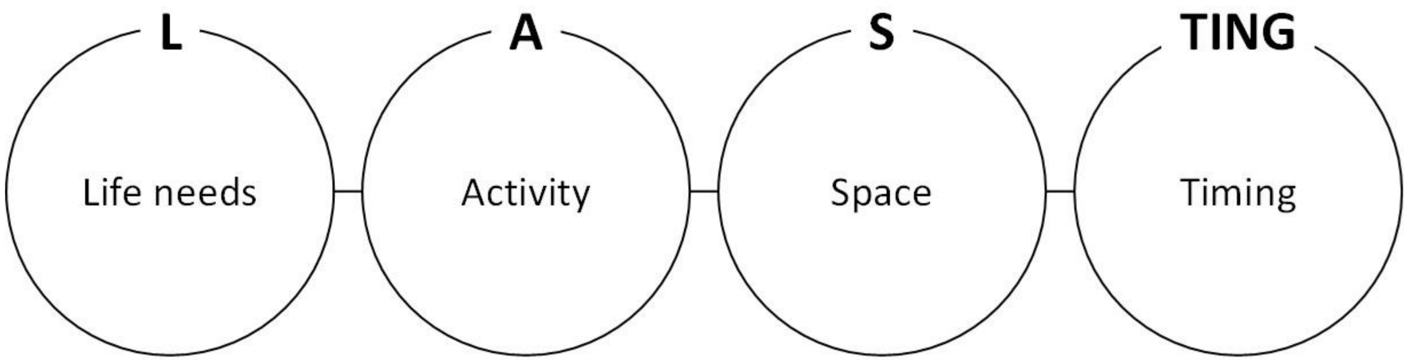


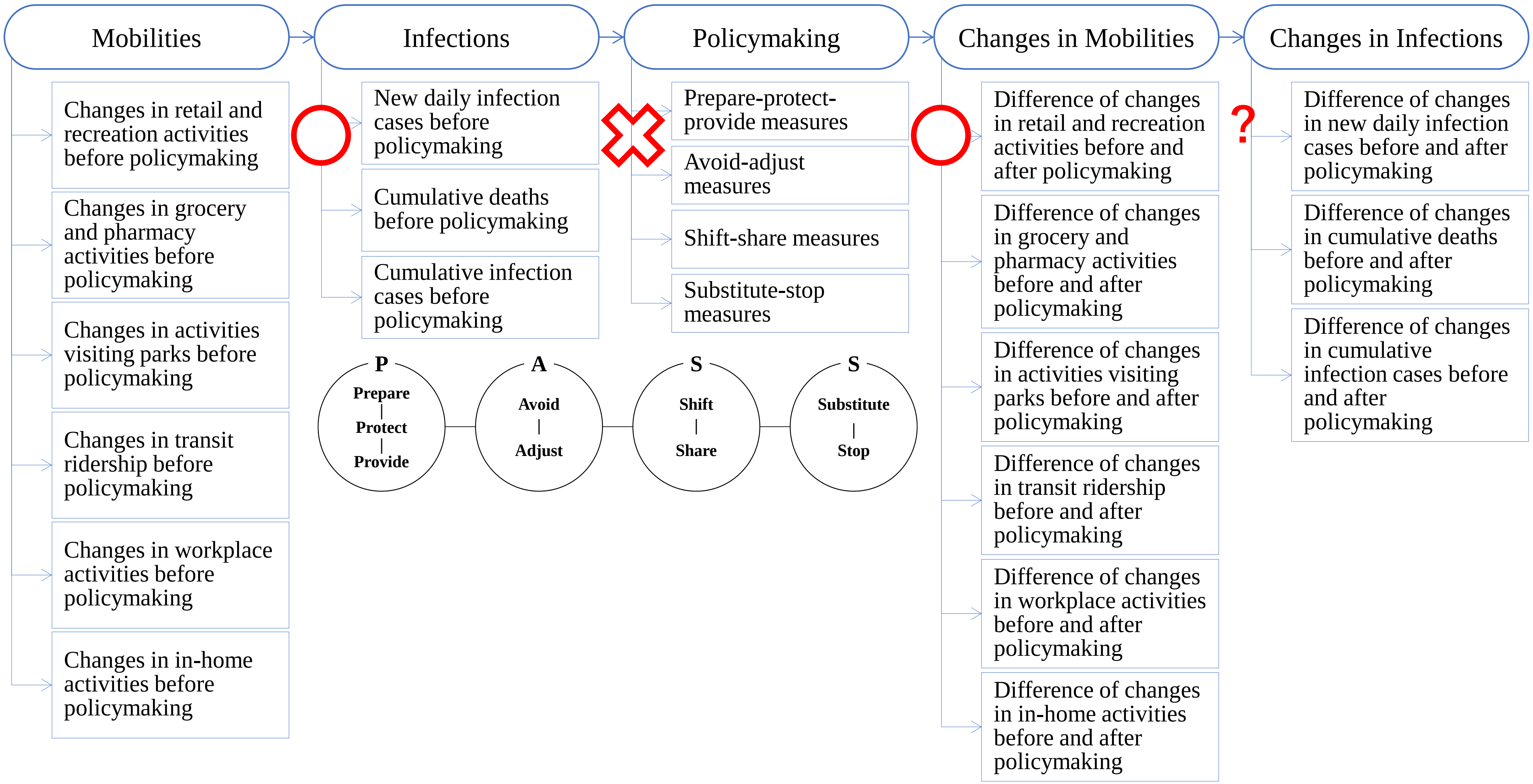
Proposed by Junyi Zhang, Mobilities and Urban Policy Lab, Hiroshima University in April 2020.

Junyi Zhang (2021) People's responses to the COVID-19 pandemic during its early stages and factors affecting those responses. **Nature – Humanities and Social Sciences Communications**, 8: 37. https://doi.org/10.1057/s41599-021-00720-1 [**Highly Cited Paper**]

Lower levels of behavioral changes may be due to the lack of a sense of crisis and people's lack of awareness or concern about their contribution to society. Unclear requests for self-restraint, poor role specifications of central and local governments in COVID-19 policies, and the resulting policy turmoil, discourage people from following governmental requests/recommendations. This research suggests that it is important to figure out effective differentiated communication methods for informing the public to make cooperative behavioral changes. To avoid/mitigate the infection risk, physical distancing has to be better practiced. Therefore, it is necessary for people to re-think what kinds of essential needs in life [L] have to be met and accordingly to re-design their daily life schedules. Based on the re-designed schedules, people needs to further carefully think about what kinds of out-of-home or out-of-office activities [A] have to be performed, at what kinds of places with sufficient space [S] and proper duration of time and at the proper timing [TING] (for example, to perform activities as quickly as possible and to shift departure timing). In other words, a Life-oriented Activity-Space-Timing (LASTING) approach is required for people to survive COVID-19. Such a LASTING approach is crucial to enhance the effects of massive public involvement in mitigating the spread of COVID-19.

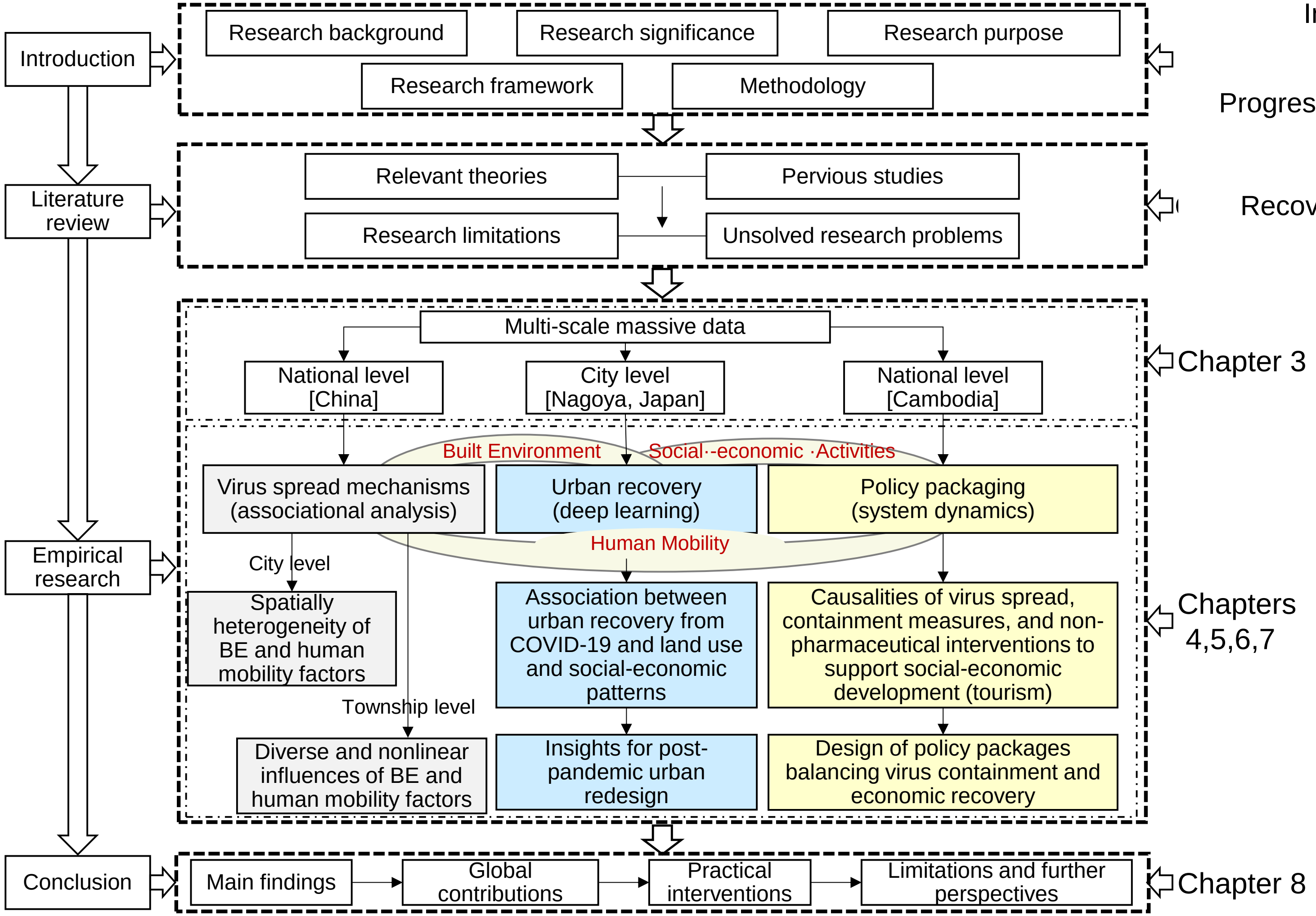
Zhang, J., et al. (2021) Effects of transport-related COVID-19 policy measures: A case study of six developed countries, Transport Policy, 110, 37-57.

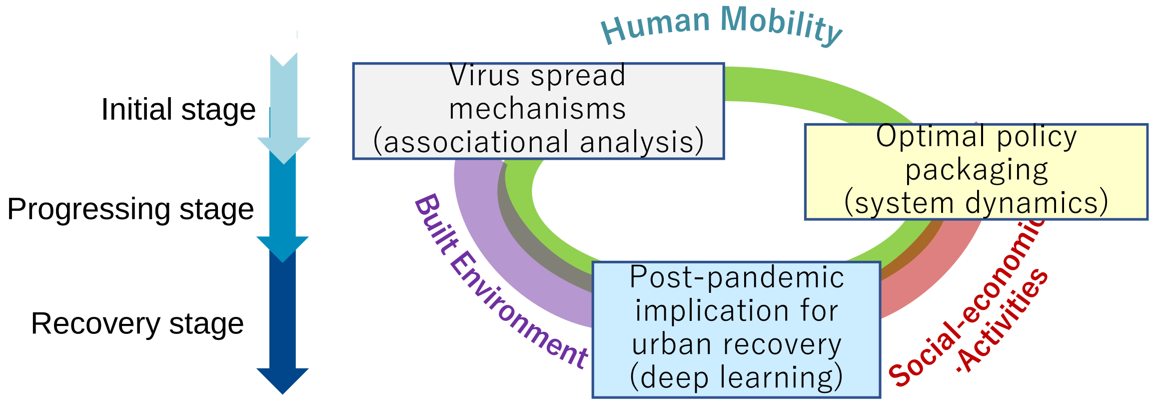
The USA, the UK, Australia, Canada, New Zealand, Japan



Shuangjin LI (2022.09) Exploring associational factors to COVID-19 and evaluating non-pharmaceutical interventions and recovery measures: Perspectives of built environment and human mobilities

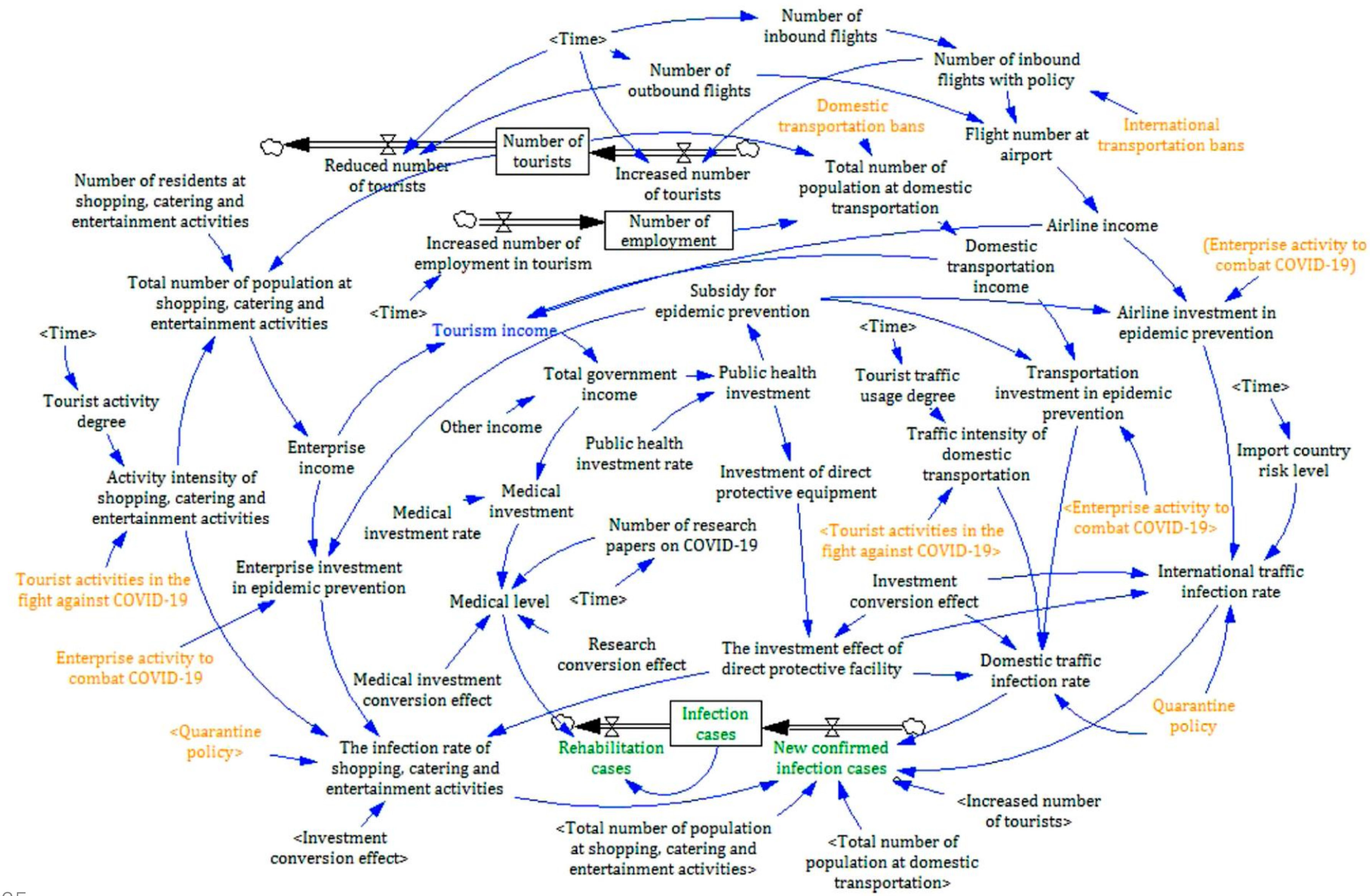
The following is one of the first doctoral dissertations on COVID-19 in the context of urban and regional planning as well as transportation planning (graduate in Sept 2022).





1. (*joint first-author*) Ma, S., **Li, S.**, & Zhang, J.* (2021). Diverse and nonlinear influences of built environment factors on COVID-19 spread across townships in China at its initial stage. **Nature - Scientific Reports [Q1]**, 11, 12415. https://doi.org/10.1038/s41598-021-91849-1 (Chapter 5) **[IF=4.380]**
2. **Li, S.**, Ma, S., & Zhang, J.* (2021). Association of built environment attributes with the spread of COVID-19 at its initial stage in China. **Sustainable Cities and Society [Q1]**, 102752. https://doi.org/10.1016/j.scs.2021.102752 (Chapter 4) **[IF=7.587]**
3. **Li, S.**, Ma, S., & Zhang, J.* (2022.01). Building a system dynamics model to analyze scenarios of COVID-19 policymaking in tourism-dependent developing countries: A case study of Cambodia. **Tourism Economics [Q1]** https://doi.org/10.1177/13548166211059080 (Chapter 6) **[IF=4.438]**
4. (*joint first-author*) Ma, S., **Li, S.**, & Zhang, J.* (2023) Spatial and deep learning analyses of urban recovery from the impacts of COVID-19. **Nature - Scientific Reports**, 13, 2447. **[IF=4.996]**

Shuangjin LI (2022.09) Exploring associational factors to COVID-19 and evaluating non-pharmaceutical interventions and recovery measures: Perspectives of built environment and human mobilities



Shuangjin Li#, Shuang Ma#, Junyi Zhang* (2021) [Scenario analyses of COVID-19 policymaking in highly tourism-dependent developing countries by developing a system dynamics model: A case study on Cambodia](). Tourism Economics (First Published January 17, 2022) [**IF=4.582**]

Hongxiang DING (2023.03) Behavioral research for the COVID-19 pandemic policymaking: Focusing on activity-travel behavior and social contact

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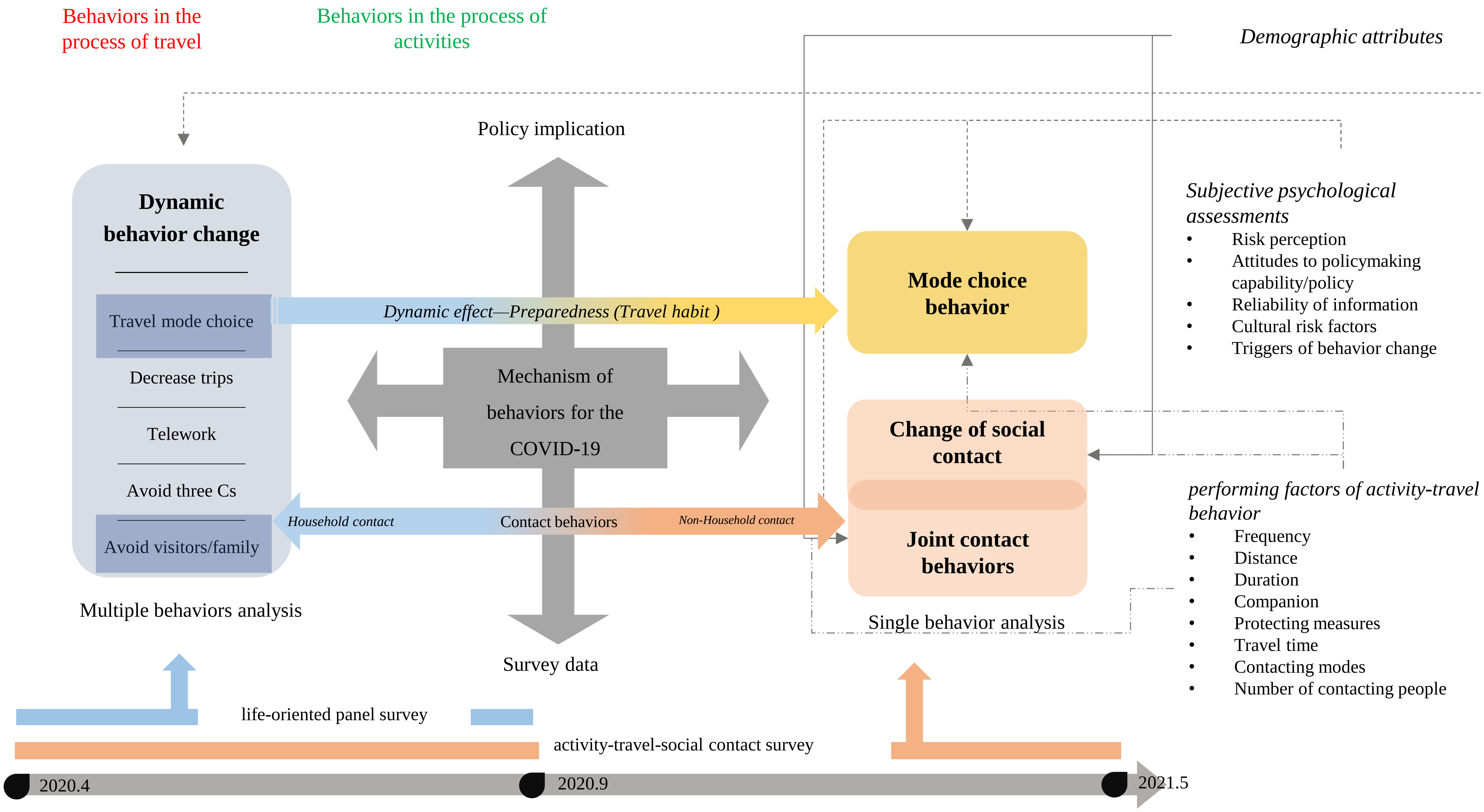
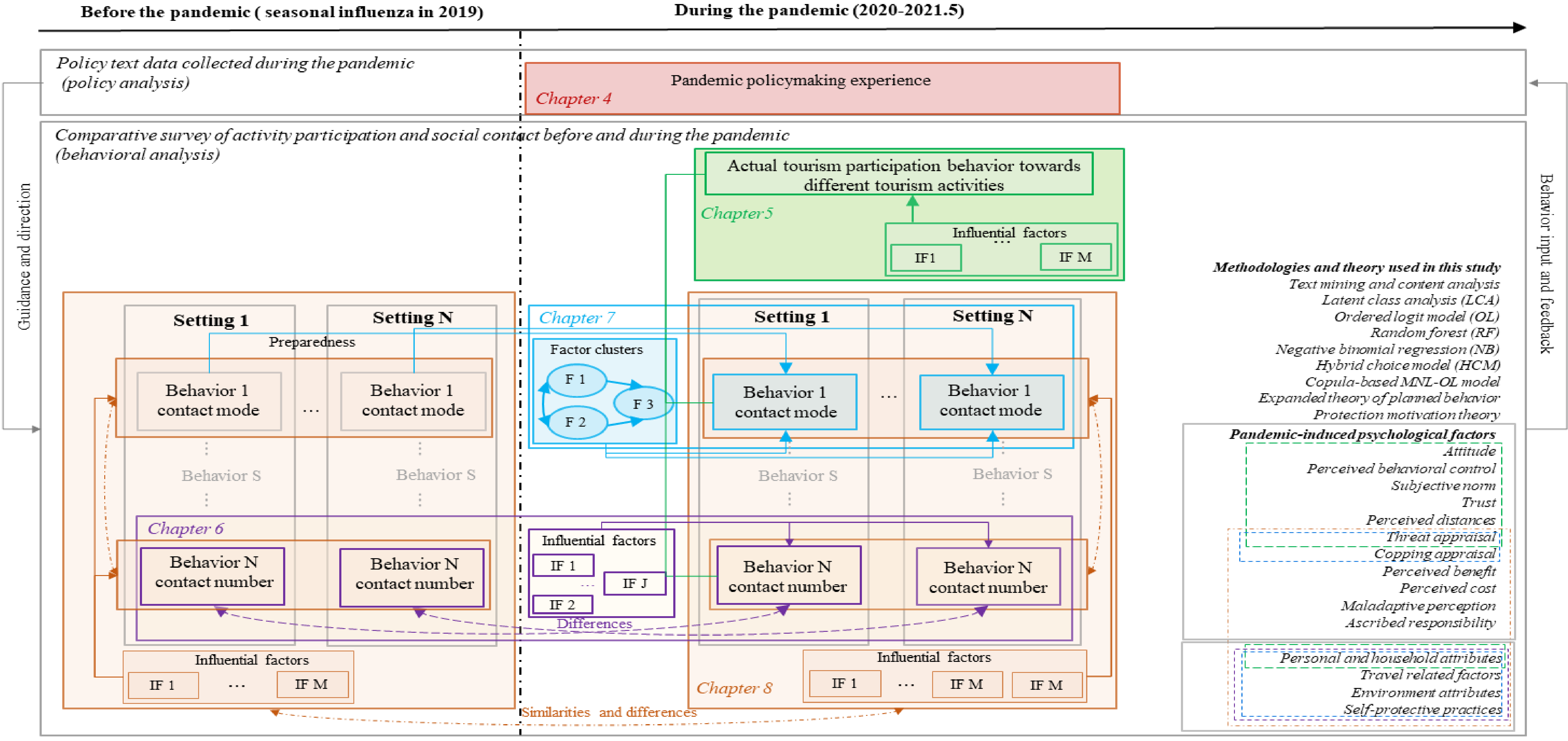


Junyi Zhang

Rui LIU (2023.09)
Tourism Activity Participation and Social Contact during the COVID-19 Pandemic



New concepts/theories

Challenges

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Planetary health

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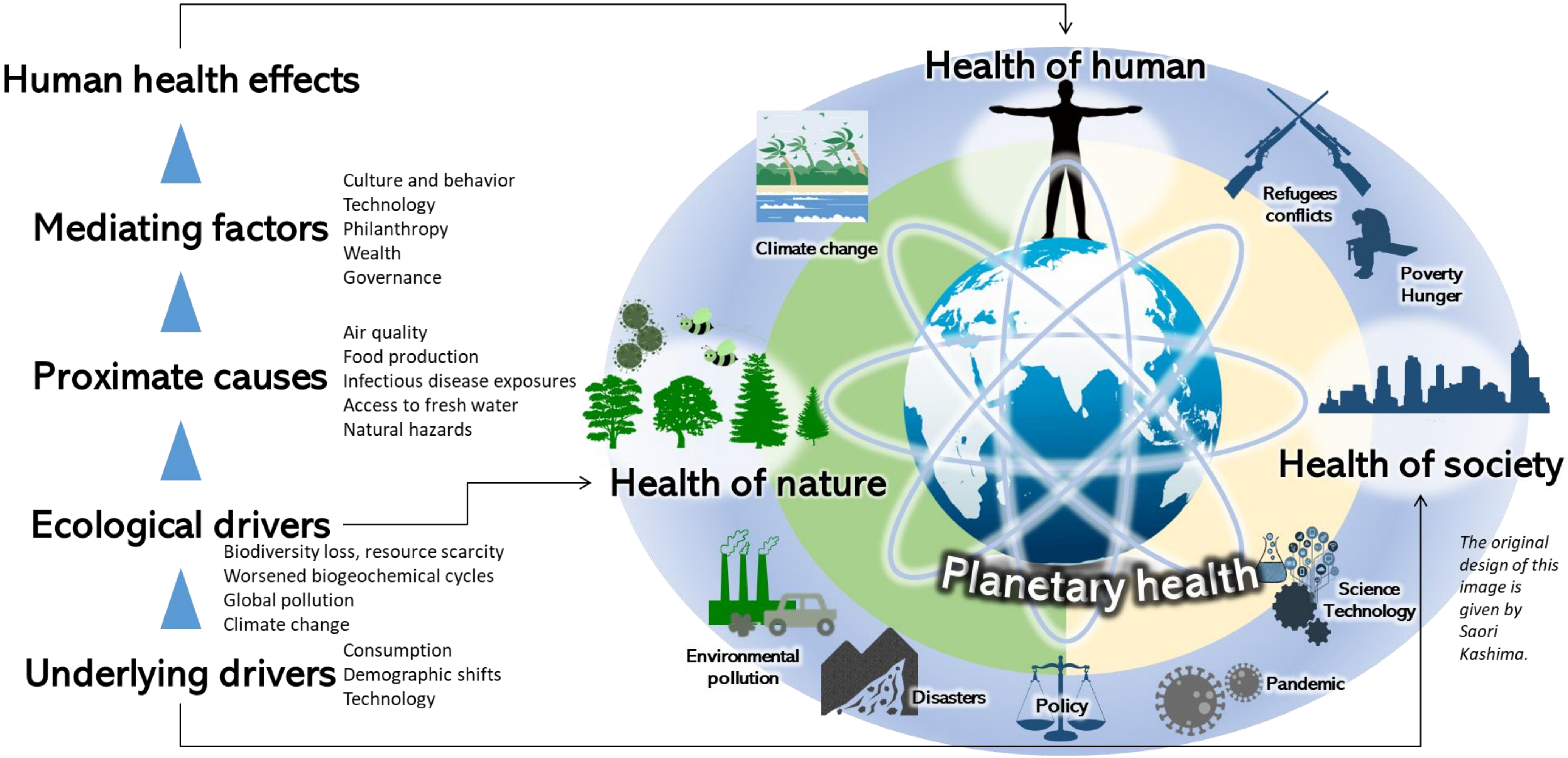
The health of human civilization and the state of the natural systems on which it depends (Lancet, 2015).

(= **Co-health of individuals, society and nature** ← Redefined by Junyi Zhang, 2021)



The original design of this image is given by Saori Kashima.

Modified by Junyi Zhang, based on https://www.thelancet.com/action/showPdf?pii=S0140-6736%2817%2932846-5

It is necessary to build a human-society-nature nexus modeling system

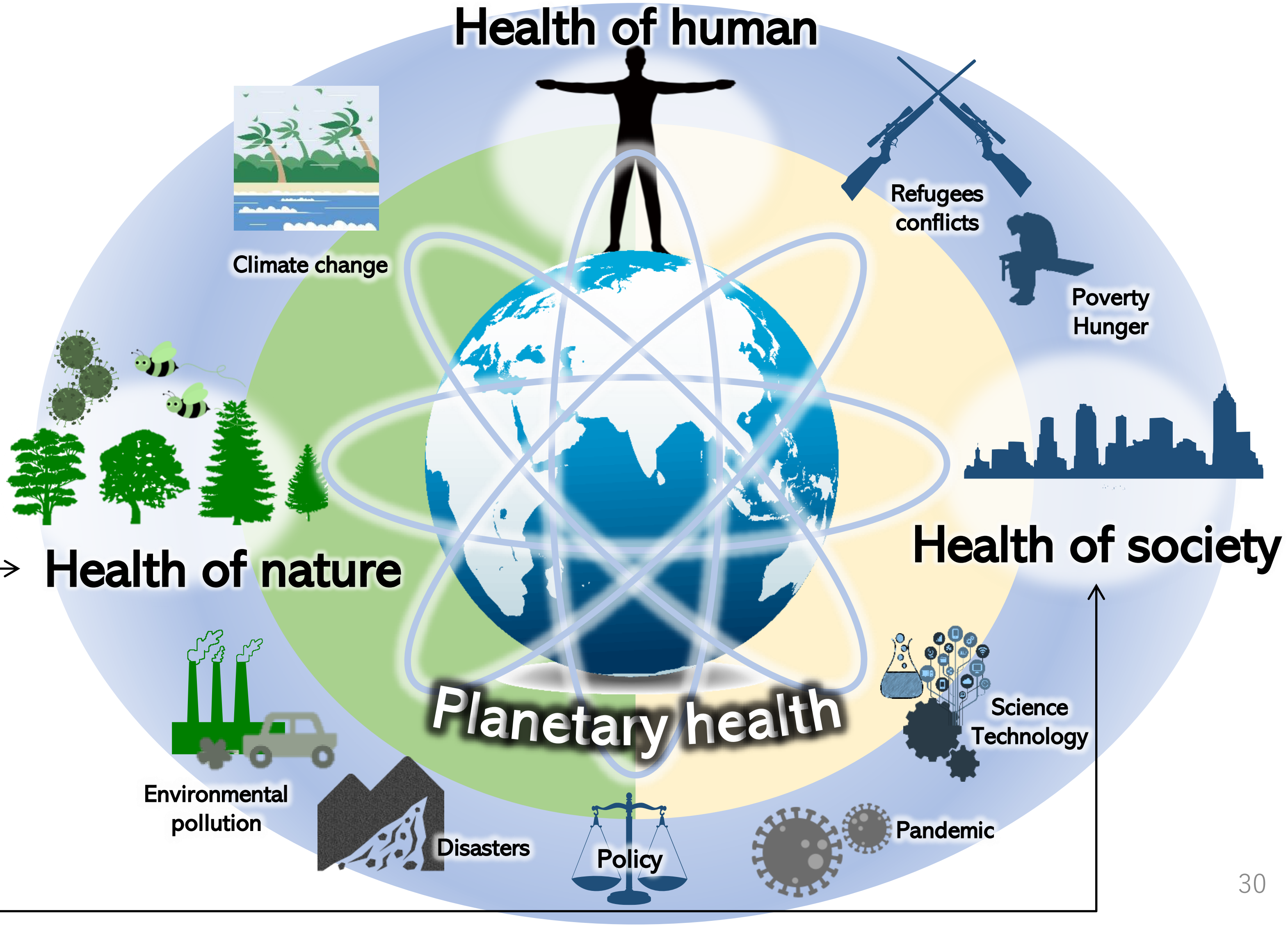
Human health effects

Mediating factors
- Culture and behavior
- Technology
- Philanthropy
- Wealth
- Governance

Proximate causes
- Air quality
- Food production
- Infectious disease exposures
- Access to fresh water
- Natural hazards

Ecological drivers
- Biodiversity loss, resource scarcity
- Worsened biogeochemical cycles
- Global pollution
- Climate change

Underlying drivers
- Consumption
- Demographic shifts
- Technology



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Future development goals and new sciences

https://home.hiroshima-u.ac.jp/~zjy/wp-content/uploads/2021/10/Harmonization-Science_Proposed-in-Sept-2020-2.pdf

Harmonized Development Goals (HDGs)

Junyi Zhang (2020.09)
Harmonization Science

Sustainable Development Goals (HDGs)

Millennium Development Goals (MDGs)

Well-harmonized
vs.
Less-harmonized

Developed
vs.
Developing

Now, it is a critical time to re-define the long-existing country classification!

e.g., post-pandemic scenario: thoughtful 2020s

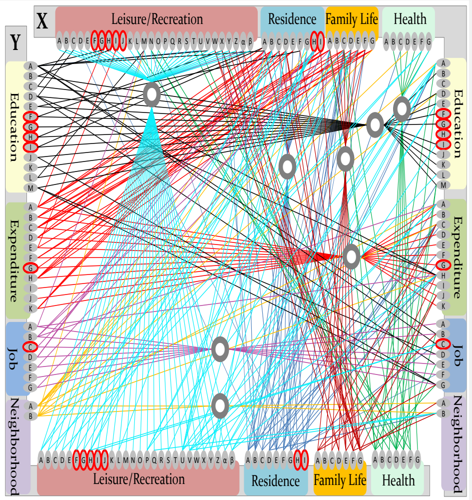
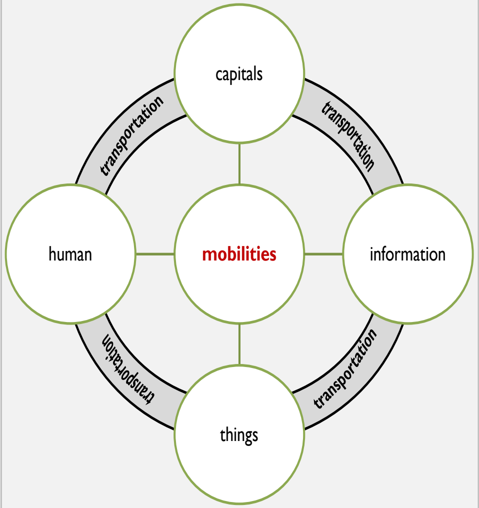
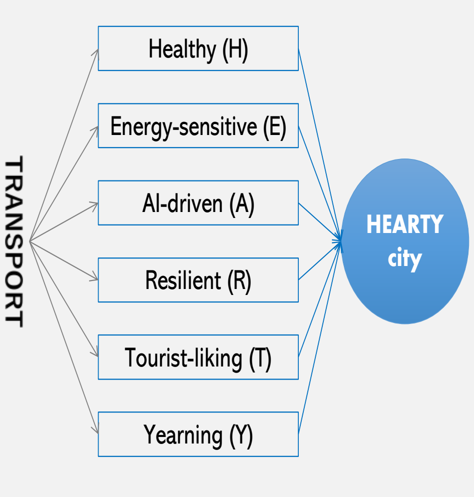
- Harmonizing with nature
- Harmonizing with life

Werner Rothengatter, Junyi Zhang, Yoshitsugu Hayashi, Anastasiia Nosach, Kun Wang, Tae Hoon Oum (2021) Pandemic waves and the time after Covid-19 – Consequences for the transport sector, Transport Policy, 110, 225-237

New theory/approach

A “Transport in All Policies” (TiAP) approach

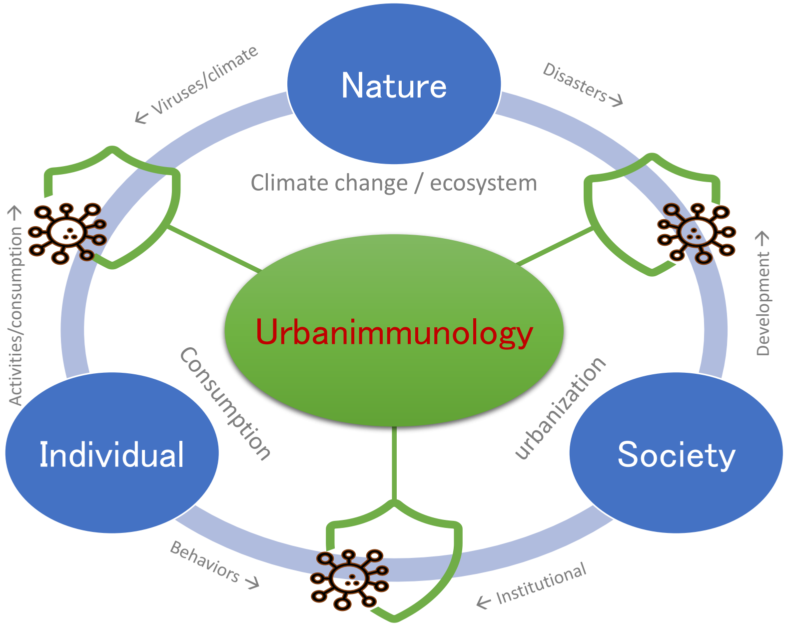
An approach to the formulation of public policies designed to resolve all transport issues of the whole society.

Transport is closely connected with people’s daily lives!	Transport is closely connected with various economic and social sectors!	Transport is closely connected with many policy goals!
		
The life-oriented approach (proposed by Junyi Zhang in 2010) has revealed various interdependencies across life domains.	*Junyi ZHANG, Cheng-Min FENG (2018) Routledge Handbook of Transport in Asia*	*HEARTY City: A new urban/regional development concept proposed by Junyi Zhang in 2022.*

Junyi ZHANG (2023) A “Transport in All Policies” Approach. In: Junyi Zhang et al. (2023), Research Handbook on Transport and COVID-19. Edward Elgar Publishing.

Urbanimmunology

A new discipline to understand the capacities that a city can protect itself by resisting to disruptions and adapt to disruptions, and to develop responses that can help the city to enhance its immunity level and consequently, to evolve into a resilient system.



Junyi ZHANG (2023) Urbanimmunology. In: Junyi ZHANG et al. (2023) COVID-19 & Pandemics, Lifestyles, and the Built Environment: A Perspective of Planetary Health, Springer.

Urbanimmunology

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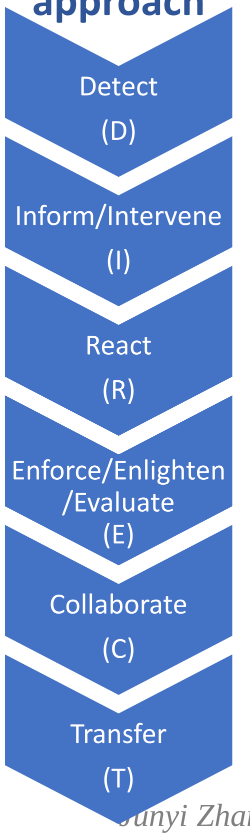
Deriving a policy process management approach (DIRECT) based on Urbanimmuology

Original paper: 张峻屹 (2021) 后疫情时代交通运输领域的一体化碳减排政策. 城市交通, 19(5), 43-52. [in Chinese]
→ Junyi Zhang (2022) Governance for post-COVID-19 carbon reduction: A case study of the transport sector. In: Junyi Zhang and Yoshitsugu Hayashi (eds.), Transportation Amid Pandemics: Lessons Learned from COVID-19, Chapter 34, Elsevier.

[Mechanisms of immune responses for planetary health (PH) based on DIRECT approach] The DIRECT approach can be derived from the human immune system, as shown below. The urban immune system can be built and managed for PH.

①Detect (**D**): Always detect and monitor whether there is an abnormality (an urban problem: an invasive pathogen) in a city, by learning the roles of the TLR of epithelial cells and phagocyte.
②Inform (**I**): Inform the urban immune system about the detected abnormalities, by learning the roles of T lymphocytes activated by lymphocytes produced by phagocytes. T lymphocytes are lymphocytes that have been selected and graduated in the thymus. Most graduated lymphocytes do not misinterpret themselves as enemies and have the ability to accurately identify enemies.
③React (**R**): Stakeholders being responsible of urban elements with abnormalities react properly to the detected abnormalities and handle the abnormalities, by learning the roles of antibodies dedicated to invading pathogens. The antibodies are produced by B lymphocytes released through T lymphocytes.
④Enforce (**E**): Thoroughly investigate the influences of the detected abnormalities and strengthen various measures to prevent the reoccurrence of the abnormalities and influences, by learning the roles of killer T lymphocytes, which receive antigenic information from dendritic cells, attach the infected cells and cancer cells and eliminate (kill) them.
⑤Collaborate (**C**): Stakeholders collaborate to address the various urban issues, by learning the role of various cells responsible for various immunities.
⑥Transfer (**T**): The experience gained through the above complex process (acquired immunity) is transferred to deal with the next abnormality. Acquired immunity is complementary to natural immunity. With the acquired immunity, foreign substances that have invaded once will be remembered, and they will be attacked the next time when they invade the body.

DIRECT approach



Policymaking process management: DIRECT approach

During-pandemic Pandemic-sensitive mobilities	DIRECT approach	Post-pandemic Resilient-sustainable mobilities
Detect infection risks and risky mobilities.	Detect	Detect unresilient and unsustainable mobilities.
Inform the public and stakeholders about the above detected results for interventions.	Inform/Intervene	Inform the public and stakeholders about the above detected results for interventions.
The public and stakeholders react to the above intervention.	React	The public and stakeholders react to the above intervention.
To enforce/enlighten and evaluate the above interventions.	Enforce/Enlighten /Evaluate	To enforce/enlighten and evaluate the above interventions.
The public and stakeholders collaborate to control the pandemic.	Collaborate	The public and stakeholders collaborate to realize smart management of mobilities.
Transfer the during-pandemic experiences to post-pandemic smart management of mobilities.	Transfer	Transfer the post-pandemic experiences of smart management of mobilities to other places.

Zhang, J. (2022) Governance for Post-COVID-19 Carbon Reduction: A Case Study of the Transport Sector. In: Zhang, J. & Hayashi, Y. (eds), Transportation Amid Pandemics: Lessons Learned from COVID-19. Elsevier

Identity of carbon reduction in the transport sector

Kaya identify & life-oriented approach

$$CO_2(s,t) = \frac{CO_2(s,t)}{\text{Energy}(s,t)} * \frac{\text{Energy}(s,t)}{\text{Transport}(s,t)} * \frac{\text{Transport}(s,t)}{\text{Activities}(s,t)} * \frac{\text{Activities}(s,t)}{\text{Needs in life/business }(s,t)} * \frac{\text{Needs in life/business }(s,t)}{\text{Population}(s,t)} * \text{Population}(s,t)$$

- *Identity of transport-generated CO2 emissions reduction*

$$\Delta\{CO_2(s,t)\} = (1)\Delta\left\{\frac{CO_2(s,t)}{\text{Energy}(s,t)}\right\} + (2)\Delta\left\{\frac{\text{Energy}(s,t)}{\text{Transport}(s,t)}\right\} + (3)\Delta\left\{\frac{\text{Transport}(s,t)}{\text{Activities}(s,t)}\right\} + (4)\Delta\left\{\frac{\text{Activities}(s,t)}{\text{Needs in }\frac{\text{life}}{\text{business}}(s,t)}\right\} + (5)\Delta\left\{\frac{\text{Needs in }\frac{\text{life}}{\text{business}}(s,t)}{\text{Population}(s,t)}\right\} + (6)\Delta\{\text{Population}(s,t)\}$$

Governance for post-pandemic carbon reduction

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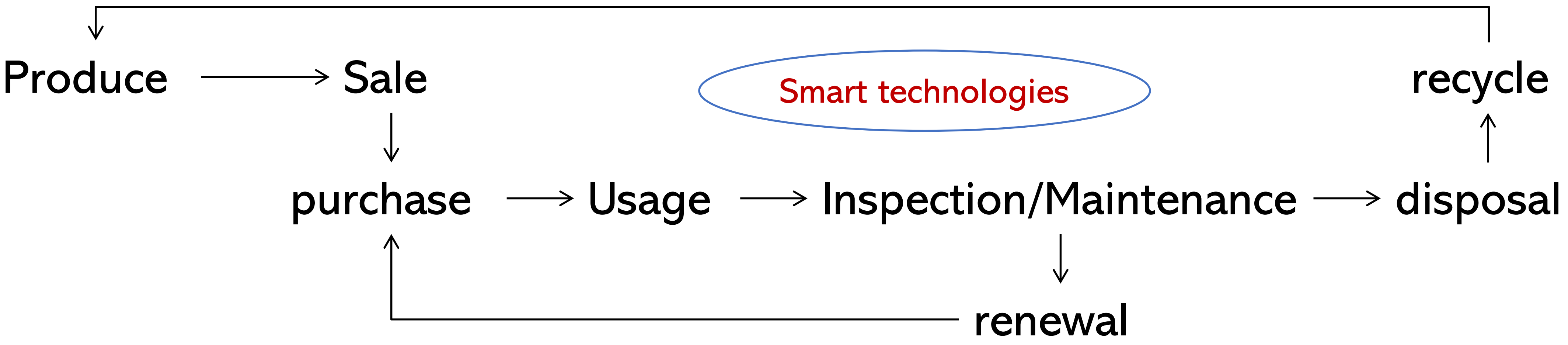
Carbon identity (six domains) DIRECT (6 steps)	(1) Reducing carbon intensity from transport energy consumption	(2) Reducing transport energy consumption	(3) Reducing transport pressure from life and economic activities	(4) Reducing life and economic activities for meeting needs in life and business	(5) Changing the needs in life and business	(6) Population policy
(1) Detect	① Develop smart carbon detection technologies	⑦ Detect transport energy consumption that can be reduced	⑬ Detect transport pressures that can be reduced	⑲ Detect high-carbon life and economic activities	㉕ Detect high-carbon needs in life and business	㉛ Detect population mobility/ migration
(2) Inform/ Intervene (I/I)	② Develop smart technologies for I/I	⑧ I/I measures on energy reduction policy measures (ERPM)	⑭ I/I measures to encourage low-carbon transport decisions (LCTD)	⑳ I/I measures to encourage decisions on low-carbon life and economic activities (LCLEA)	㉖ I/I measures to promote low-carbon needs in life and business (LCNLB)	㉜ Inform and intervene (I/I) measures in population mobility/migration
(3) React	③ Develop smart technologies for supporting reactions	⑨ React to I/I measures on ERPM	⑮ React to I/I measures on LCTD	㉑ React to I/I measures on decisions on the LCLEA	㉗ React to I/I measures on recommendations for the LCNLB	㉝ React to I/I measures on population policy
(4) Enlighten/ Enforce/ Evaluate	④ Develop smart technologies for supporting E/E/E	⑩ E/E/E_I/I measures on ERPM	⑯ E/E/_I/I measures on LCTD	㉒ E/E/E_I/I measures on decisions on the LCLEA	㉘ E/E/E_I/I measures on recommendations for the LCNLB	㉞ E/E/E_I/I measures on population policy
(5) Collaborate	⑤ Technology development based on collaboration between stakeholders.	⑪ C between government-firms-public for I/I measures on ERPM	⑰ C between government-firms-public for I/I measures on LCTD	㉓ C between government-firms-public for I/I measures on decisions on the LCLEA	㉙ C between government-firms-public for I/I measures on recommendations for the LCNLB	㉟ C between government-firms-public for I/I measures on population policy
(6) Transfer	⑥ Transfer experience of low-carbon tech. dev.	⑫ Transfer I/I measures on ERPM	⑱ Transfer I/I measures on LCTD	㉔ Transfer I/I on decisions on the LCLEA	㉚ Transfer I/I on recommendations for the LCNLB	㊱ Transfer I/I measures on population policy

Zhang, J. (2022) Governance for Post-COVID-19 Carbon Reduction: A Case Study of the Transport Sector.
In: Zhang, J. & Hayashi, Y. (eds), Transportation Amid Pandemics: Lessons Learned from COVID-19. Elsevier

Reducing energy consumption from transport

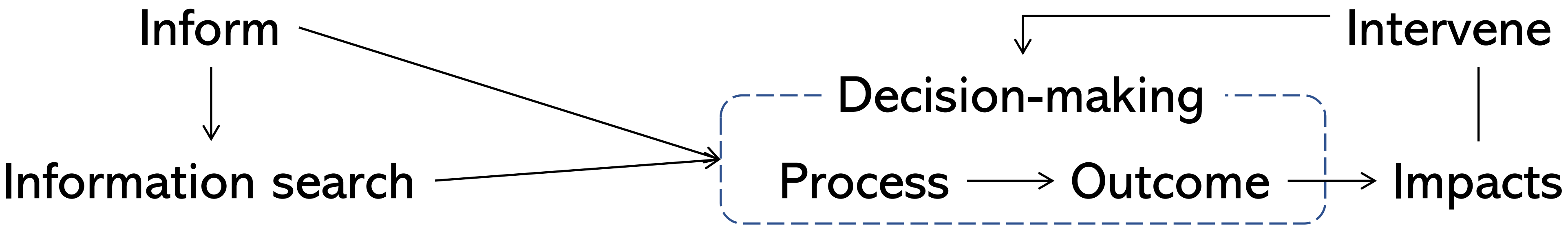
transport suppliers and users: (1) energy choice, (2) energy use.

- [⑦ Detect] detecting energy consumption from transport activities is helpful to guide a user's energy consumption decision-making.



Reducing energy consumption from transport

- [⑧ Inform/Intervene] The energy consumption detected should be conveyed to transport users in a timely way to reduce the information searching burden on the user and to provide the user with a credible basis for energy consumption decision-making. Interventions into decision-making are also required for some users.



Reducing energy consumption from transport

- [⑨ React] Here it should be noted that there are rebound effects of users' energy consumption when using energy-saving technologies.

- **Direct/pure price rebound effect** (micro-effect): Improved energy efficiency for a particular energy service will lead to an increase in consumption of that service.
- **Income effect** (micro-effect): The reduction in the cost of an energy service implies the consumer has more money to spend on other goods and services.
- **Substitution effect** (micro-effect): When the price of an energy service drops, consumers substitute for the cheaper energy service.
- **Indirect/secondary effect** (macro-effect): the energy efficiency improvement results in the increase of energy consumption for other goods and services.
- **Economy wide effect** (macro-effect): a fall in the real price of energy services may reduce the price of intermediate and final goods throughout the economy.

(Sorrell and Dimitropoulos, 2008; Hertwich, 2005 and Greening et al., 2000)

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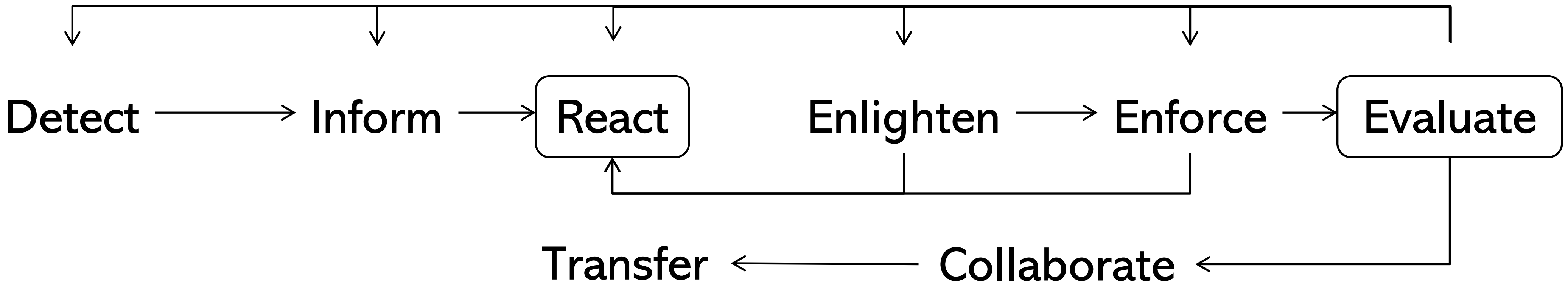
Reducing energy consumption from transport

- [⑩ Enlighten/Enforce/Evaluate] Because of the rebound effects of energy consumption related to energy-saving technologies, reducing energy consumption from transport activities needs to first “enlighten” consumers to nudge them into making voluntary reactions, and depending on the degree of reactions, to further utilize appropriately-enforced interventions to facilitate the desired reactions. The above D/I/R/E steps require a scientific evaluation based on a better understanding of the decision-making mechanisms of transport activities and energy consumption. But the decision-making mechanisms of households and firms are different, and implementing each step needs to reflect the differences in the decisions and behaviors of different transport decision makers.



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Reducing energy consumption from transport

- [⑪ Collaborate]

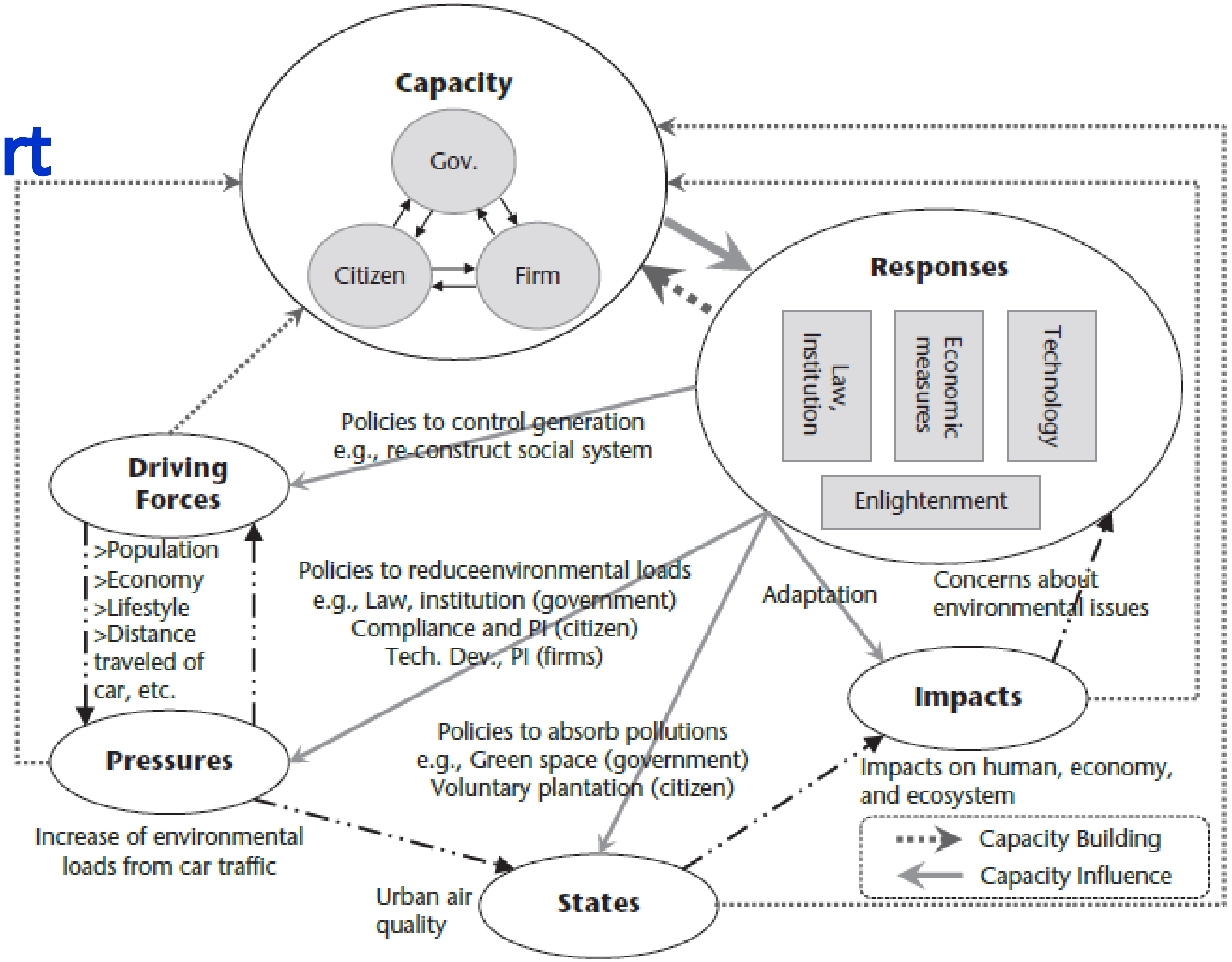
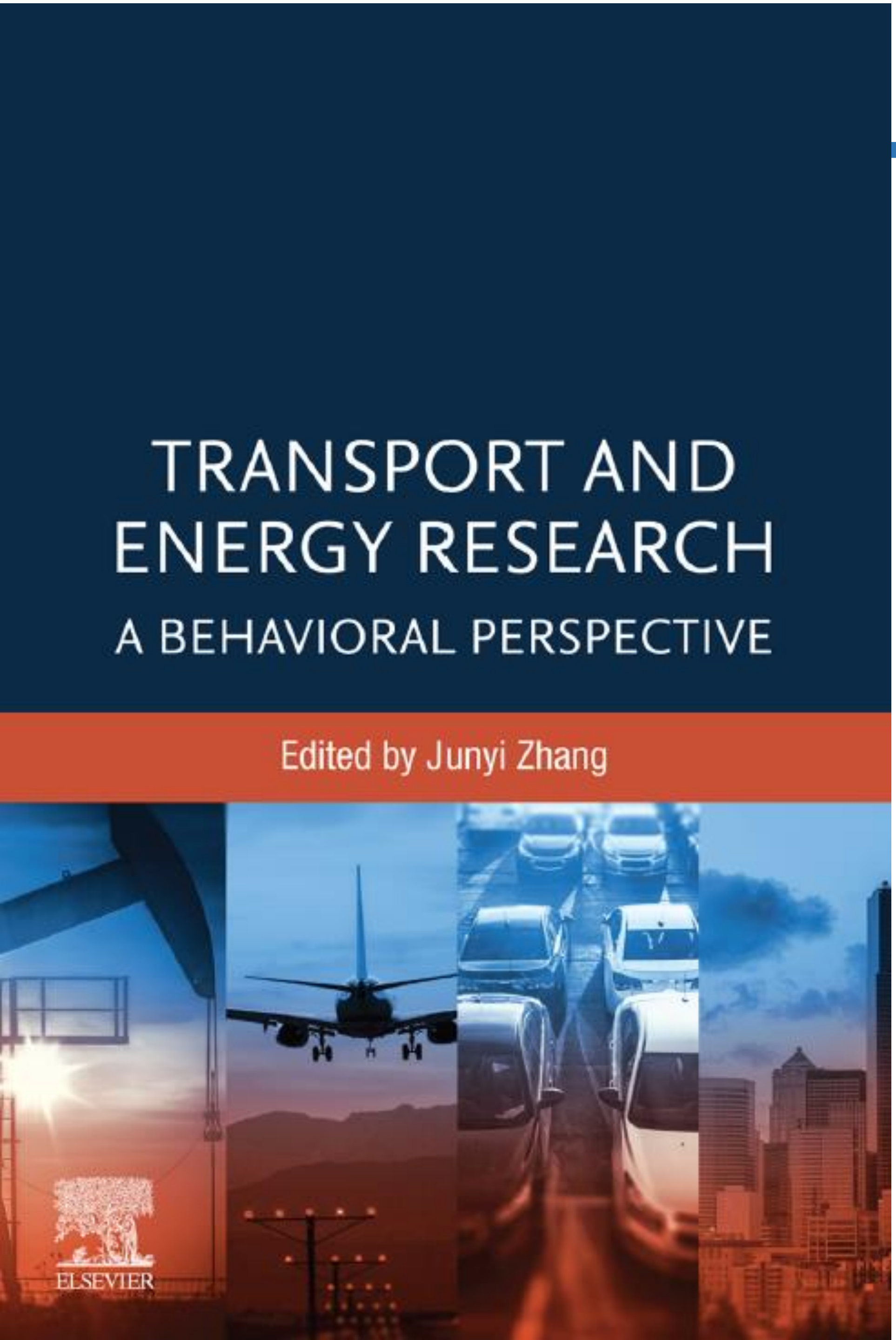


Figure 20.3 DPSIR+C framework: an example of air quality management

Zhang J (2018) Social Capacity Building for Environmental Management Related to Transport Sector: A Broader Perspective. In: Zhang J & Feng C-M (eds), Routledge Handbook of Transport in Asia, Chapter 20.



Reducing energy consumption from transport

1. Policies should be packaged.
2. Behavioral interventions should be taken in a continuous way.
3. Transport and energy policymaking should address heterogeneous responses of different actors.
4. Environmental pricing policy should be made.
5. Technologies for personal usage should be developed at a proper level.
6. Land use should be supported by suitable transportation.
7. Reducing car dependence should consider how it affects people's daily life.
8. Shared mobility should be prompted.
9. City boundary should be properly controlled.
10. A city should be walkable and walking environment should be safe and comfortable.
11. A neighborhood should meet its residents' most daily necessities.
12. Transportation system should be comprehensive and affordable.
13. Public transport should be prioritized and seamless connectivity of different public transport modes should be guaranteed.
14. Transit-oriented development with affordable houses should be promoted.
15. Transportation facilities, vehicles, and equipment should be environment-friendly through the whole lifecycles.
16. Travel demand should be better managed.
17. Transport-related energy-consumption issues should be resolved under a cross-sectoral scheme.
18. Accountable transport and energy policymaking should be supported by models with behavioral mechanisms.
19. After transport and energy planning/policy are made, it should be properly monitored continuously.
20. Stakeholders' behaviors should be better understood.
21. Advanced technologies should be developed for use in all countries.

A proposal of GREAT system

(**g**reen and **r**egion-friendly **e**Highway and **a**utonomous freight **t**ransport)

for green and smart transport development

As a part of a project "Road networks and transport centers for an efficient logistics system", sponsored by the Ministry of Land, Infrastructure, Transport and Tourism, Japan, 2022-2024

Led by Junyi Zhang

A GREAT System

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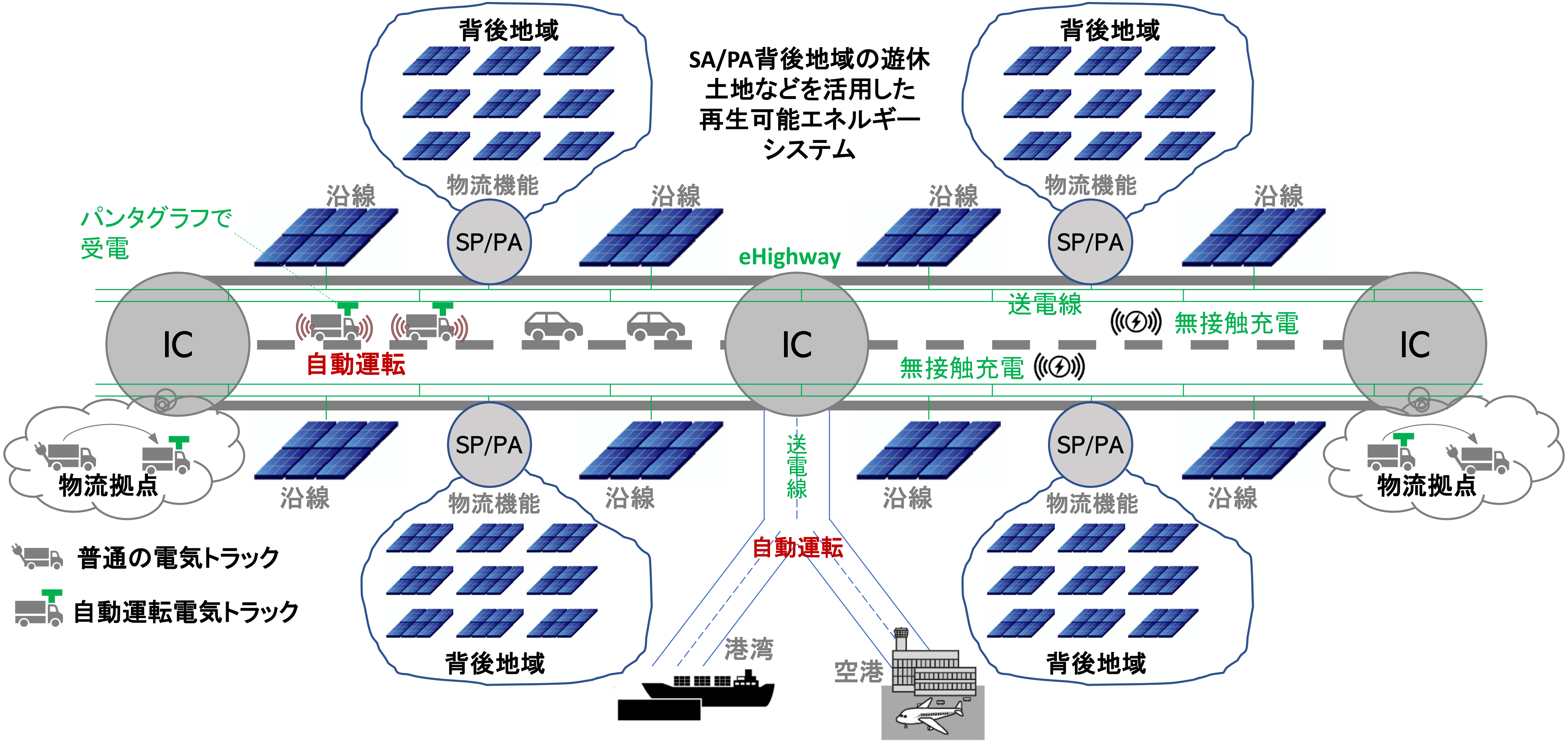
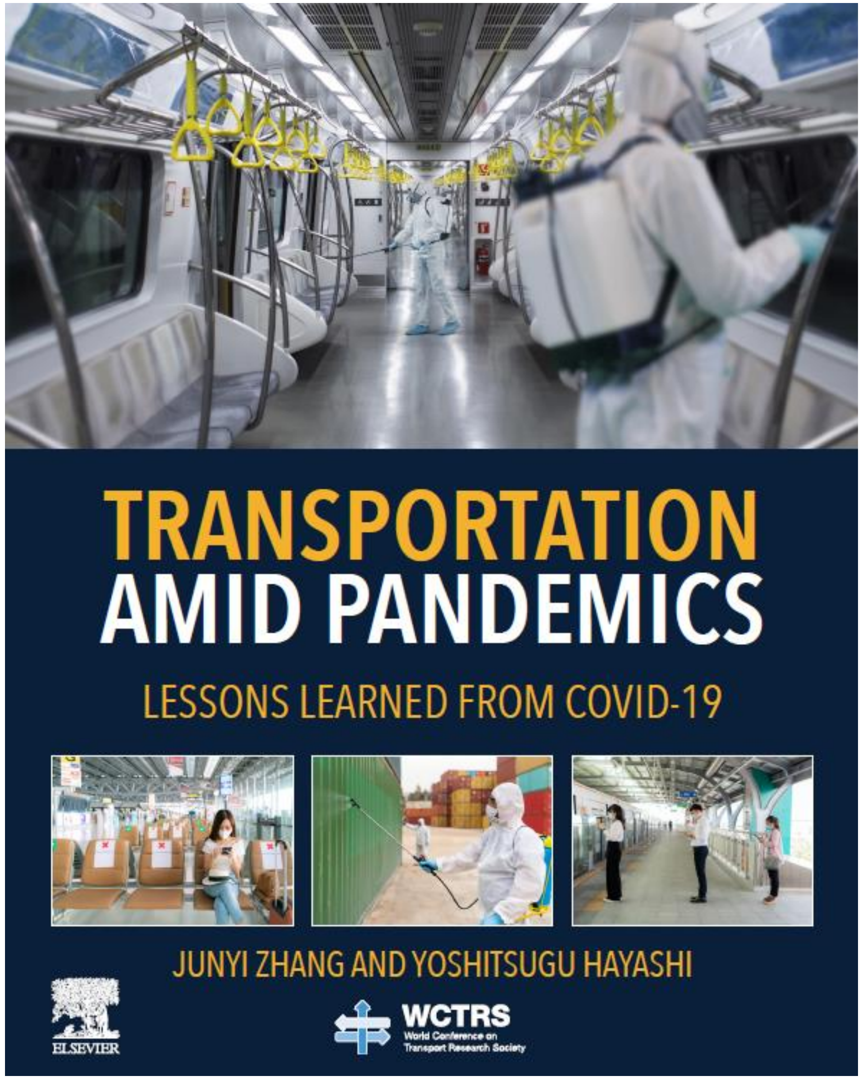


As a part of a project "Road networks and transport centers for an effective logistics system", sponsored by the Ministry of Land, Infrastructure, Transport and Tourism, Japan, 2022-2024 (Led by Junyi Zhang)

HEARTY City

Challenging a realistic future city

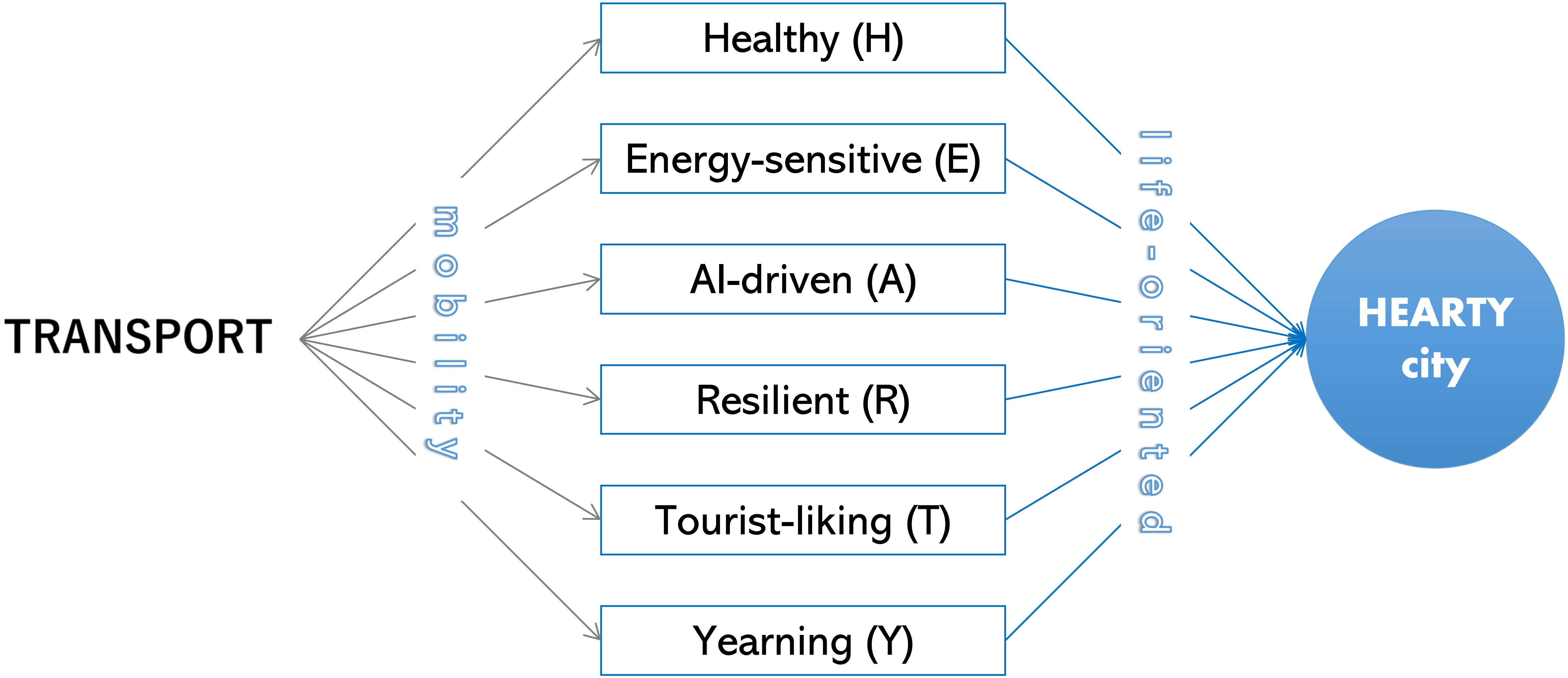
Junyi Zhang



All lessons learned from history and from the current COVID-19 pandemic suggest that

we, as human beings, should be kinder to nature, and that each of us should be kinder to each other.

HEARTY City


TRANSPORT
mobility
Healthy (H)
Energy-sensitive (E)
AI-driven (A)
Resilient (R)
Tourist-liking (T)
Yearning (Y)
life-oriented
HEARTY city

Q & A

For a transdisciplinary research future

zjy890321@seu.edu.cn

Books on COVID-19 and transport

Published

- Junyi ZHANG, Yoshitsugu Hayashi (2022) Transportation Amid Pandemics: Lessons Learned from COVID-19. Elsevier (September 2022)

Underwriting/editing

- Junyi ZHANG et al. (2023) Research Handbook on Transport and COVID-19. Edward Elgar Publishing (welcome contribution)
- Junyi ZHANG, et al. (2023) COVID-19 & Pandemics, Lifestyles, and the Built Environment: A Perspective of Planetary Health, Springer (welcome contribution)

Travel behavior research in key universities of China

(In alphabetic order)

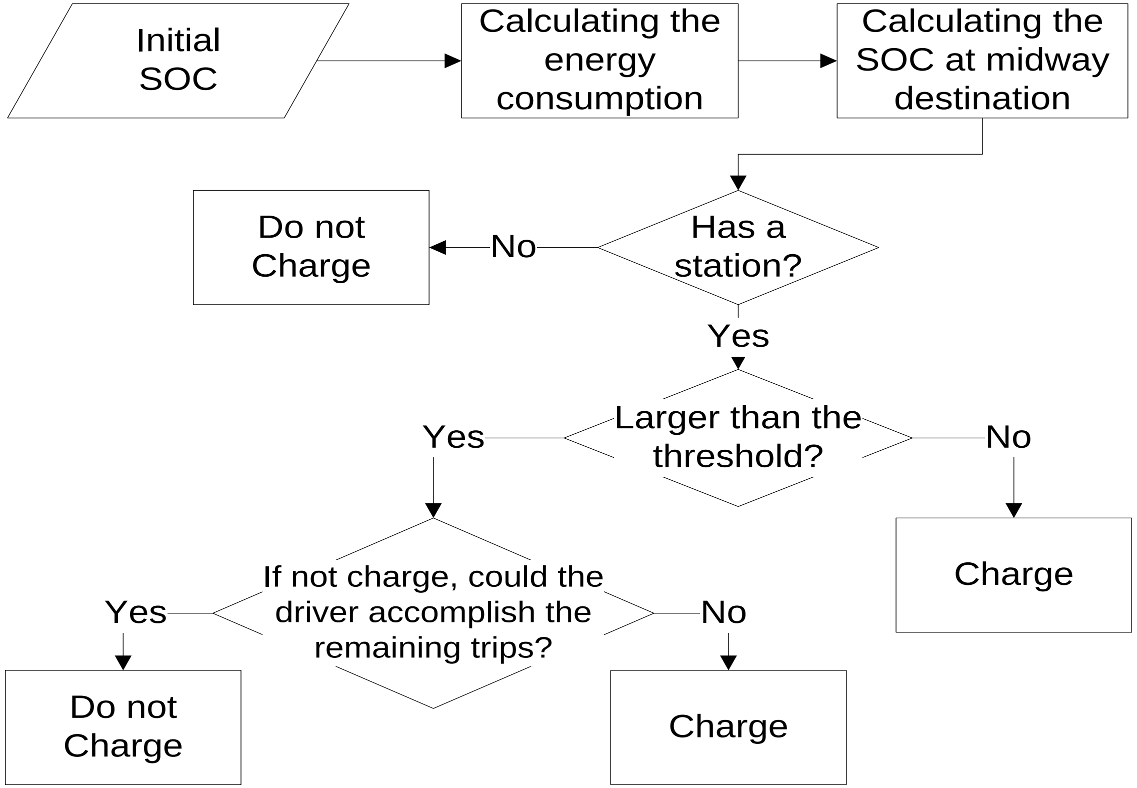
- Beihang University
- Beijing Jiaotong University
- Southeast University
- Tongji University

Beihang University: Haijun Huang's lab

- Origin-Destination matrix estimation
- Traffic assignment with elastic demand or constraints
- Combined trip distribution and assignment models
- Dynamic TA, evolution from disequilibrium to equilibrium
- Stochastic user equilibrium (logit or probit based)
- Upper bound of difference betwee UE and SO
- Mixed TA model (some UE and some SO)
- Use pricing scheme to implement SO
- Realize SO through information induction
- Bicriteria TA (time-based and cost-based)
- TA with multiple or heterogeneous users
- Mixed TA (some with autonomous vehicles, some non)
- TA combined with parking
- Activity-based TA models
- Evaluate the effects of information release
- Traffic network design, bi-level programming
- Location of monitoring devices and EV charging stations
- Carpool, HOV, shared travel
- Transportation issues of urban agglomeration
- Bottleneck models, corridor problem
- Operation of shared mobility, online car-hailing platforms
- Car following models, stability analysis, overtaking
- LWR equation + Acceleration dynamic equation
  - Muti-lane road, mixed flow, shock wave formation and dissipation, perturbation propagation, consequences of changing lanes, influences of driver personality (conservative, risky, learning ability, memory and prediction ability)
- Cellar automata (CA) models
- Pedestrian moving model
- Evacuation model
- Aircraft and subway train boarding model (using CA or improved DTA together with LWR)

A Location Model of EV Public Charging Station Considering Drivers' Daily Activities and Range Anxiety: A Case Study of Beijing (Long Pan, Enjian Yao)

- A charging decision model considering daily activities and range anxiety



□ **Two main assumptions**
1. Keep a comfortable range
2. Maintain daily trips and activities under current time schedule

- A location model of EV public charging stations aiming at accomplishing more daily activities of EV drivers

$$\min f(x) = \sum_j Y_j$$ (Minimize the entire missed trips of all the drivers)

subject to:

(1) $Y_j = \sum_{k=1}^{K_j} y_j(k)$

(2) $\sum_{i \in I} x_i = p$

(3) $E_j(k) = \min((1 - SOC_j(k)) \cdot BC_j, P_i t_j(k))$

(4) $SOC_j(k) = SOC_j(k-1) + \dfrac{E_j(k-1) - EC_j(k)}{BC_j}$

(5) $EC_j(k) = d_j(k) \cdot EF_j$

□ **Constraints:**
Number of charging stations is fixed
Maximum of utilizing parking time
SOC balance equation
Calculation of trip energy cost

□ **Solving Algorithm**
Integer programming problem
Genetic Algorithm (GA)

A Location Model of EV Public Charging Station Considering Drivers' Daily Activities and Range Anxiety: A Case Study of Beijing (Long Pan, Enjian Yao)

Case study

Area	430.8 km^2
Population	3.28 million

- **Data**

Obtained by Beijing Household Survey in 2014 (40,000 families with their trips)

- **Study Area**

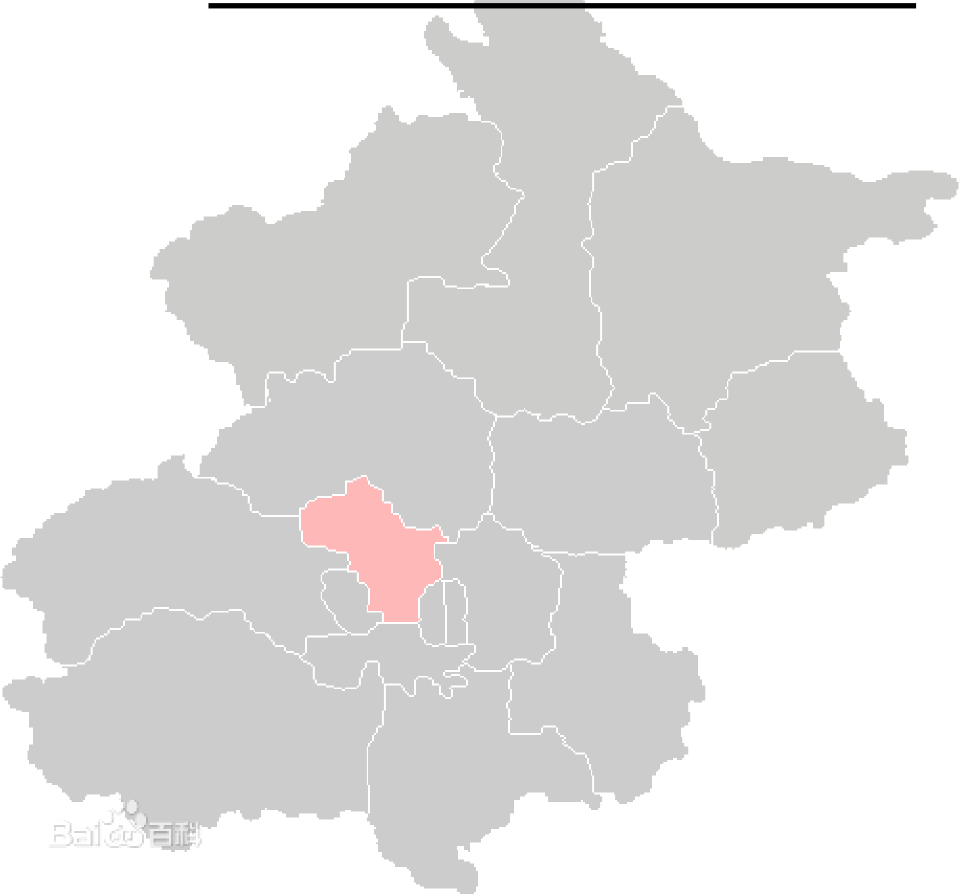
Haidian District of Beijing,184 Traffic Analysis Zones

- **Study Database**

Extract drivers having destinations in the study area

sample rate ⇩ EV adoption rate

2,500 EV drivers with 6,000 trips



Beijing Jiaotong University: Enjian Yao's lab

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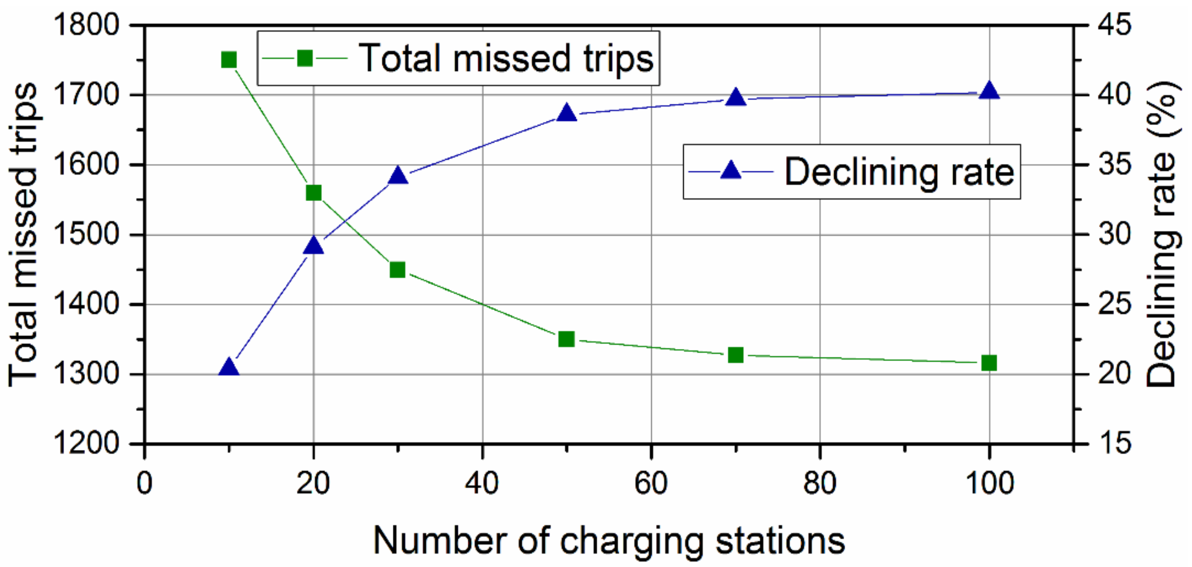
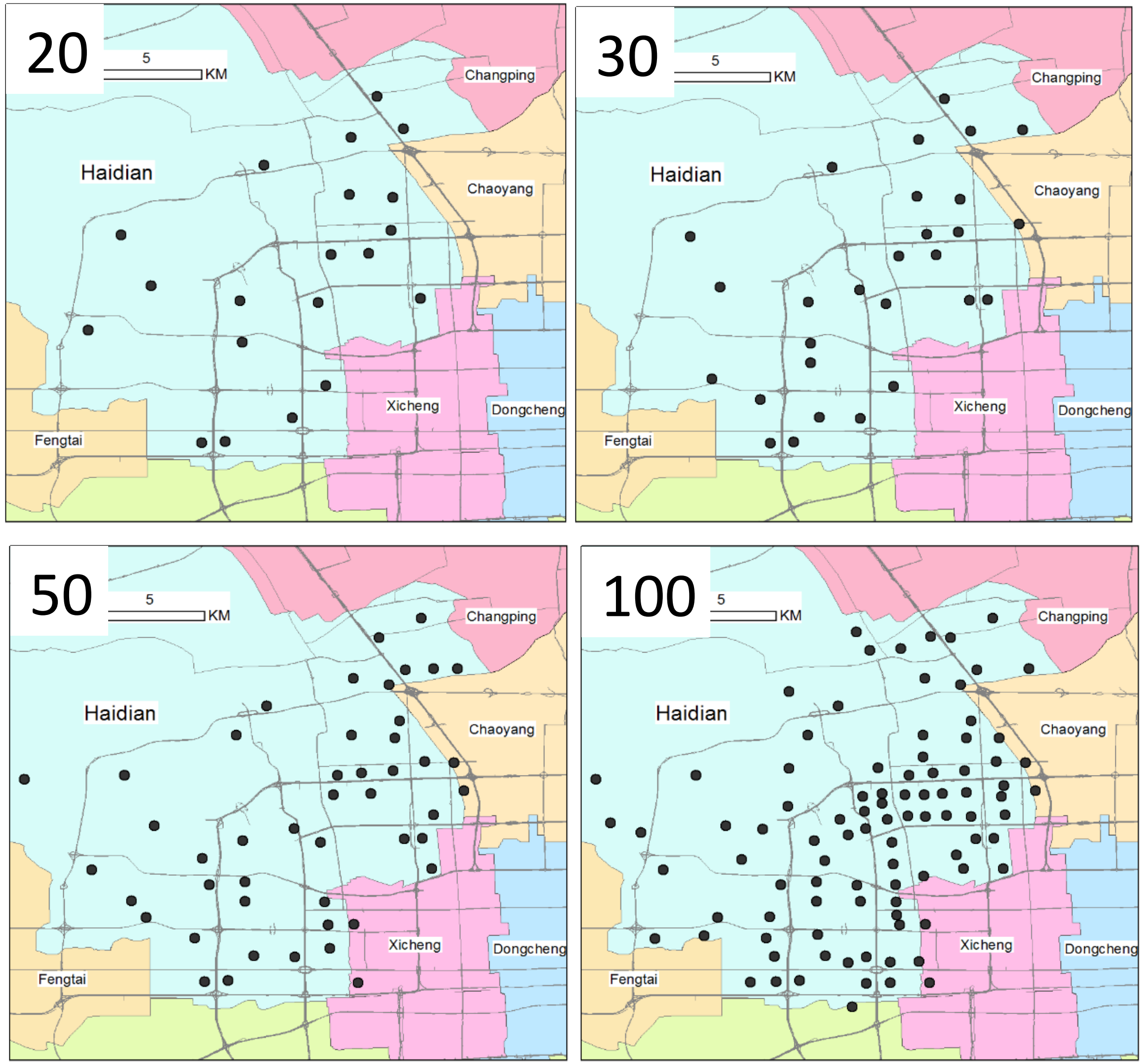
A Location Model of EV Public Charging Station Considering Drivers' Daily Activities and Range Anxiety: A Case Study of Beijing (Long Pan, Enjian Yao)





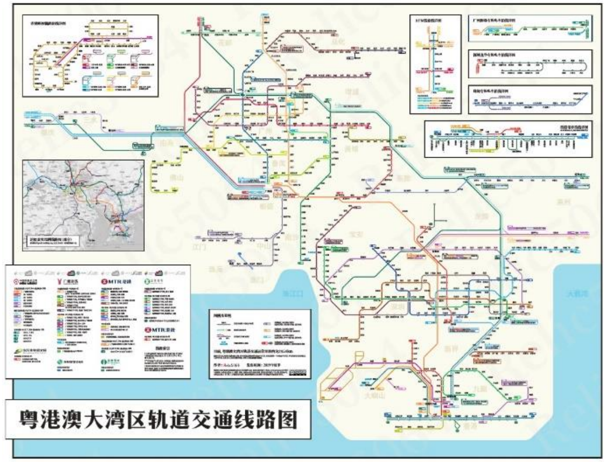
- ✓ Installing more stations could effectively decrease the missed trips
- ✓ Obey the law of diminishing returns
- ✓ Missed trips still exist even with a large number of charging stations

Beijing Jiaotong University: Enjian Yao’s lab

Metro demand forecasting and passenger flow control based on Multi source data
(Enjian Yao, Ning Huan, Yongsheng Zhang)

New trend: integrated rail system

Metro + rapid metro + intercity metro + rail



With the integration of rail systems, the ridership will continue increasing.

Passenger flow control becomes regular

Morning (7:00-9:00)

Mainly at residential area

Afternoon (5:30-8:30)

Mainly at workplaces

Entrance

Security check

Turnstile

Transfer tunnel

measures

Metro demand forecasting and passenger flow control based on Multi source data
(Enjian Yao, Ning Huan, Yongsheng Zhang)

Passenger Flow Forecasting

Integrated estimation

Entry/Exit volume
- **Accessibility analysis**
- **Historical data**

Accessibility Measure： Logsum Value
ARIMA model, Bayesian estimation, deep learning method

OD distribution
- **Destination choice model**
- **Logit model**

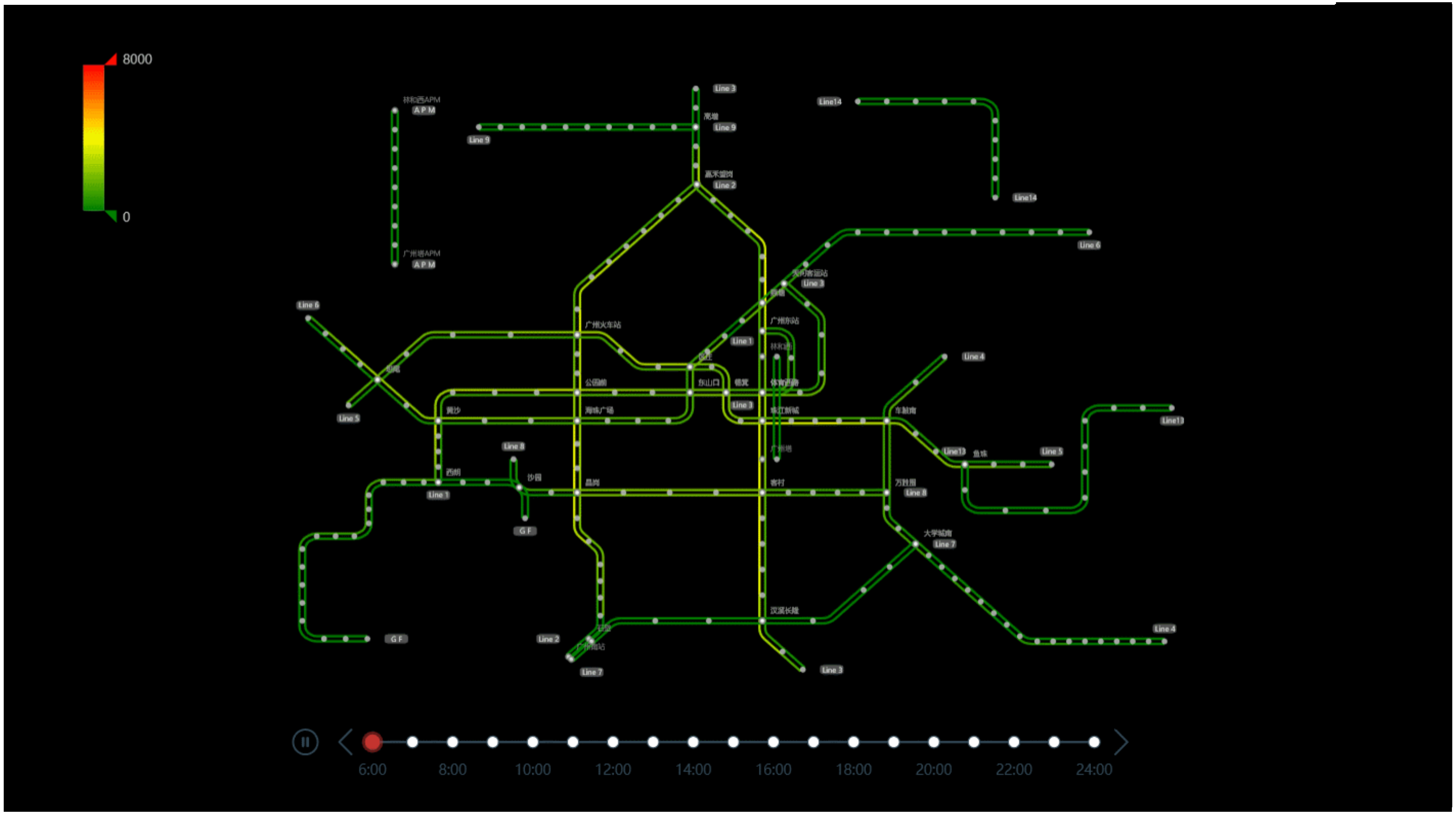
WESML：
Aggregated Data → Disaggregated Data → Choice model

Passenger flow assignment
- **Route choice model**
- **Flow assignment model**

Metro users' choice preference

Beijing Jiaotong University: Enjian Yao's lab

Metro demand forecasting and passenger flow control based on Multi source data (Enjian Yao, Ning Huan, Yongsheng Zhang)



Southeast University

Dawei LI

■Behavioral modeling in China: passenger choice

➢ Passenger choice behavior of carpool drivers

- ➢ The platform was accused of providing an opportunity for prospective criminals to **exploit sensitive passenger information** after two criminal cases happened in May and August 2018.
- ➢ A stated preference (SP) survey was conducted to explore the carpool drivers' passenger choice behavior.
- ➢ Findings:
  - ➢ The carpooling service seemed like a platform to make social contact for specific drivers;
  - ➢ Gender, age, and appearance discrimination existed when choosing passengers;
  - ➢ Sharing a trip with people they prefer is much more important than earning a little more money.

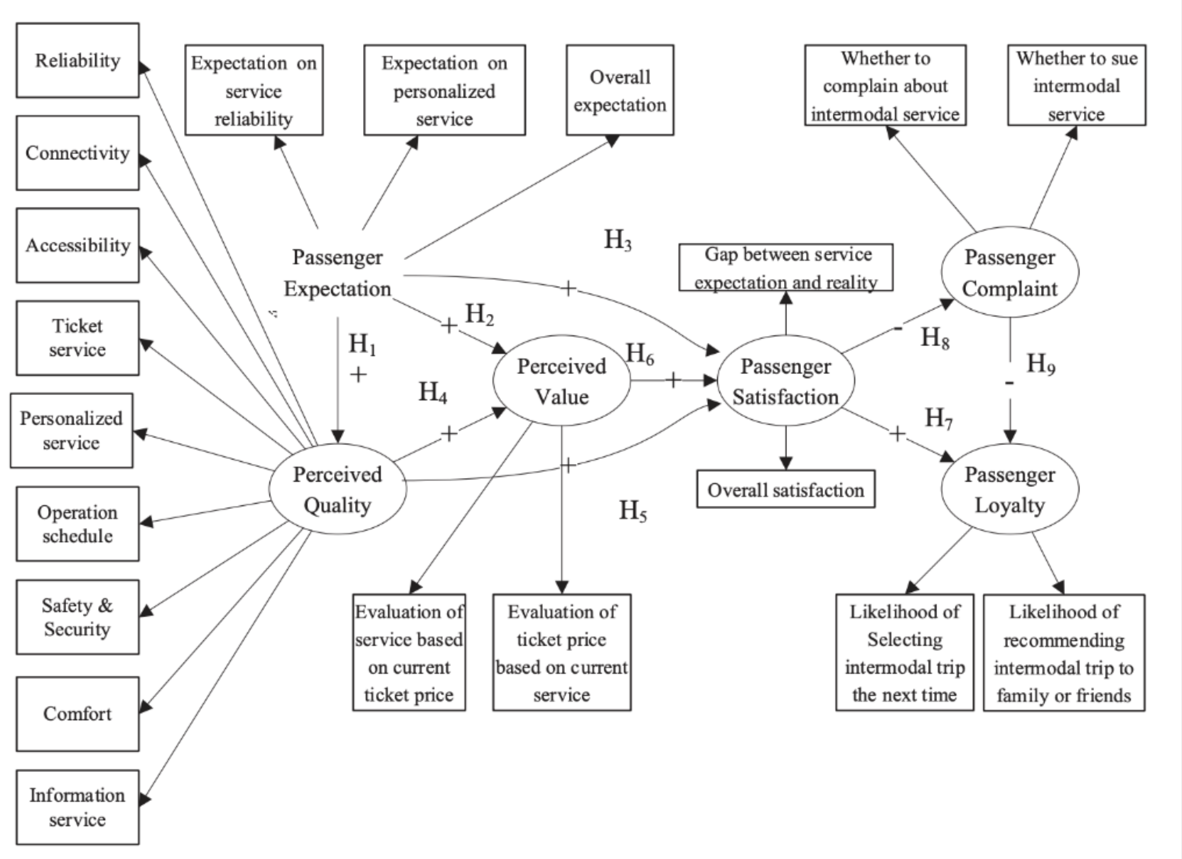
Passenger selection interface of DiDi platform before 2018

Li, D., Song, Y., Liu, D., Cao, Q., & Chen, J. (2023). How carpool drivers choose their passengers in Nanjing, China: effects of facial attractiveness and credit. *Transportation*, *50*(3), 929-958.

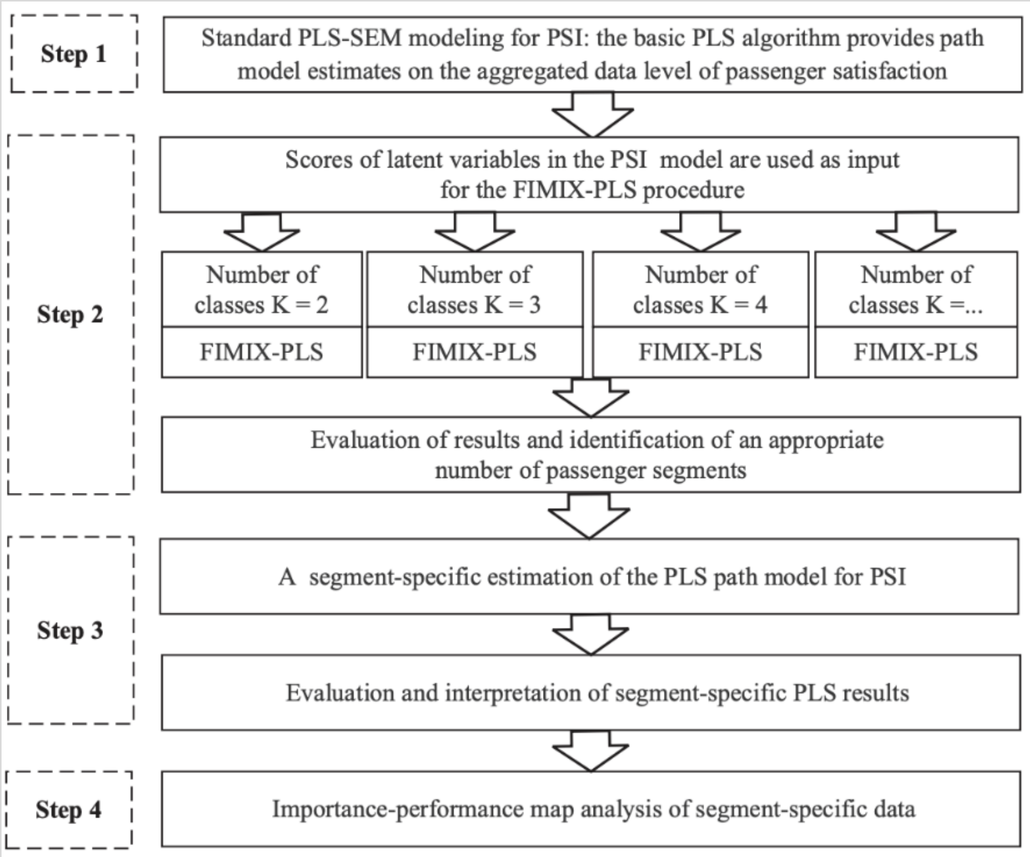
Behavioral modeling in China: travel mode choice

- Heterogeneity in passenger satisfaction with air-rail integration services

Conceptual framework of passenger satisfaction index (PSI) model



Analytical procedures of finite mixture partial least squares method

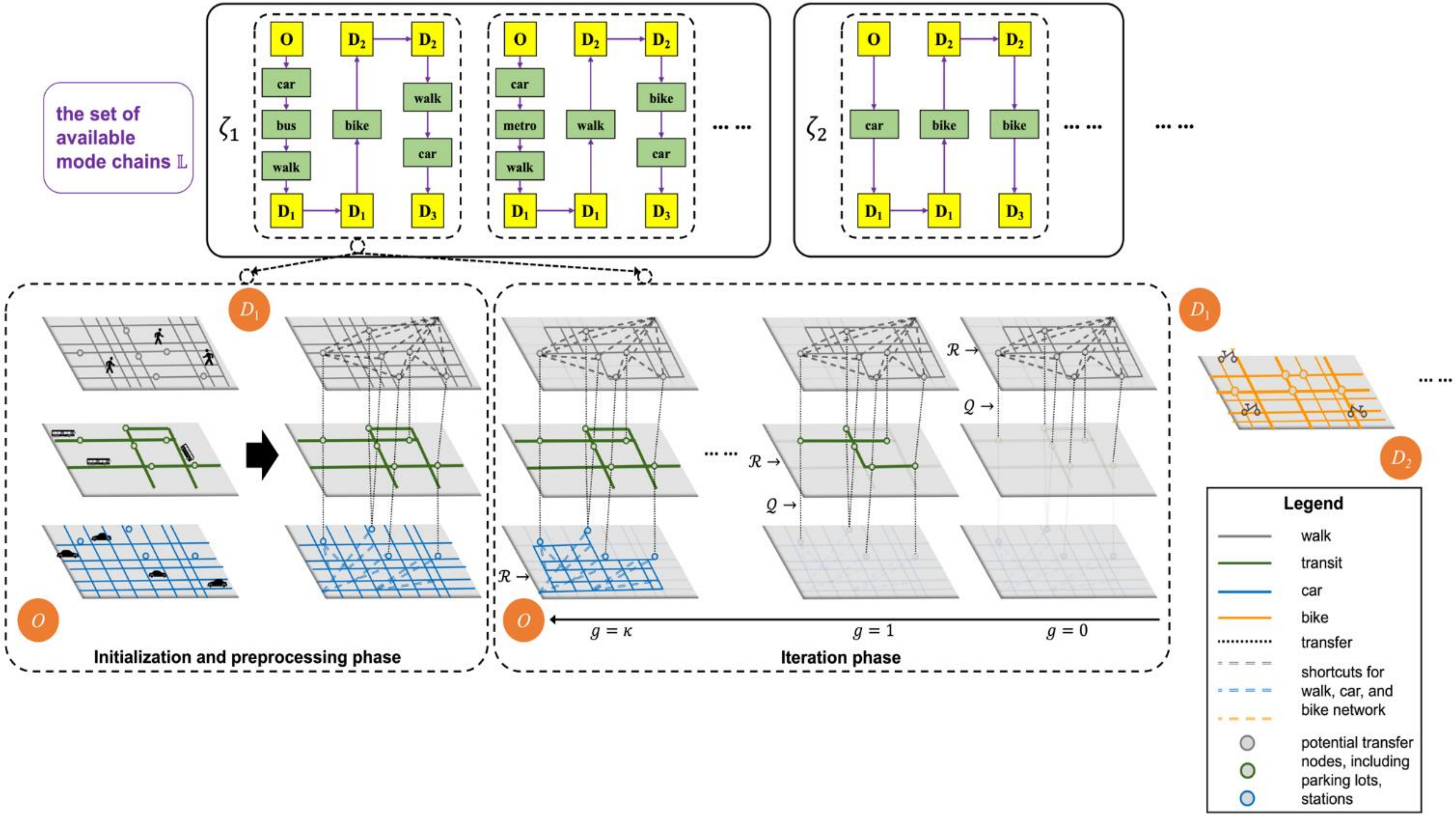


Yuan, Y., Yang, M., Feng, T., Rasouli, S., Li, D., & Ruan, X. (2021). Heterogeneity in passenger satisfaction with air-rail integration services: Results of a finite mixture partial least squares model. *Transportation Research Part A: Policy and Practice*, *147*, 133-158.

Behavioral modeling in China: travel mode choice

Tour-based mode chain modeling and multi-modal path planning

- Dynamic discrete choice model for mode chain choice
- User-constrained shortest hyperpath algorithm for multi-modal path planning
- They can be used as the recommended system in the MaaS platform.

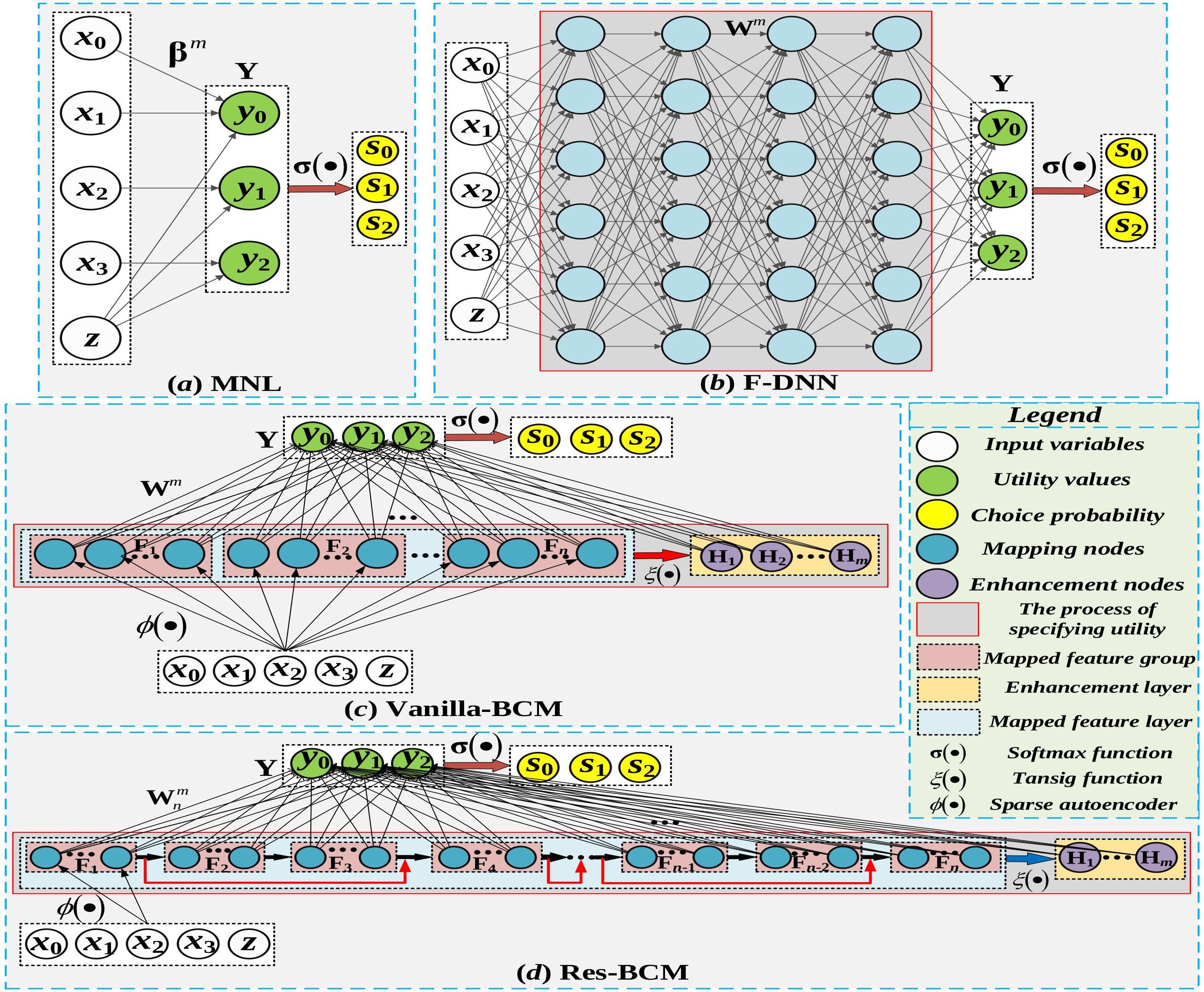


Song, Y., Li, D., Cao, Q., Yang, M., & Ren, G. (2021). The whole day path planning problem incorporating mode chains modeling in the era of mobility as a service. *Transportation Research Part C: Emerging Technologies*, *132*, 103360.

Behavioral modeling in China: travel mode choice

➢ Broad learning system (BLS) for choice modeling

- Explore the fast training of DCMs on large-scale samples, and introduces a novel concept of Broad Choice Model (BCM) for the first time.
- Complement and enhance the dynamic inference properties of traditional DCMs and recently developed deep choice models on time-varying continuous data streams.
- Provide a novel solution to address the unreliable interpretation information obtained by deep choice models from smaller-scale data.

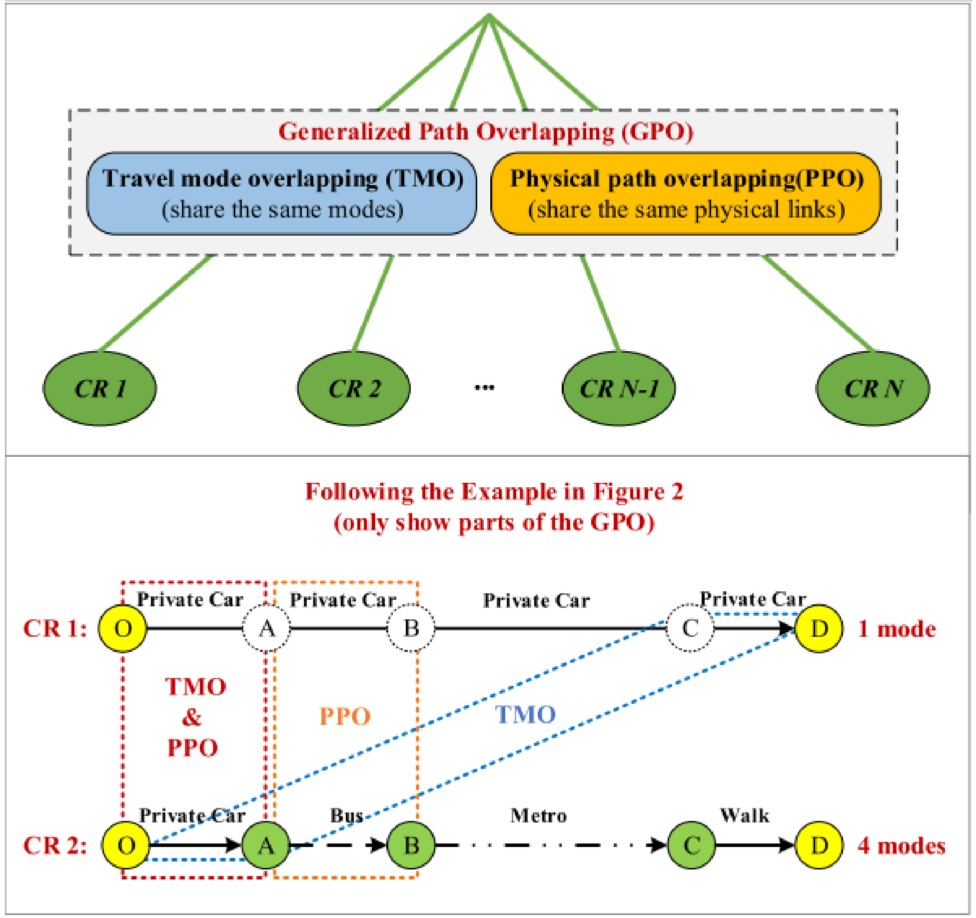


Liu, D., Li, D., Song, Y., Kun, G., & Zhang, T. (2023). An Interpretable Broad Choice Model for Enhancing the Computational Efficiency, Predictive Performance and Dynamic Inference of Discrete Choice Models. *Travel Behaviour and Society*.

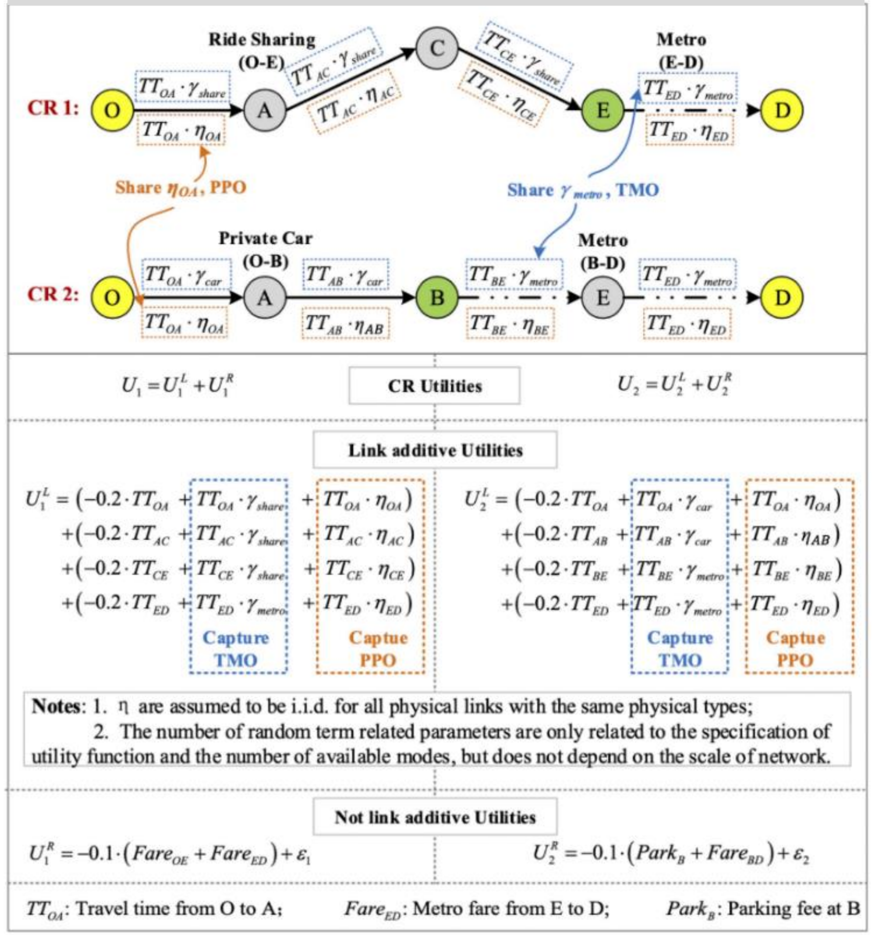
■ Behavioral modeling in China: route choice

➢ Correlations in multi-modal route choice modeling

Generalized path overlapping problem



Multi-modal logit kernel model

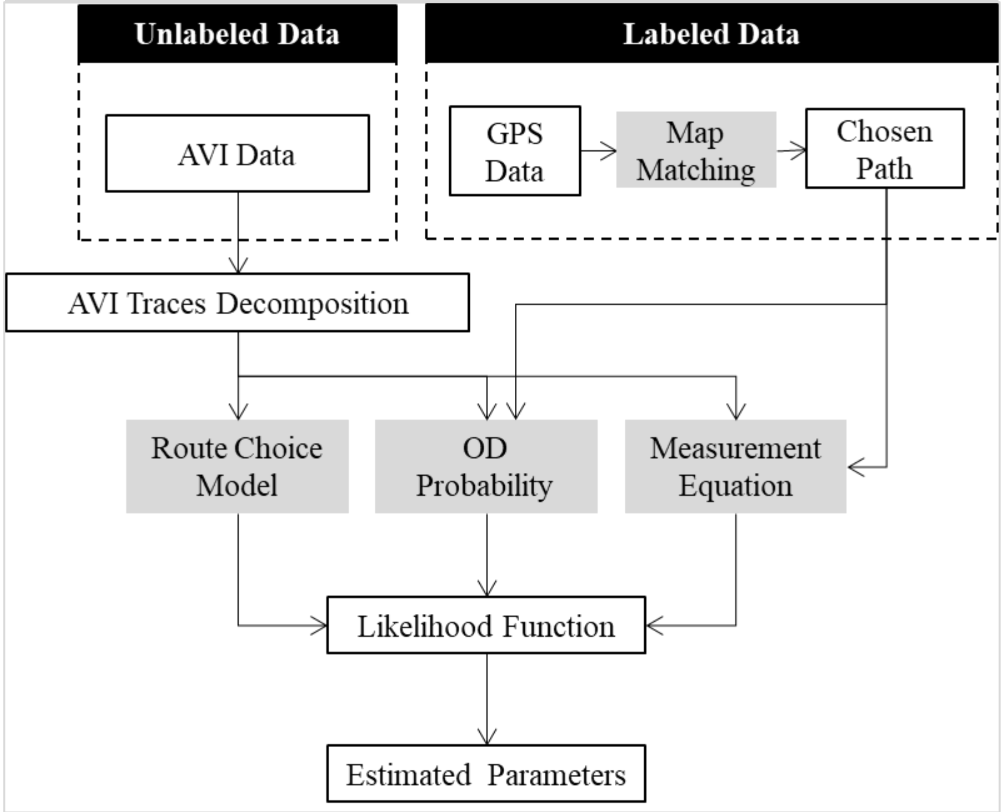


Li, D., Yang, M., Jin, C. J., Ren, G., Liu, X., & Liu, H. (2020). Multi-modal combined route choice modeling in the MaaS age considering generalized path overlapping problem. *IEEE Transactions on Intelligent Transportation Systems*, *22*(4), 2430-2441.

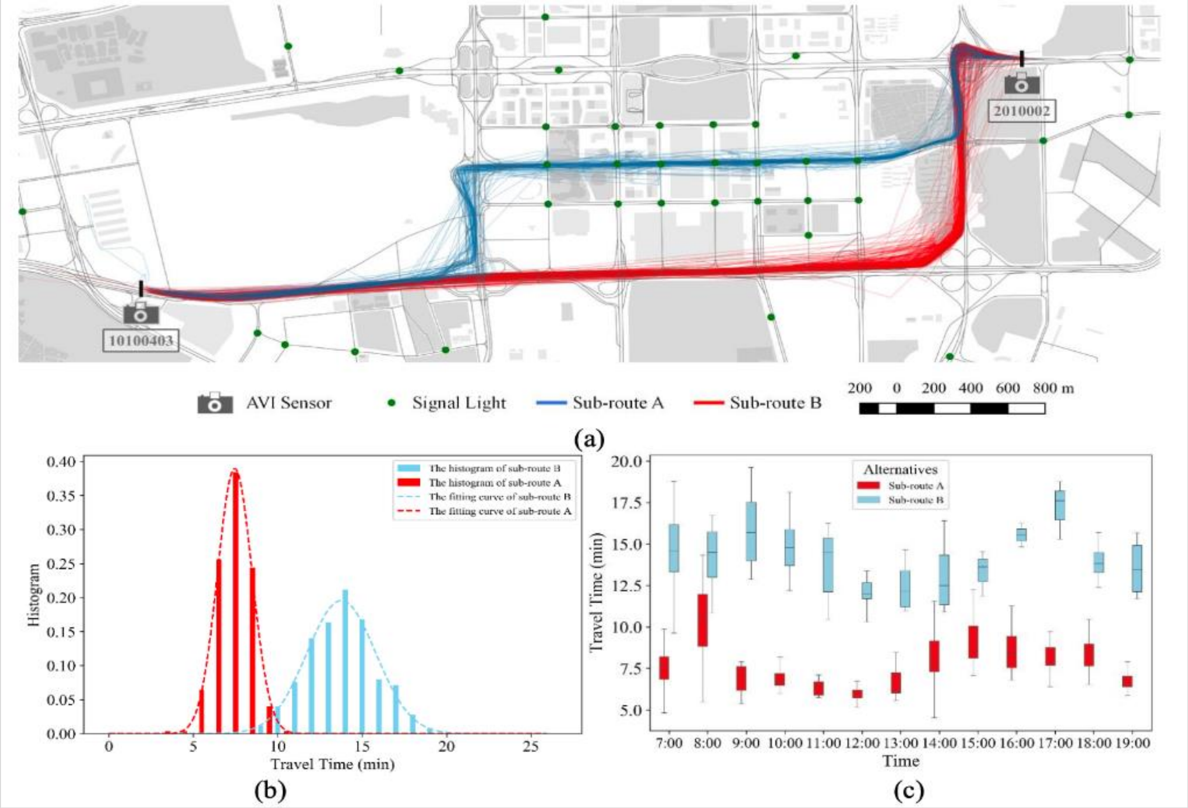
Behavioral modeling in China: route choice

- Route choice modeling with sparse Automatic Vehicle Identification (AVI) data

Conceptual framework of Semi-supervised model



The construction of measurement equation in likelihood function using GPS samples



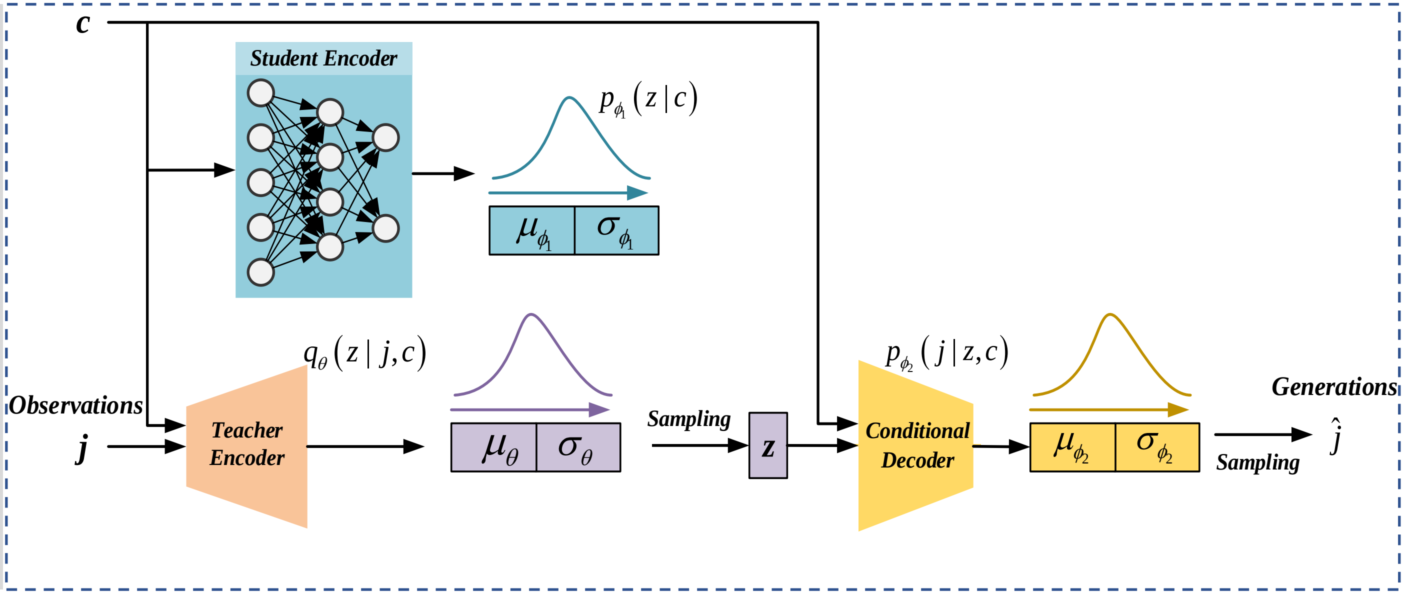
Cao, Q., Ren, G., Li, D., Ma, J., & Li, H. (2020). Semi-supervised route choice modeling with sparse Automatic vehicle identification data. *Transportation Research Part C: Emerging Technologies*, *121*, 102857.
Cao, Q., Ren, G., Li, D., Li, H., & Ma, J. (2021). Map matching for sparse automatic vehicle identification data. *IEEE Transactions on Intelligent Transportation Systems*, *23*(7), 6495-6508.

Behavioral modeling in China: route choice

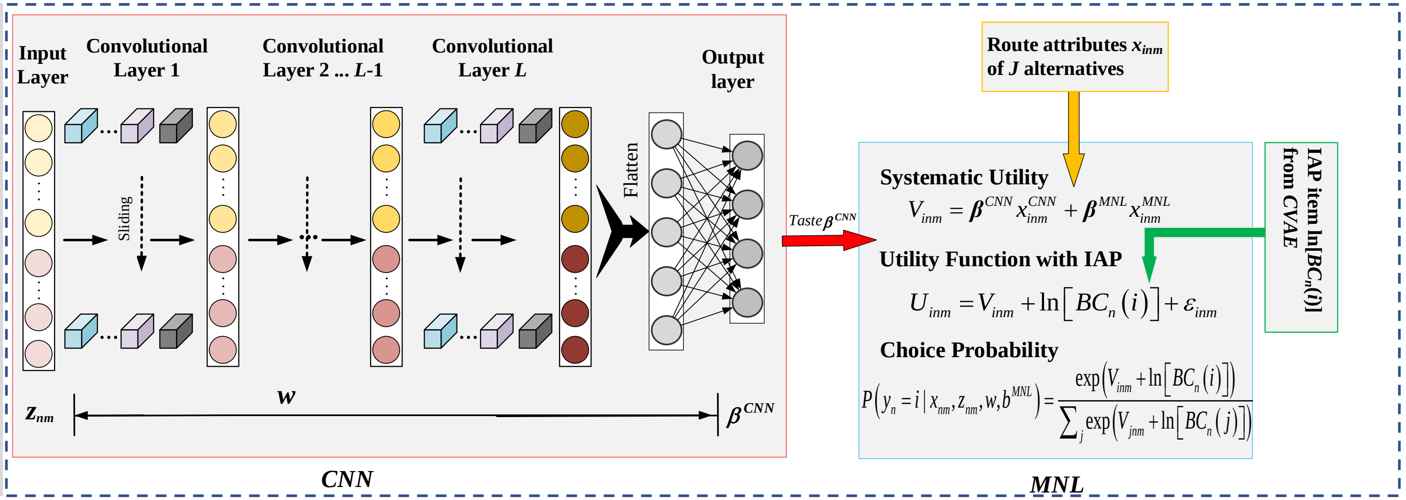
- Data- and knowledge-driven approach choice-set generation and route choice modeling

  - Conditional Variational Autoencoder (CVAE) is used for route choice-set generation.
  - A novel approach integrating Convolutional Neural Network and Multinomial Logit is proposed.
  - Proposed data- and knowledge-driven neural-embedded model framework is versatile and equally applicable to other choice modeling tasks that possess different networks and patterns.

CVAE-based route choice-set generation



Route choice modeling integrating DCM and DNN

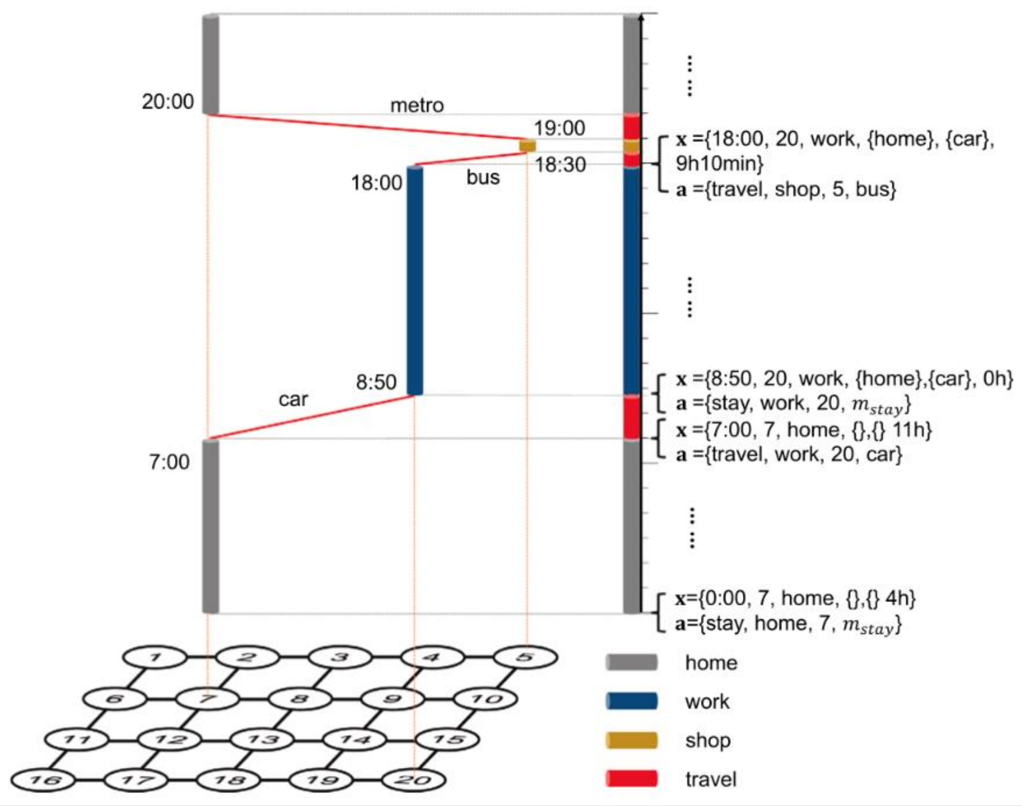


Liu, D., Li, D., Kun, G., Song, Y., & Zhang, T. (2023). Enhancing choice-set generation and route choice modeling with data- and knowledge-driven approach. *Transportation Research Part C: Emerging Technologies*.

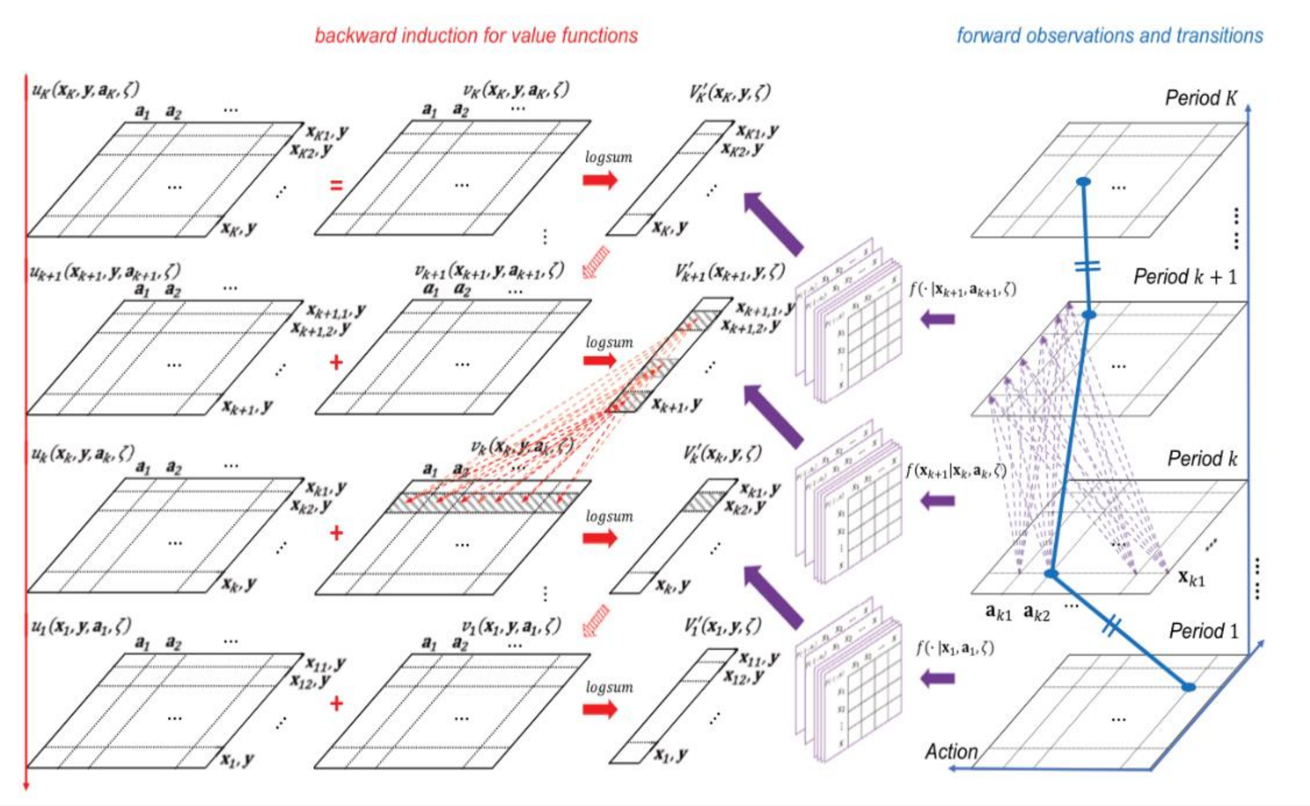
■ Behavioral modeling in China: activity-travel chain choice

➢ Activity-based modeling using dynamic discrete choice methods (DDCM)

Representation of activity-travel chain under a Markov Decision Process



Computation process in DDCM: forward state transition and backward induction



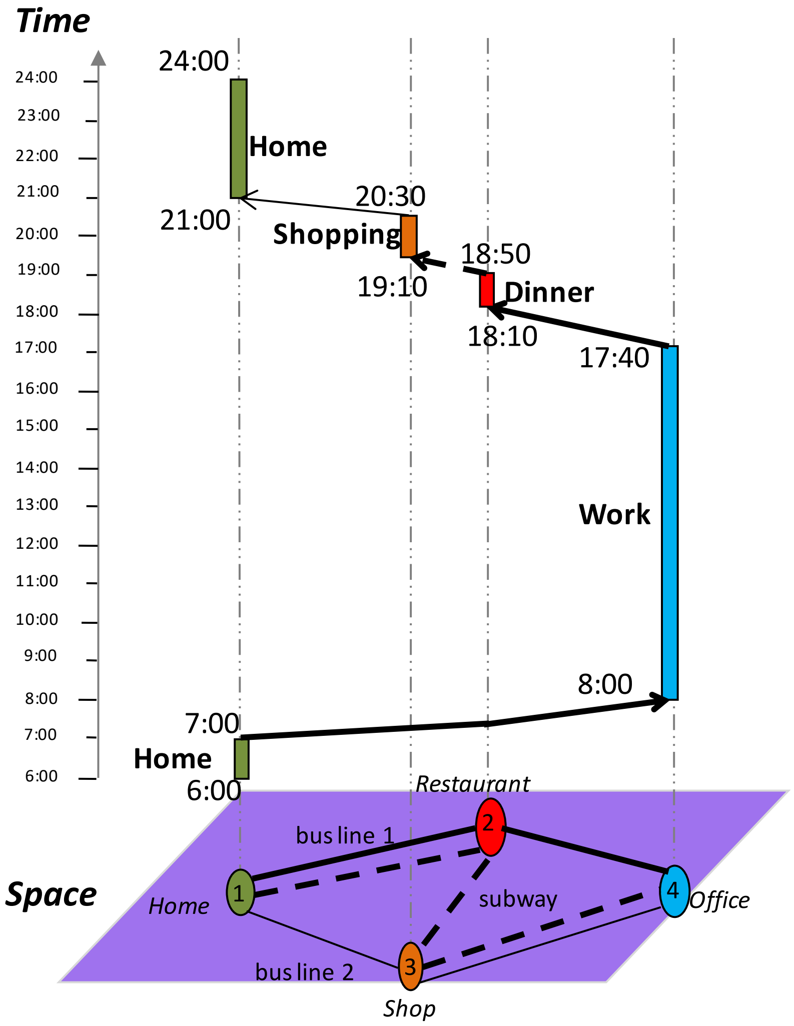
Song, Y., Li, D., Liu, D., Cao, Q., Chen, J., Ren, G., & Tang, X. (2022). Modeling activity-travel behavior under a dynamic discrete choice framework with unobserved heterogeneity. *Transportation research part E: logistics and transportation review*, *167*, 102914.

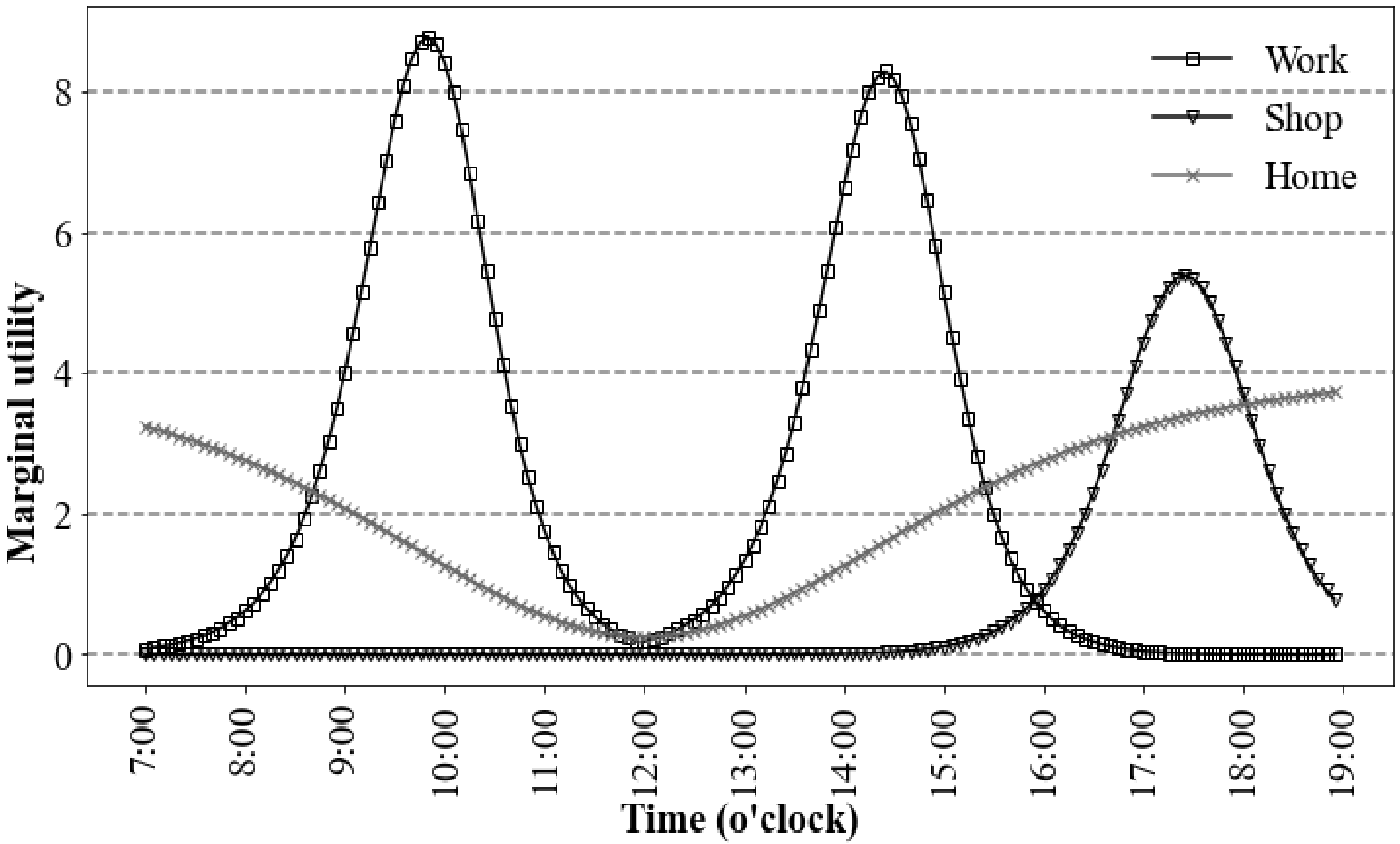
Southeast University

Xiao FU

Activity-travel pattern

Daily Activity-travel Pattern (DATP):

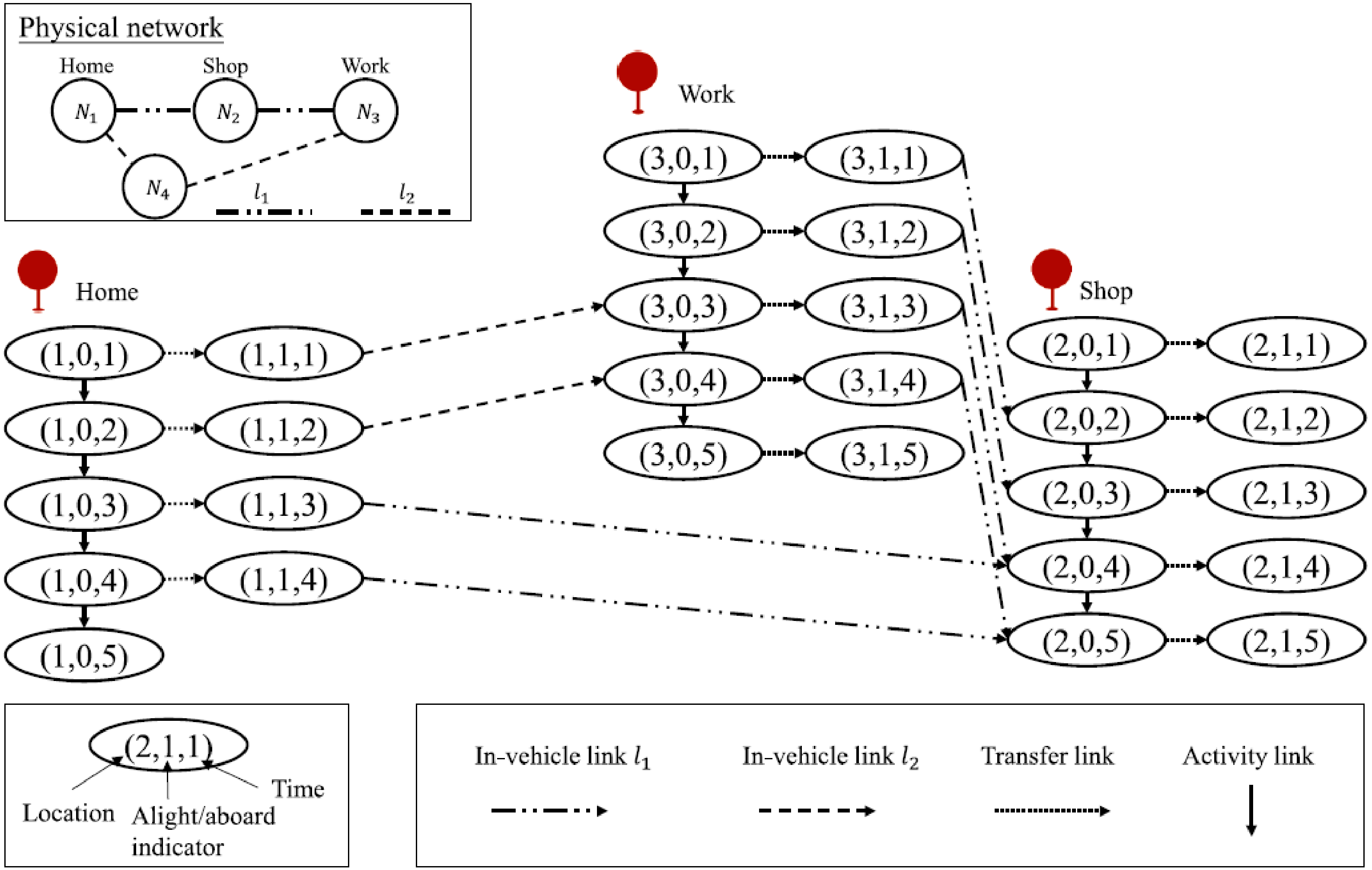




Temporal profiles of individual's marginal activity utility

need to be calibrated with real data

Xiao Fu, Y. Wu, D. Huang, J. Wu, An activity-based model for transit network design and activity location planning in a three-party game framework. *Transportation Research Part E*, 2022.



Travel time of each physical link: 1 interval.

Activity-Time-Space supernetwork

Details of ATS-SAM supernetwork: Fu and Lam (2014, 2018), *Transportation*

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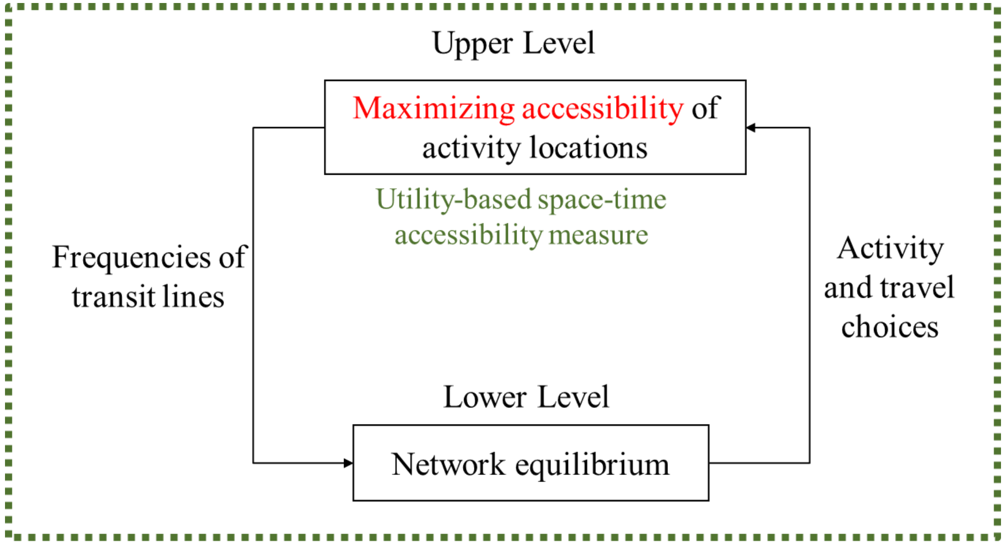
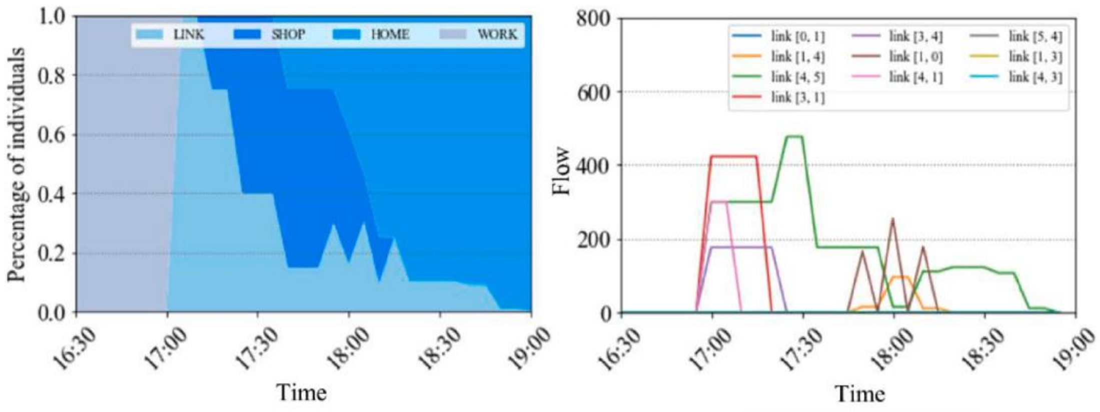
Model：



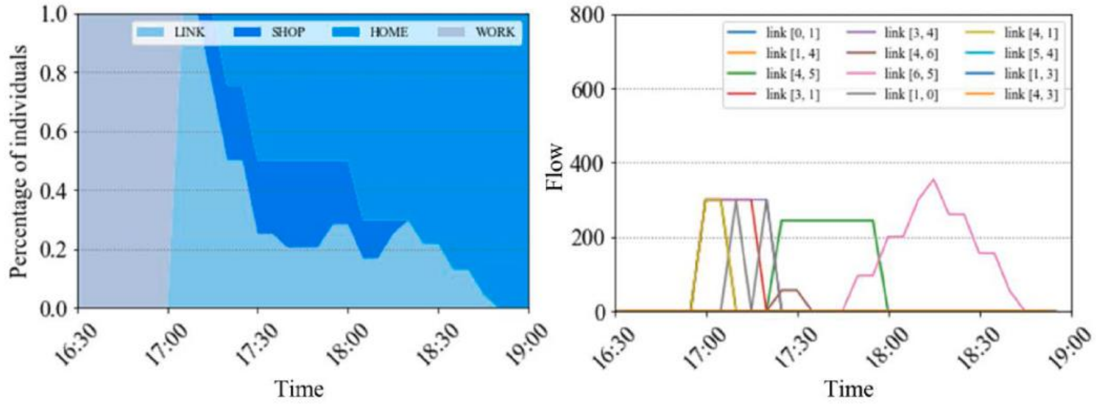
ATS-SAM super-network platform

Fu, Xiao, Y. Wu, D. Huang, Jianjun Wu, An activity-based model for transit network design and activity location planning in a three-party game framework. *Transportation Research Part E*, 2022.
Fu, Xiao, W.H.K. Lam, B.Y. Chen, et al., Maximizing space-time accessibility in multi-modal transit networks: an activity-based approach. *Transportmetrica A: Transport Science*, 2022.

Results：



(a) Scenario 1



(a) Scenario 2

Temporal flow distributions under different activity location plans

Activity-based space-time accessibility under uncertainty

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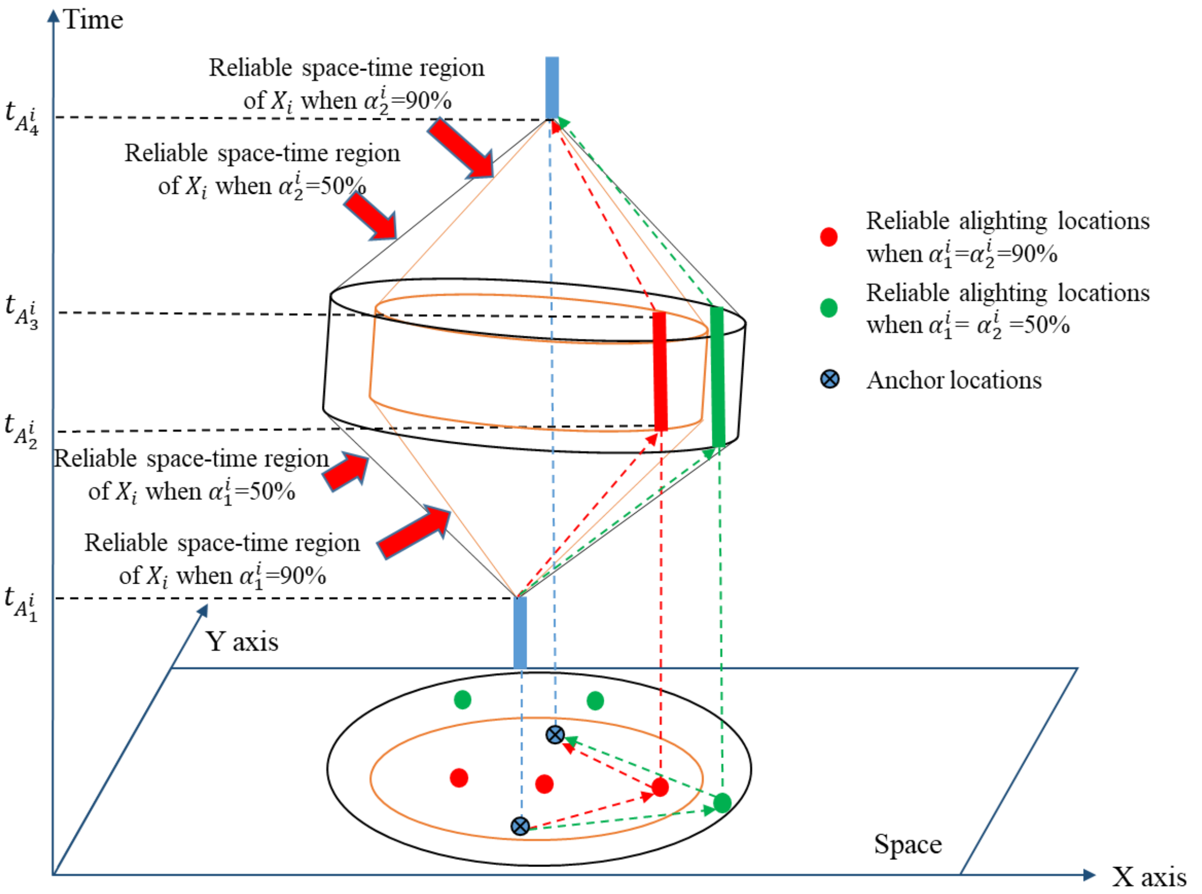
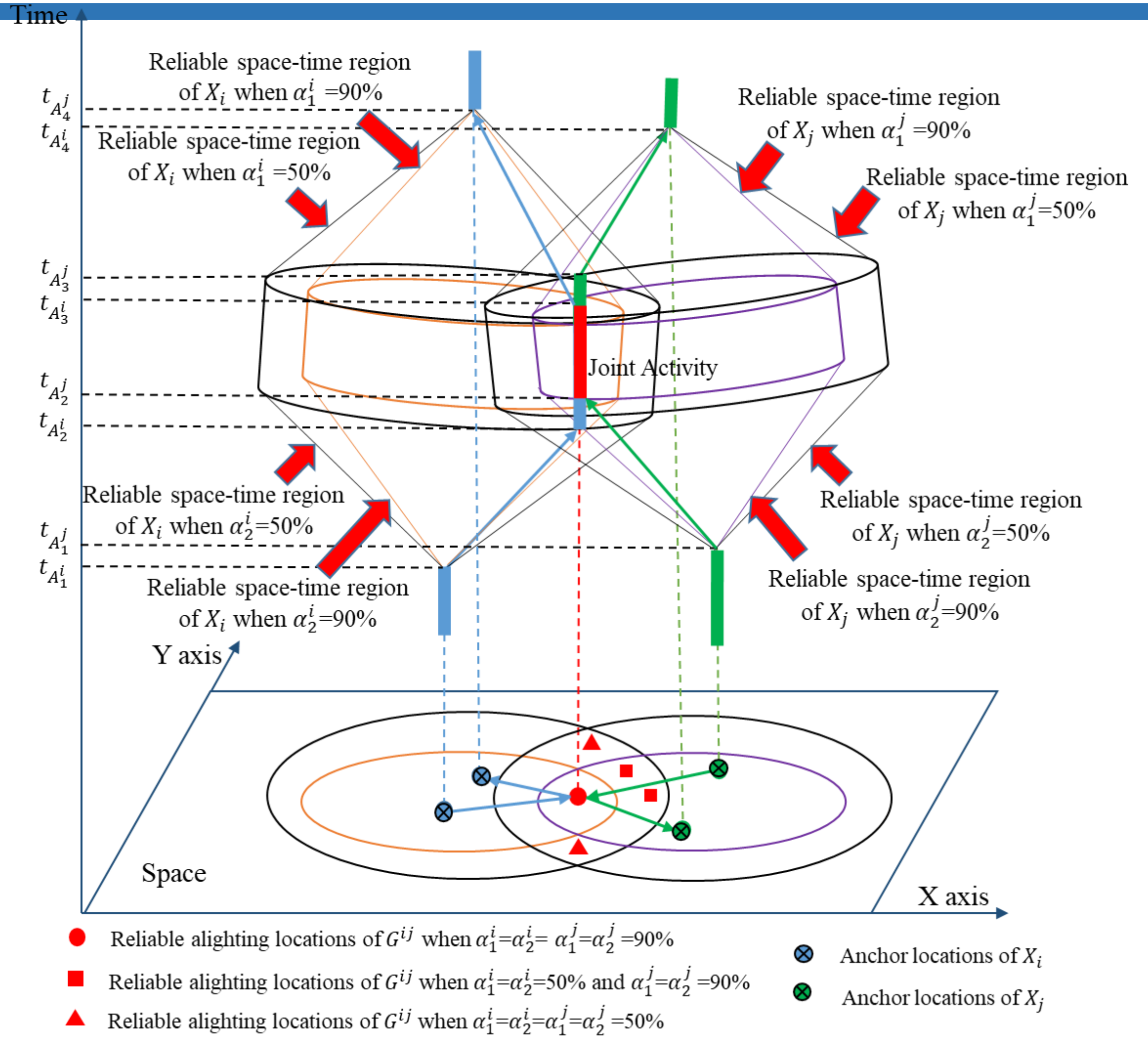


Reliable space-time regions for one individual



Reliable space-time regions for a household

Xiao Fu, Y. Zuo, et al. Measuring joint space-time accessibility in transit network under travel time uncertainty, *Transport Policy*. 2022.

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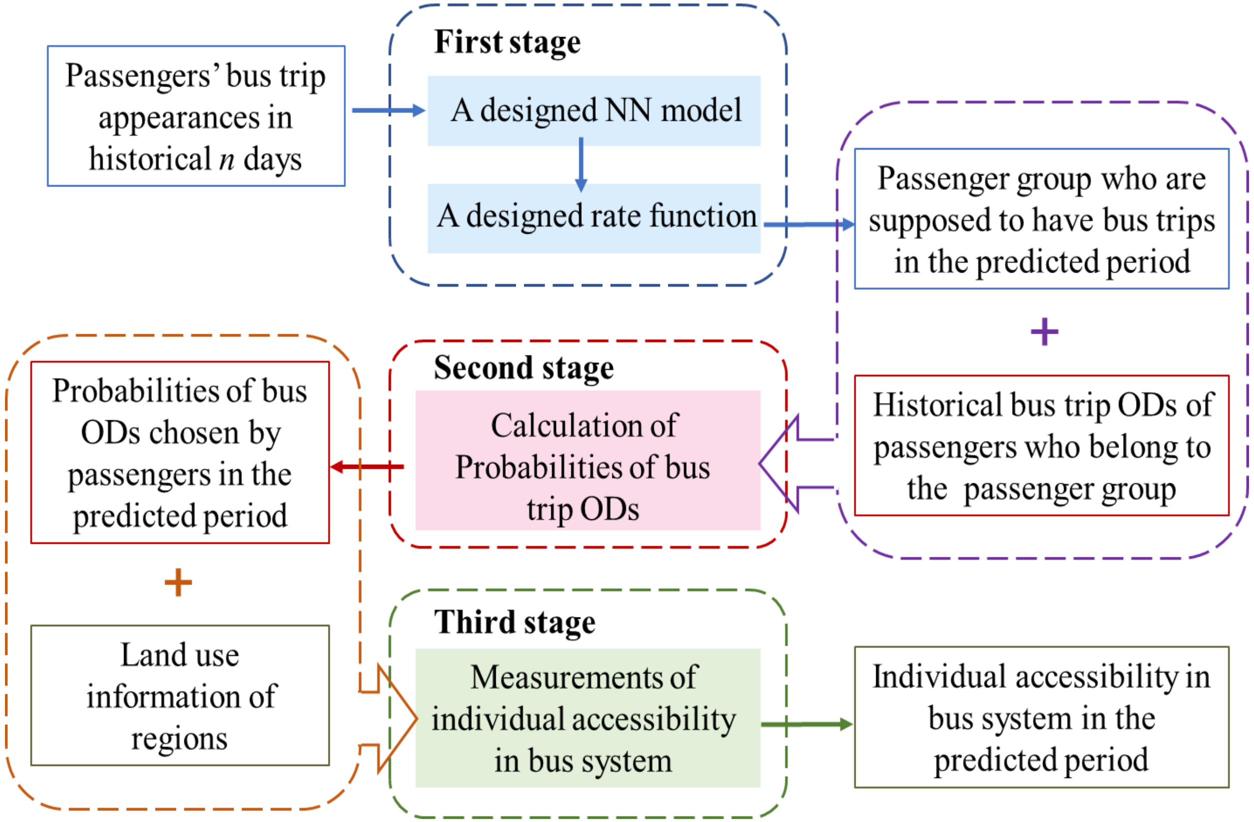
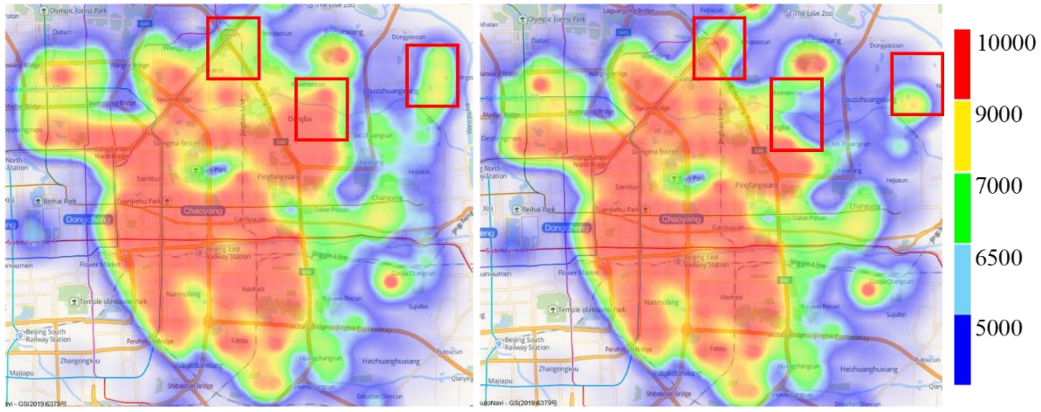
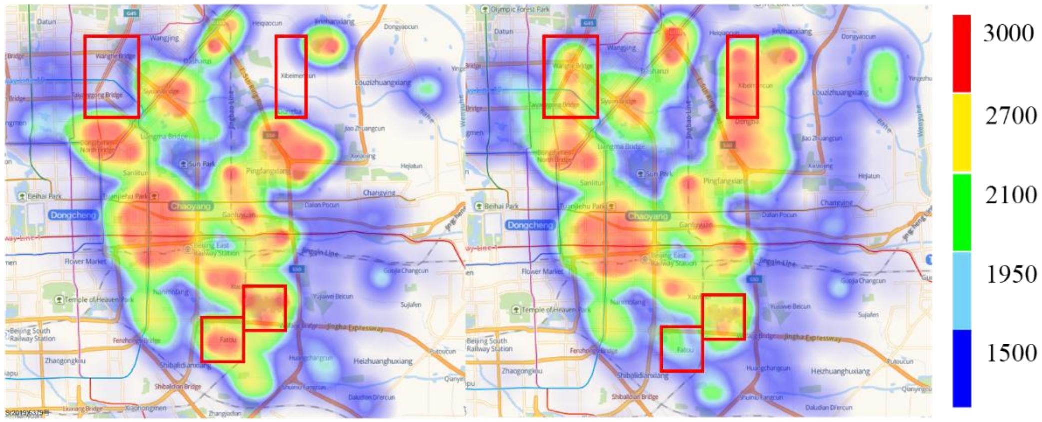
Space-time accessibility prediction based on smart card data





(a) predicted (b) real

Weekday Error: 8.37%



(a) predicted (b) real

Weekend Error: 10.13%

The prediction accuracy is high, and the error is only in the regions with low population density

Zuo, Y., **Fu, Xiao***, et al. 2021. Short-term forecasts on individual accessibility in bus system based on neural network model. *Journal of Transport Geography*, 93.

Junyi Zhang

Data-driven methods for behavioral modelling: Case 2

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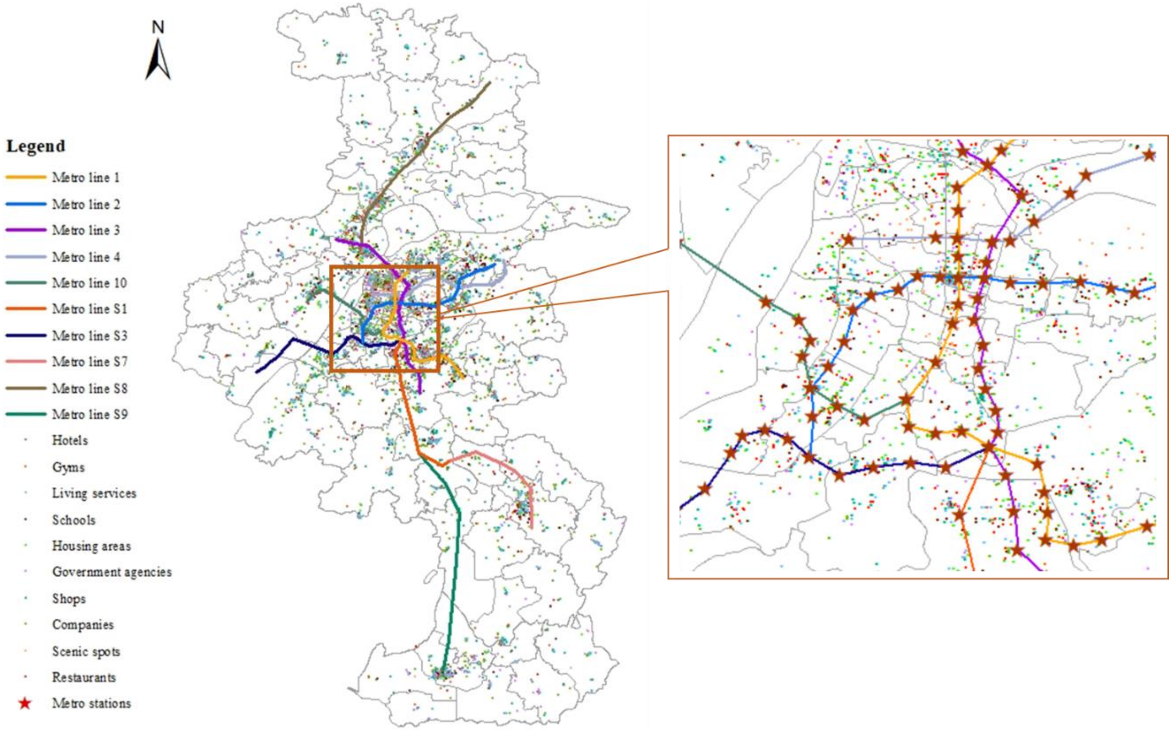
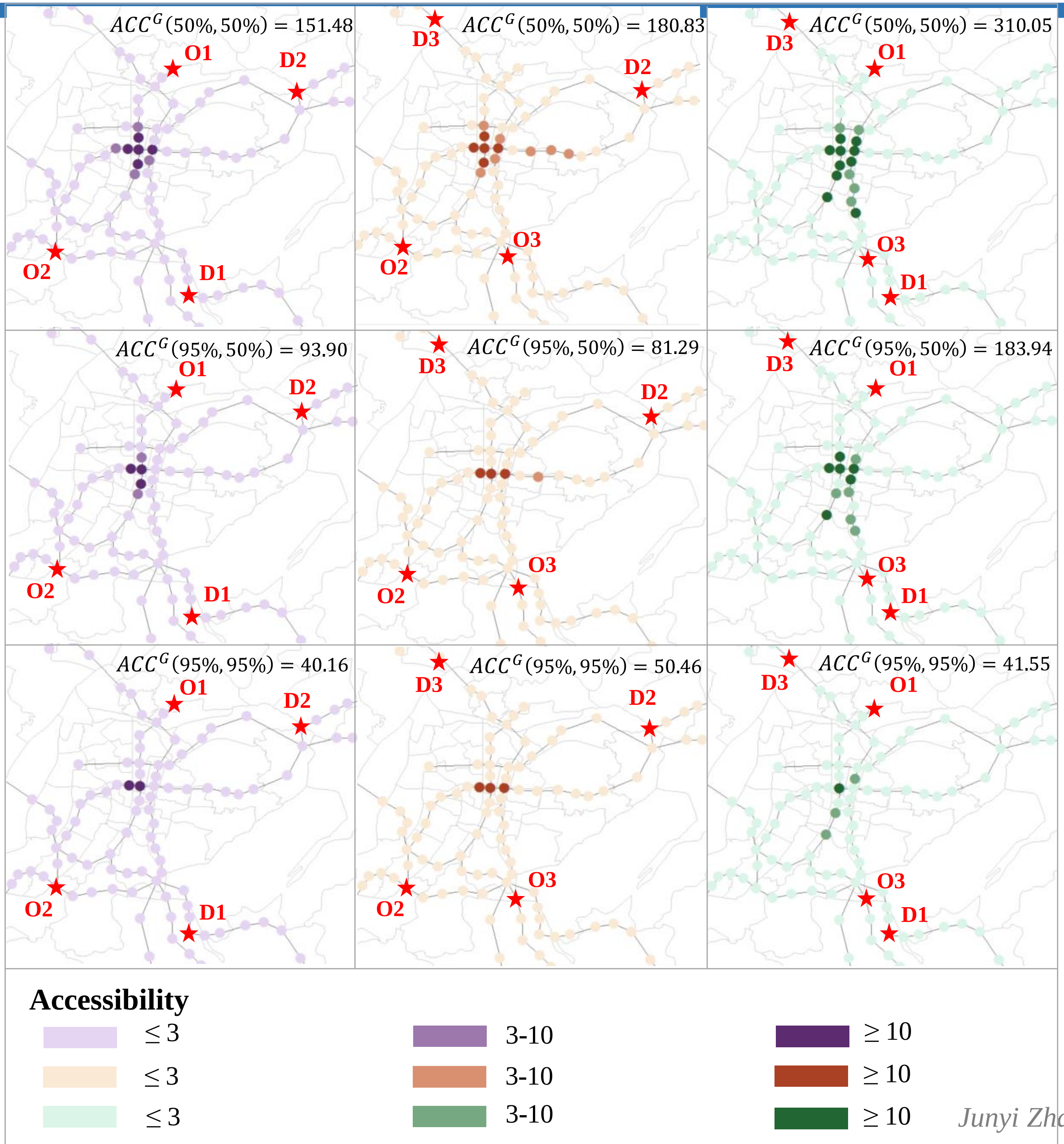
Joint accessibility measure based on smart card data





Fu, Xiao*, Zuo, Y., et al. 2022. Measuring joint space-time accessibility in transit network under travel time uncertainty, *Transport Policy*.

Junyi Zhang

School of Transportation
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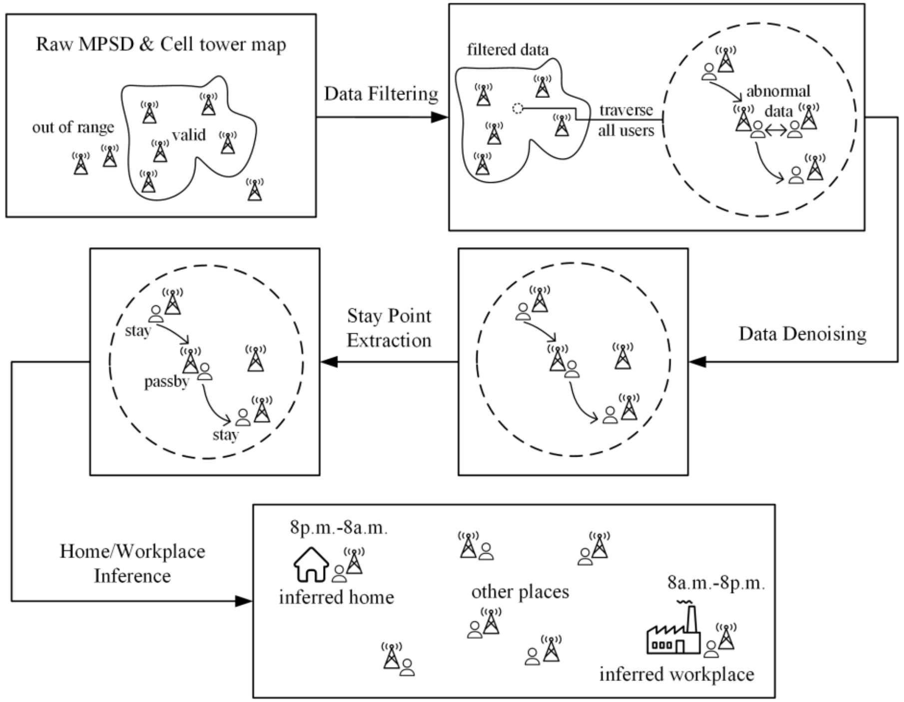
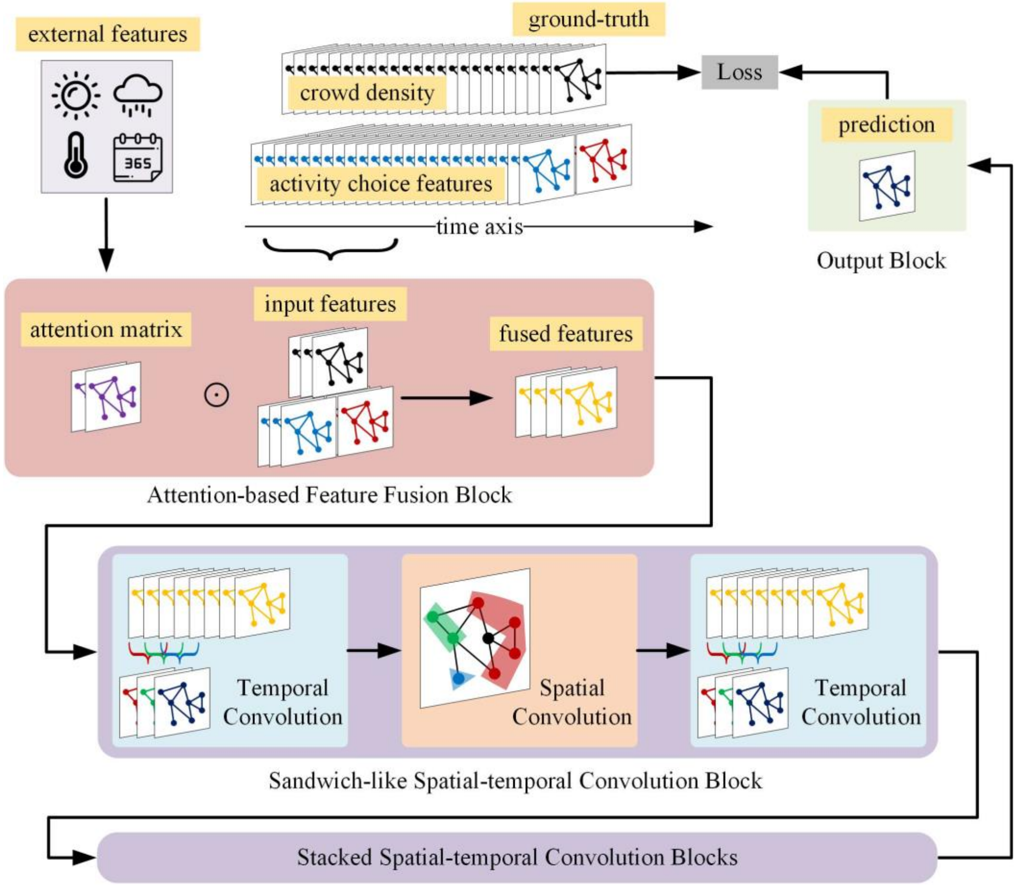
Urban Crowd Density Prediction Based on Mobile-Phone Signaling Data



Mobile phone signaling data processing procedure

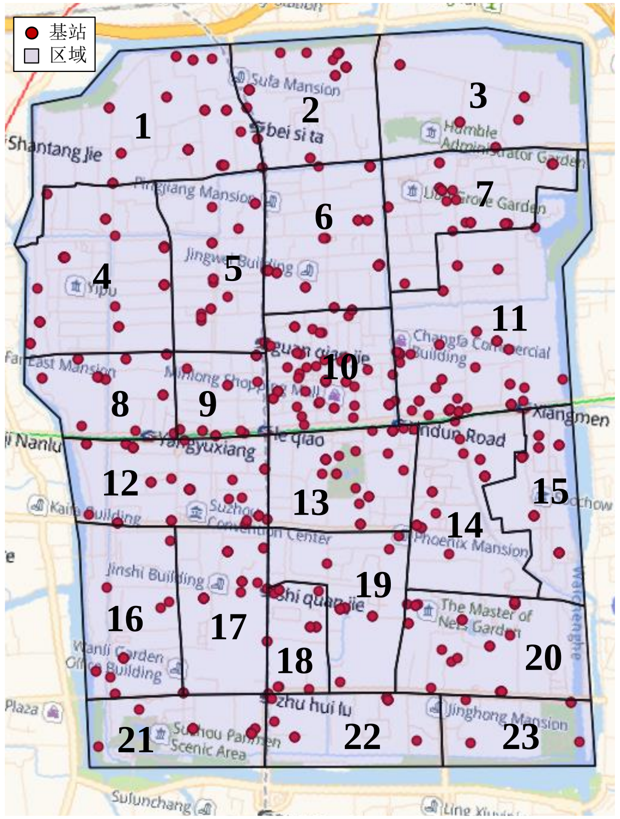


Spatial-temporal convolutional model

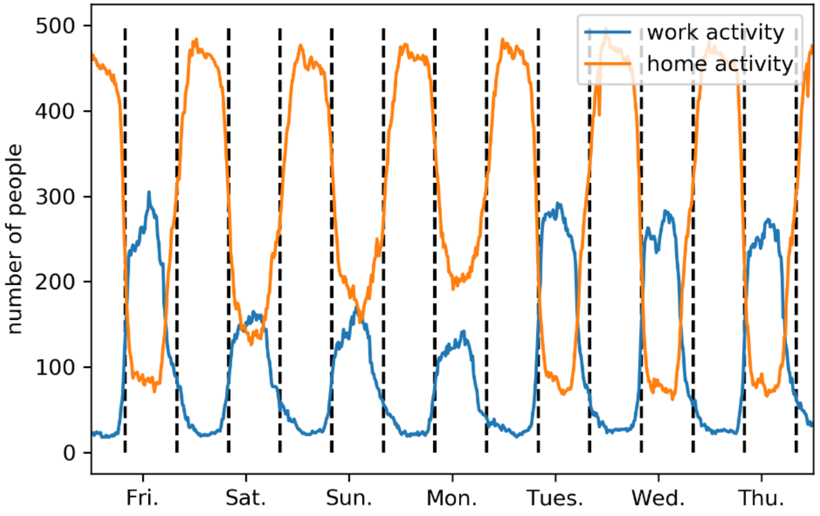
Fu, Xiao, Yu, G., et al. Spatial-temporal convolutional model for urban crowd density prediction based on mobile-phone signaling data, *IEEE Transactions on Intelligent Transportation Systems*, 2022.
Huo, J., **Fu, Xiao***, et al. Short-Term Estimation and Prediction of Pedestrian Density in Urban Hot Spots Based on Mobile Phone Data, *IEEE Transactions on Intelligent Transportation Systems*. 2021.

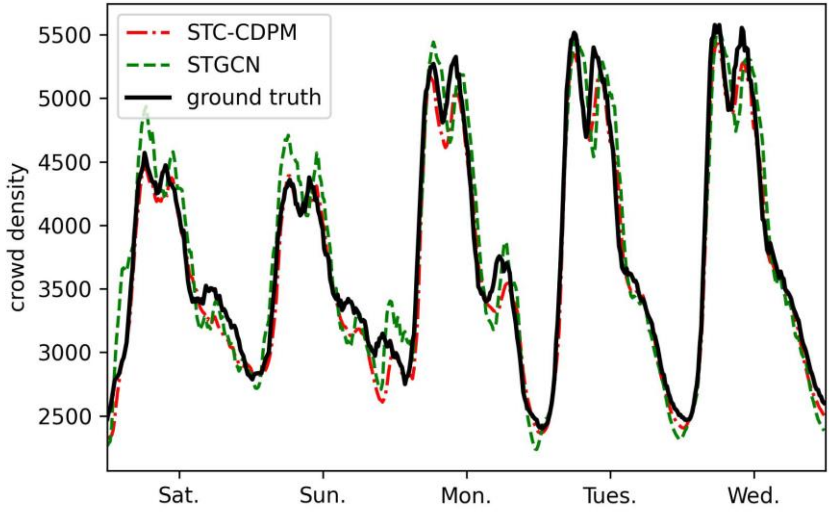
Data-driven methods for behavioral modelling: Case 3

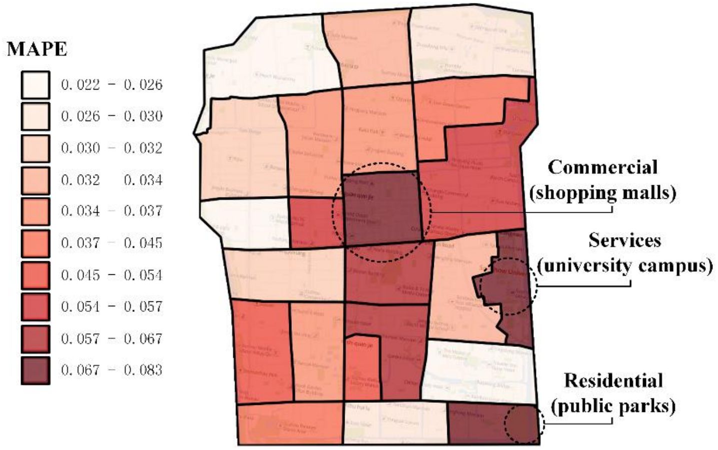
Urban Crowd Density Prediction Based on Mobile-Phone Signaling Data

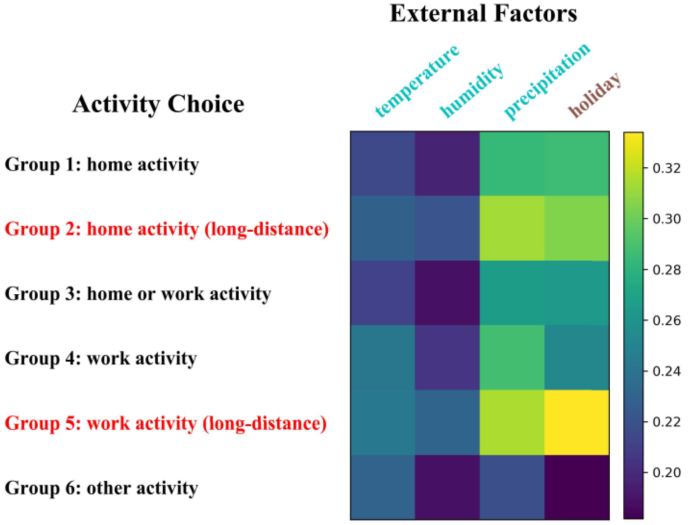


Suzhou, China









Fu, Xiao, Yu, G., et al. Spatial-temporal convolutional model for urban crowd density prediction based on mobile-phone signaling data, *IEEE Transactions on Intelligent Transportation Systems*, 2022.

Tongji University

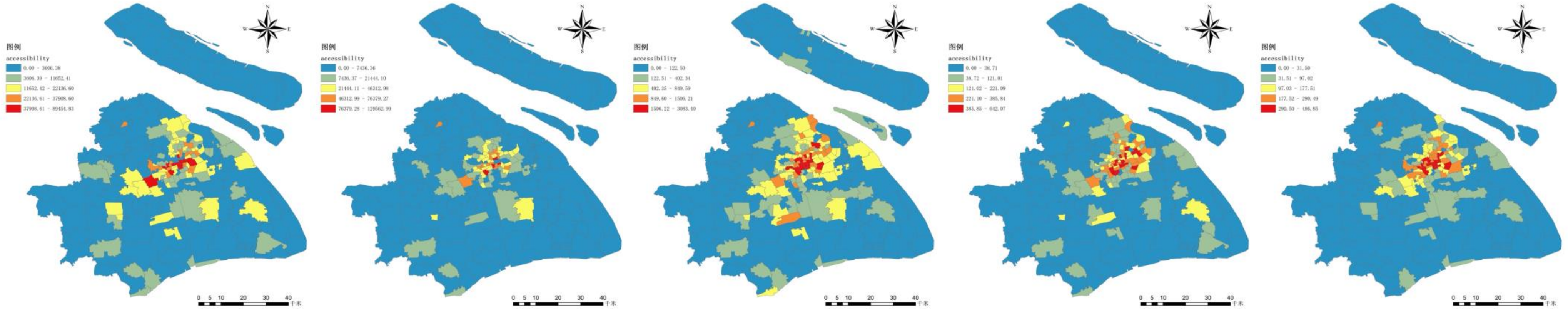
Xiao Luo

Behavior Research in Tongji

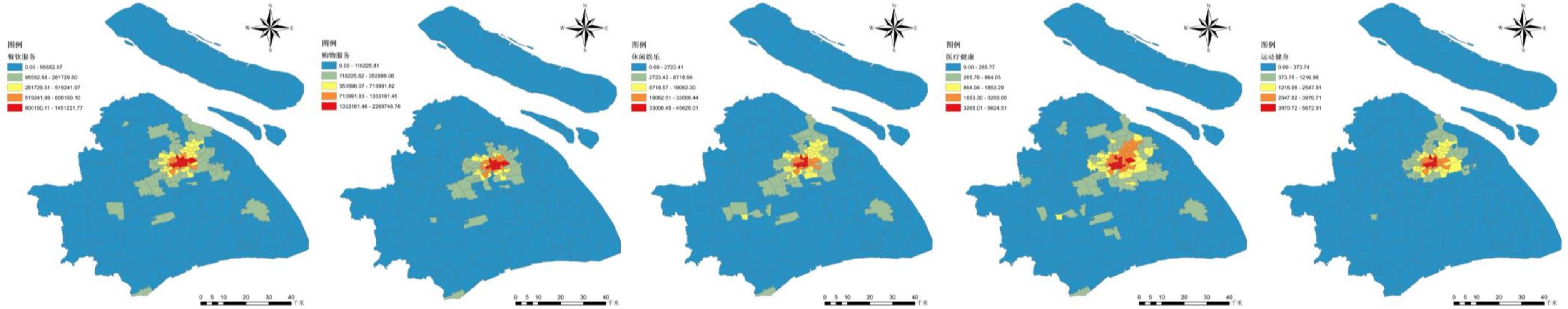
- The 15-minute walking accessibility exhibits a pattern of central aggregation with decreasing distribution around the periphery. The Nanjing East Road area has good recreational and dining resources, while the Xujiahui area boasts abundant sports and fitness facilities. Jing'an Temple area offers strong medical resources.
- The 30-minute public transportation accessibility shows a high central clustering distribution, with the highest accessibility in the inner-ring central urban districts, gradually decreasing towards the outskirts. The Nanjing East Road area has favorable shopping, dining, and fitness resources, while Huaihai Road features excellent leisure and entertainment options

Catering | Shopping | Relaxation | Hospital | Fitness

Spatial distribution of 15-minute walking accessibility



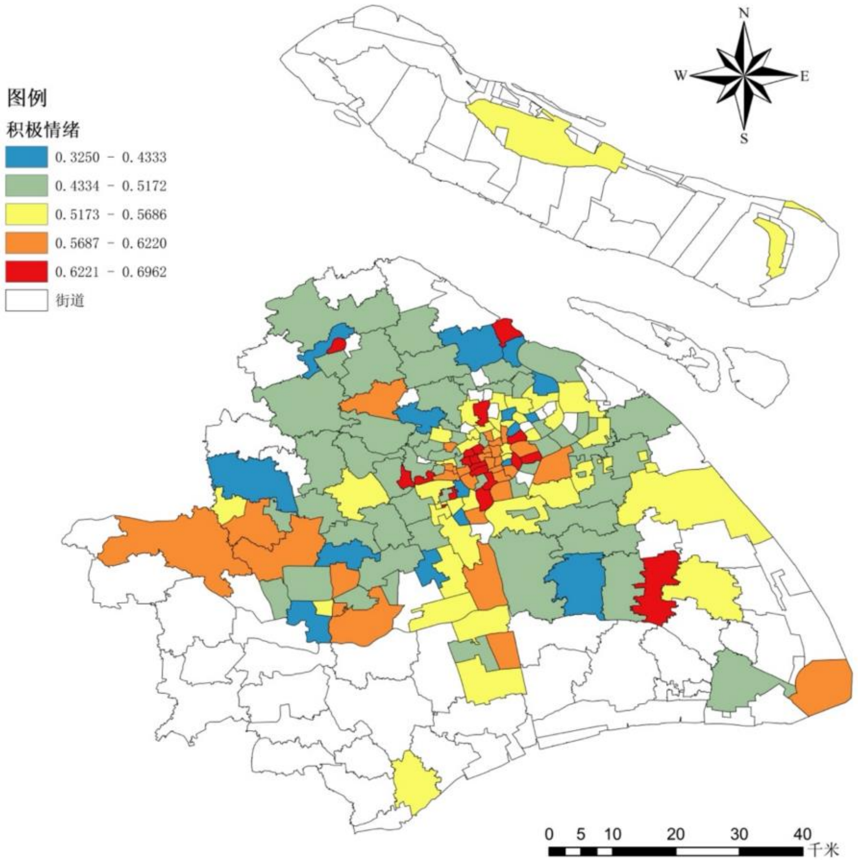
Spatial distribution of 30-minute public transport accessibility



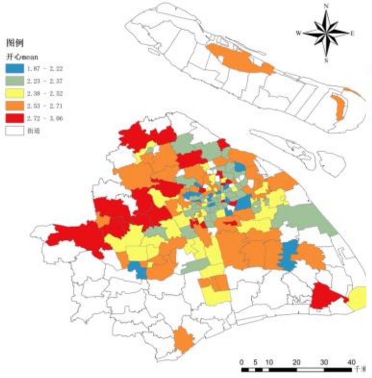
Cheng Xue, Xiao LUO* et.al.Evaluating the Enhanced Emission Reduction Effect of Carsharing with Minimum Carbon Emission Targets and the Synergistic Pollutant Reduction Effect

Behavior Research in Tongji

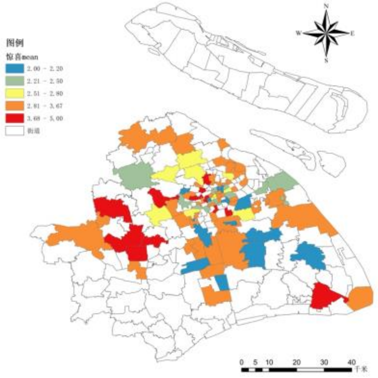
- The research data from Weibo text in Shanghai is processed to extract the intensity of each emotion. The emotional intensity ranges from 0 to 5, where a higher value indicates a stronger emotion. Taking 'happiness' as an example, '0' represents happiness, and '5' represents very happy.



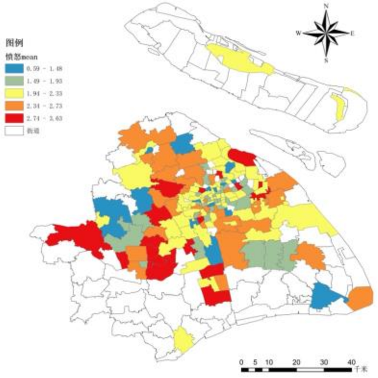
The proportion of positive emotion in each street in Shanghai



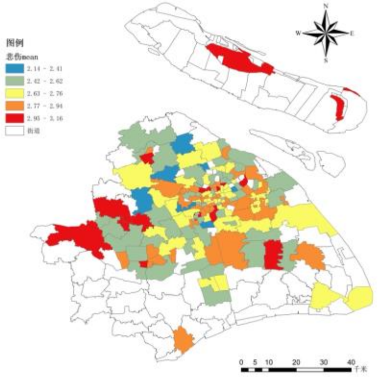
Happy emotion



Surprise emotion



Anger emotion



Sad emotion

- **A well-constructed environment can bring about more positive emotions in people**: Positive emotions exhibit an increasing trend from the inner to the outer areas, followed by a decrease. In terms of the average proportion of positive emotions, it is 57.4% within the inner ring, 54.5% between the inner and middle rings, 49.2% between the middle and outer rings, and 50.4% beyond the outer ring. Research units with a higher proportion of positive emotions mostly possess abundant public service resources and convenient transportation.

Behavior Research in Tongji

- To quantify the preferences of young individuals in Shanghai towards various facilities, problem options were generated by combining facilities and levels using orthogonal design. Subsequently, a questionnaire was distributed and logistic regression analysis was conducted on the responses to obtain the parameters for each facility variable. Finally, these coefficients were incorporated into the utility formula to calculate the selection probability of different facilities.

①Elements and levels

Elements(facilities)	Level1(1)	Level2(0)
Catering	Yes	No
Shopping	Yes	No
Entertainment	Yes	No
Living	Yes	No
Fitness	Yes	No
Scenic spot	Yes	No

②Orthogonal design (Combining elements and levels)

Combination scenario	Catering	Shopping	Entertainment	Living	Fitness	Scenic spot
1	1	1	0	0	1	0
2	1	0	1	1	0	0
3	1	0	1	0	0	1
4	0	1	1	0	1	0
5	0	1	0	1	0	1
6	0	0	0	1	1	1

③Binary logistic regression

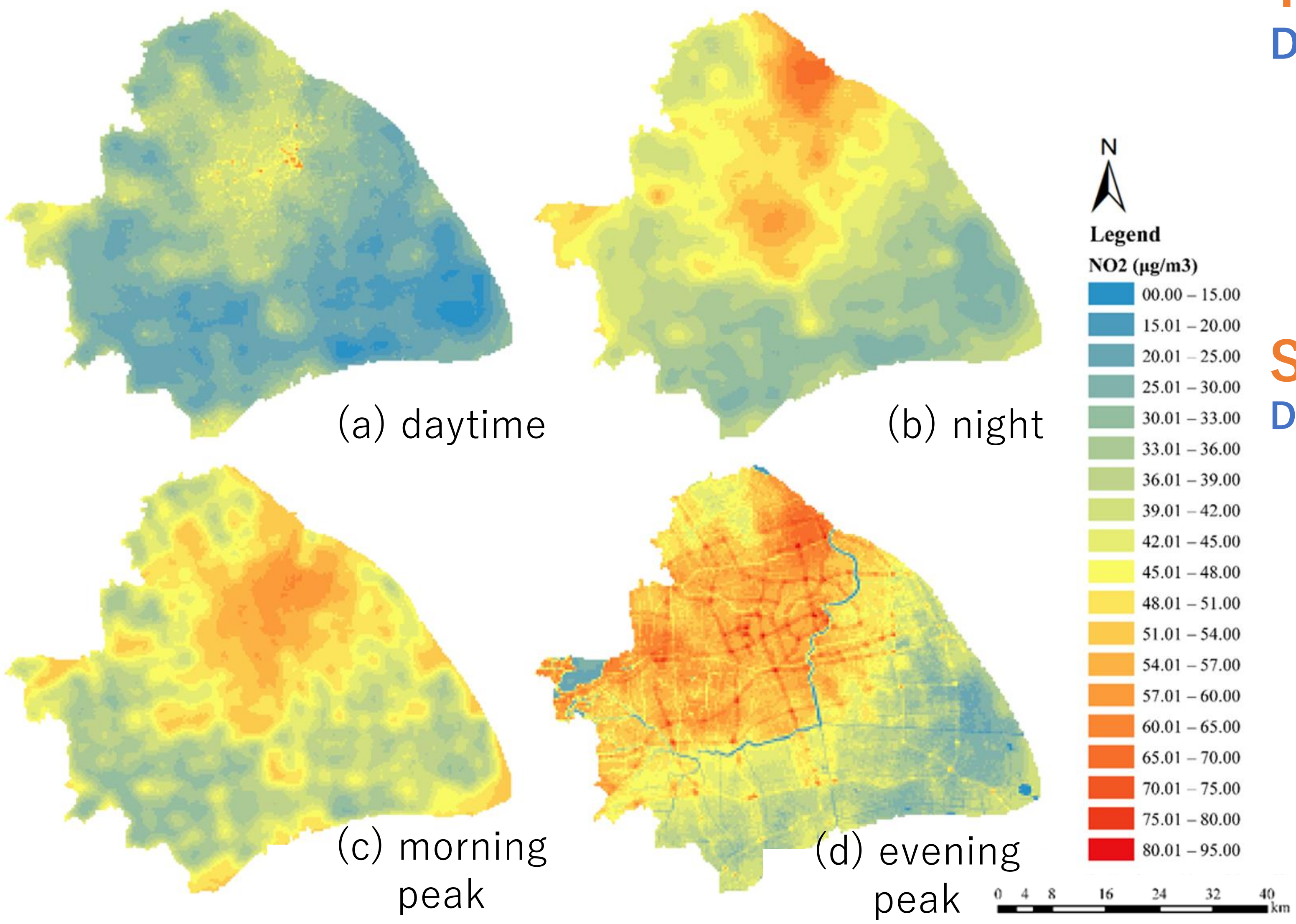
variable	coefficient	Standard Error	significance
Catering	3.394	.463	.000
Shopping	2.139	.480	.000
Entertainment	.843	.627	.038
Fitness	.590	.253	.020
Scenic spot	2.624	.552	.000
constant	-7.287	1.011	.000
Log Likelihood		986.44	

④Calculate the utility of variables

$$P_i = \frac{e^{V_i}}{\sum_{i=1}^{N} e^{V_i}}$$

Facilities	Catering	Shopping	Entertainment	Fitness	Scenic spot
P_{type}	39.76%	15.83%	16.99%	9.45%	17.97%

Behavior Research in Tongji



Time-varying feature:

Dimodal distribution

- The pollution concentration during the evening rush hour is higher than during the morning rush hour, which is more closely aligned with the temporal variations of traffic volume.

Spatial feature:

Decreasing from the city center to the suburbs

- Daytime: Heavy pollution areas are concentrated in the downtown area of the city.
- Nighttime: Heavy pollution areas shift to the suburbs with dense logistics parks and industrial zones such as Baoshan District and Minhang District.
- Peak Hours: During the evening rush hour, the impact of traffic emissions is more significant.

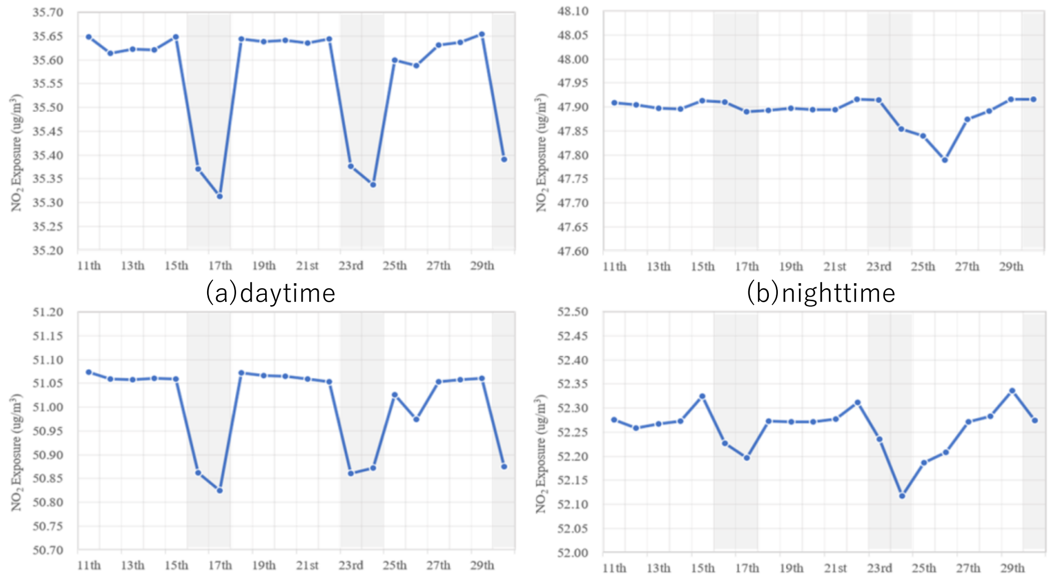
Qian Wang,Xiao Luo* et.al.Spatio-Temporal Variation and Group Disparity of Traffic-derived NO2 Pollution Exposure in Baoshan District, Shanghai Based on CALPUFF Model， Transportation Research Part D.(in circulation)

Behavior Research in Tongji

Time-varying regularity

Period	Average	Minimum	Maximum	Standard eviation
Daytime	35.56	35.23	35.7	0.13
Nighttime	47.89	47.69	48.03	0.11
Morning peak	51.01	50.8	51.15	0.06
Evening peak	52.26	52.11	52.34	0.05

Daily variation regularity



(a)daytime (b)nighttime (c)morning peak (d)evening peak

Bimodal distribution

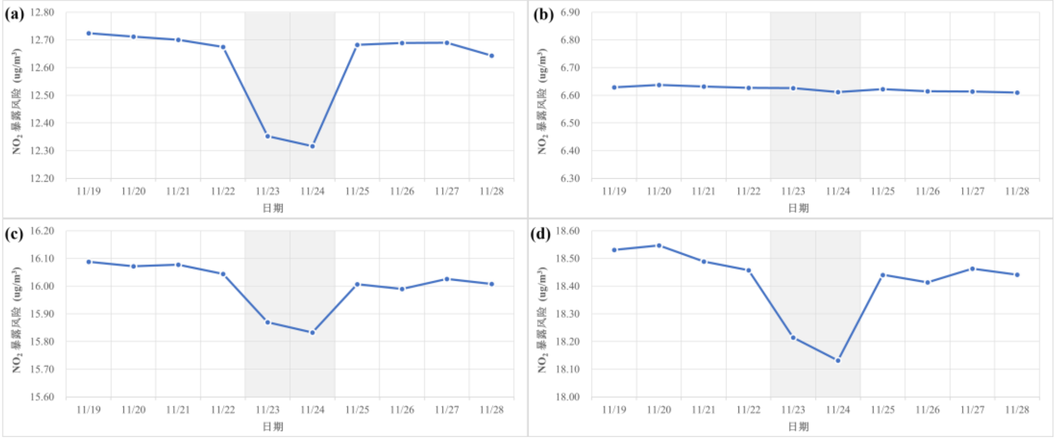
- **Evening peak>Morning peak>Nighttime>Daytime**
- The daytime exposure risk exhibits the highest level of dispersion, followed by nighttime, and the morning and evening peak hours show the least dispersion.

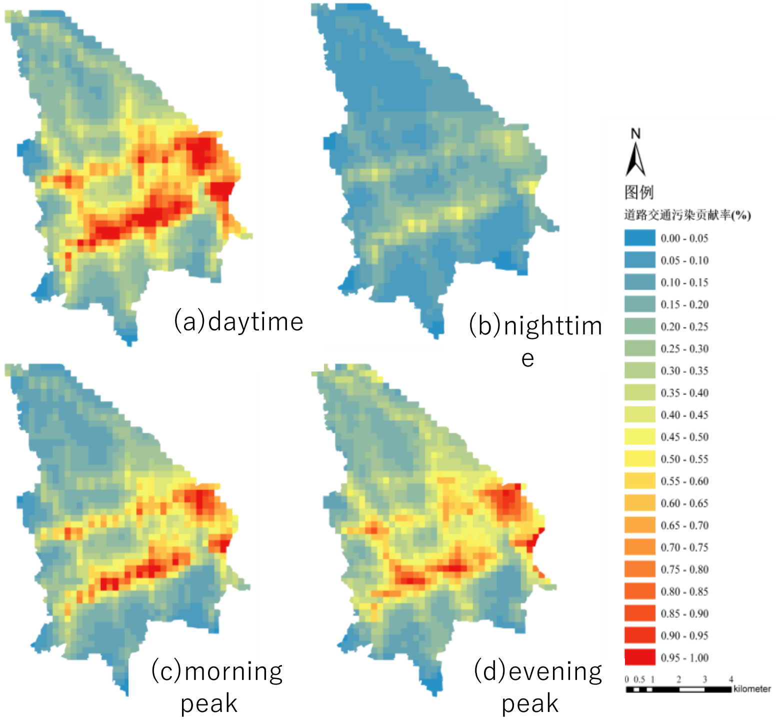
Weekend effect

- **The exposure risk shows a decreasing trend on rest days, which is more in line with the daily variation pattern of traffic volume.**
- However, this characteristic is not significant during nighttime periods.

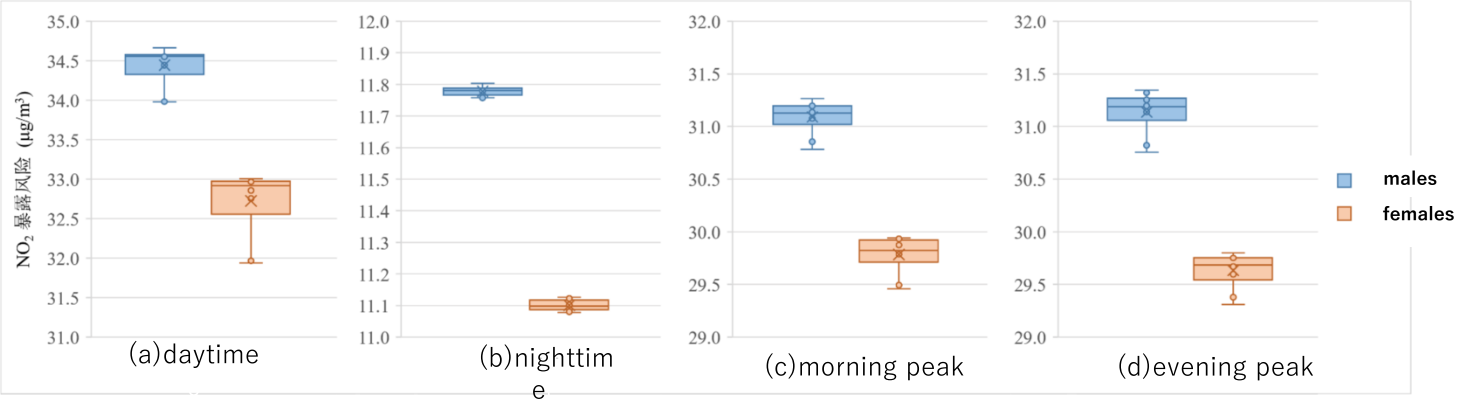
Behavior Research in Tongji

Single-peak distribution: The contribution rates of daytime, nighttime, morning peak, and evening peak are 33.8%, 11.5%, 30.7%, and 30.6% respectively, with a weighted average of approximately 22.1%.





Areas with higher contributions to traffic pollution include Wusongkou Port, Baoyang Wharf, and east-west outbound roads, while the contribution of traffic pollution from north-south highways is relatively lower.



The impact of road traffic pollution on males is significantly higher than females. The exposure differences between different gender groups reach their maximum during the daytime, followed by the morning and evening peaks, and are the lowest during the nighttime.

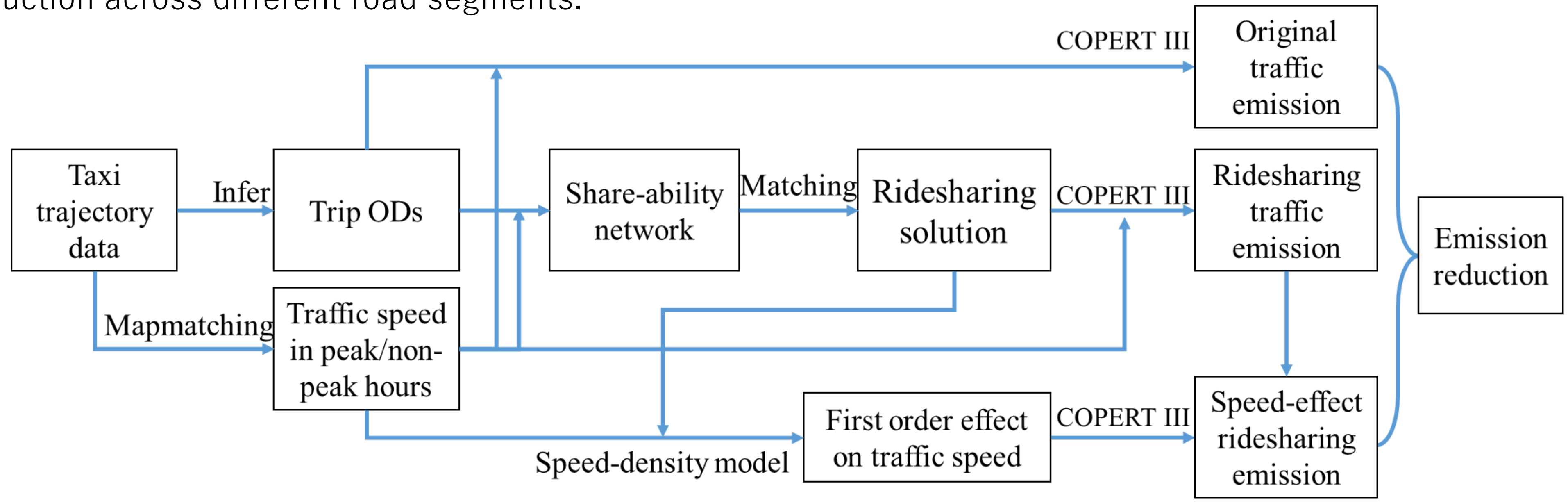
Behavior Research in Tongji

① Deduce origin-destination (OD) patterns from taxi data, and furthermore, estimate original traffic emissions by integrating the initial speed with the COPERT III model.

② Based on a shared network, determine the optimal shared mobility solution with the goal of reducing vehicle miles traveled (VMT). Integrate the COPERT III model to estimate dynamic traffic emissions in both oracle and online scenarios.

③ Utilize the traffic flow-density-speed model to reevaluate dynamic traffic emissions, taking into account the speed effect.

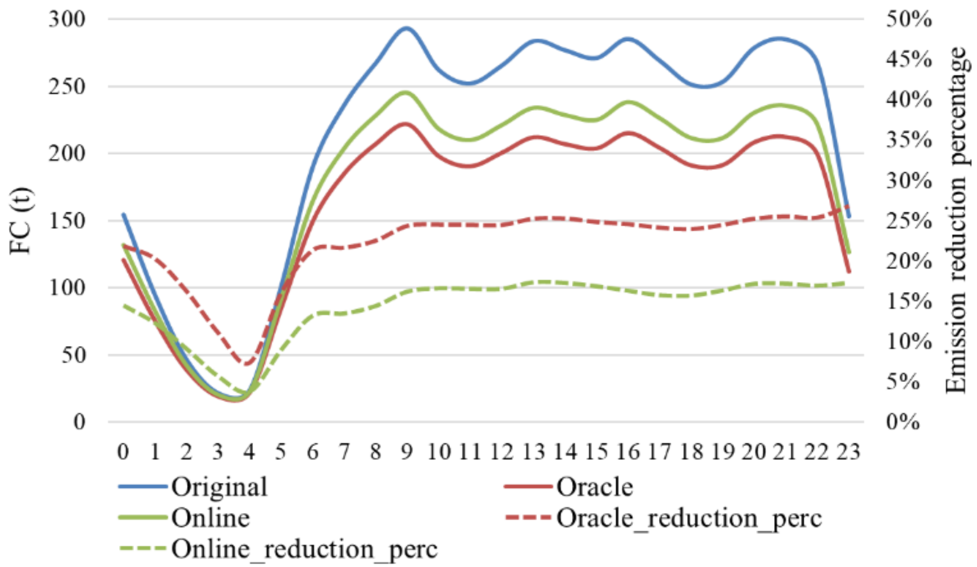
④ By comparing all emission estimates, further analyze the overall distribution and spatiotemporal characteristics of emission reduction across different road segments.



Xuanyu Liu, Xiao Luo * .Assessing the Economic and Emission Benefits of Ridesharing in a Megacity: A Case Study of Shanghai. Applied Energy.(in circulation)

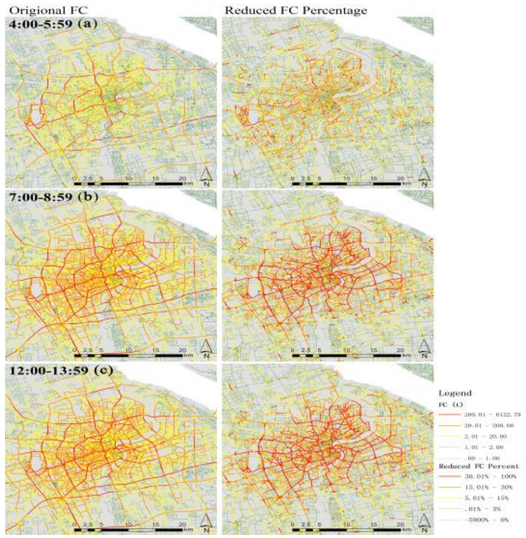
Behavior Research in Tongji

Pollutant	Cumulative emission			Reduction Percentage (RP)				Additional reduction	
	Original	Oracle	Online	Oracle -RP	Online -RP	Oracle-RP1st	Online -RP1st	Oracle -delta	Online -delta
VMT(10^6km)	81.860	62.780	69.192	**23.31%**	15.48%				
CO(t)	47.179	36.309	39.998	**23.04%**	15.22%	21.76%	14.33%	-1.28%	-0.89%
HC(t)	1.434	1.110	1.222	**22.54%**	14.78%	22.90%	15.12%	0.36%	0.34%
NOx(t)	6.011	4.613	5.083	**23.25%**	15.44%	24.00%	16.01%	0.75%	0.57%
FC(10^3t)	5.078	3.916	4.312	**22.88%**	15.09%	23.84%	15.83%	0.96%	0.74%
CO_2(10^3t)	16.148	12.453	13.711	**22.88%**	15.09%	23.84%	15.83%	0.96%	0.74%
$PM_{2.5}$(t)	0.152	0.117	0.129	**22.88%**	15.09%	23.84%	15.83%	0.96%	0.74%



In areas of high pollution, the emission reduction effect becomes even more significant.

- The Matthew effect leads to an emission reduction effect of carpooling that exhibits a single-center and concentric pattern.



Tongji University

Spatial Behavior Modeling

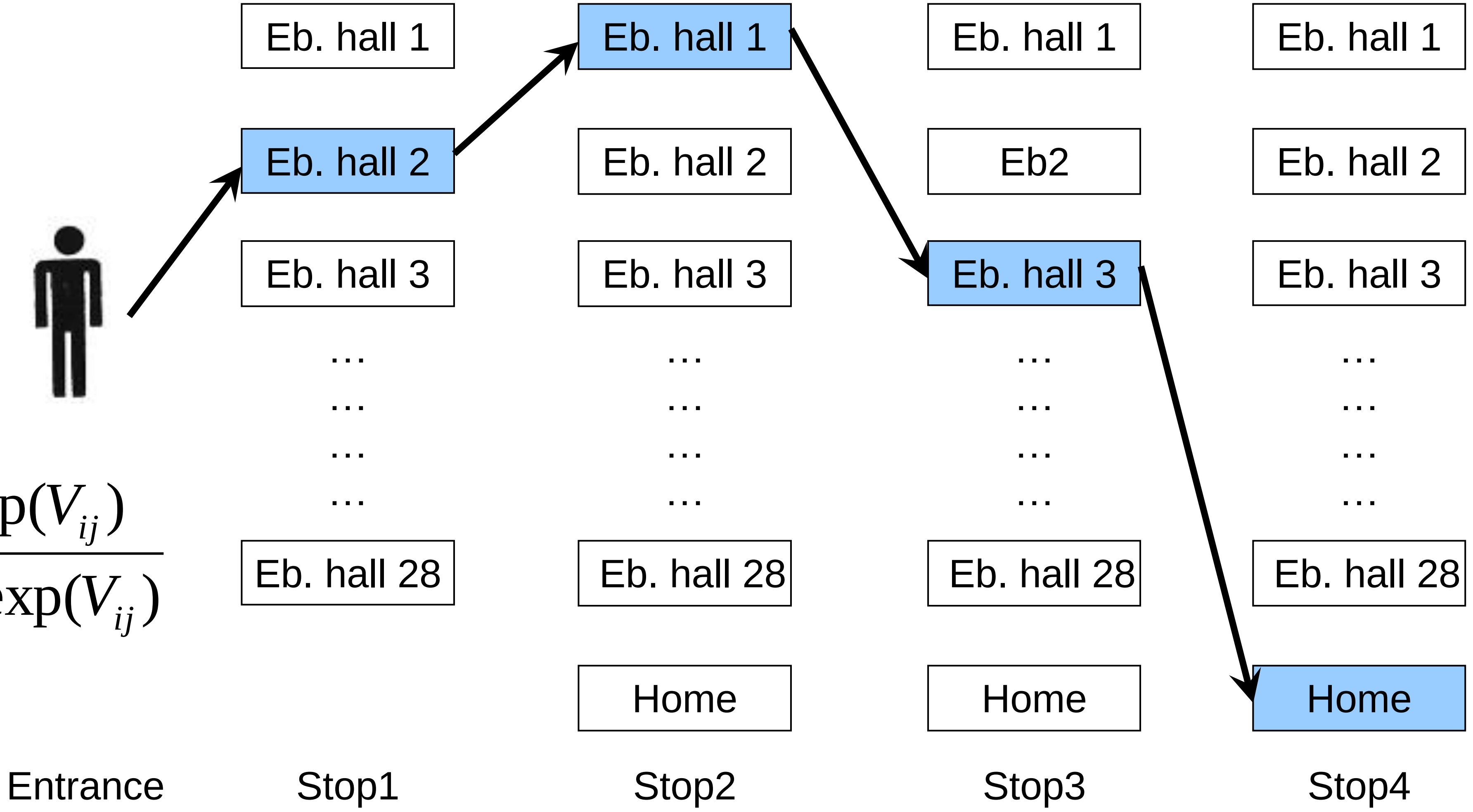
De WANG’s Planning Lab

Research history

School of Transportation
SOUTHEAST UNIVERSITY

- Before 2010: To apply conventional behavior models in large-scale important projects
  - EXPO2010 in Shanghai, 青岛世园会、南京路
- 2014-2020: Big Data-driver behavior model
  - Individual activity models
  - For supporting smart city construction
- Since 2020: Spatial-temporal behavior planning (optimization) models

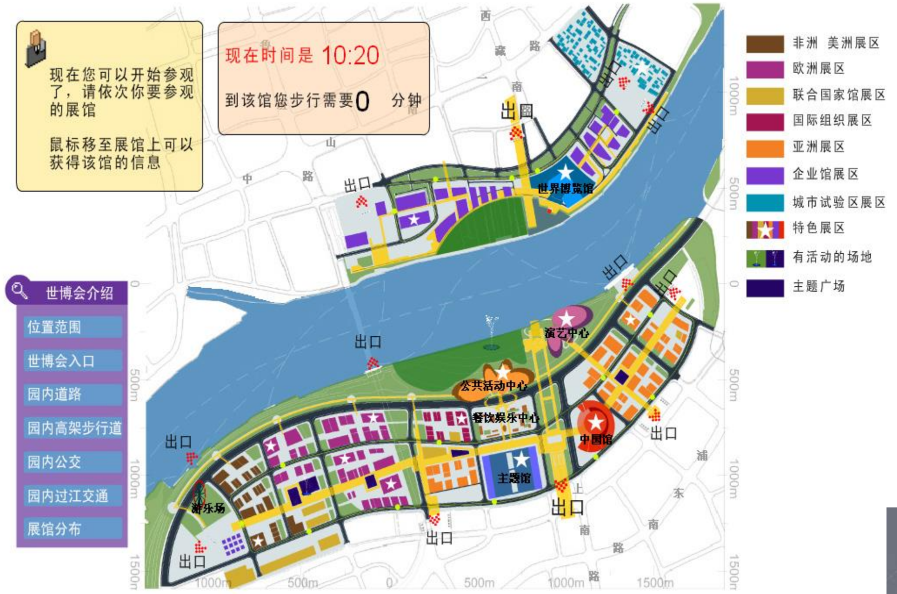
Applying discrete choice models in EXPO2010 Shanghai

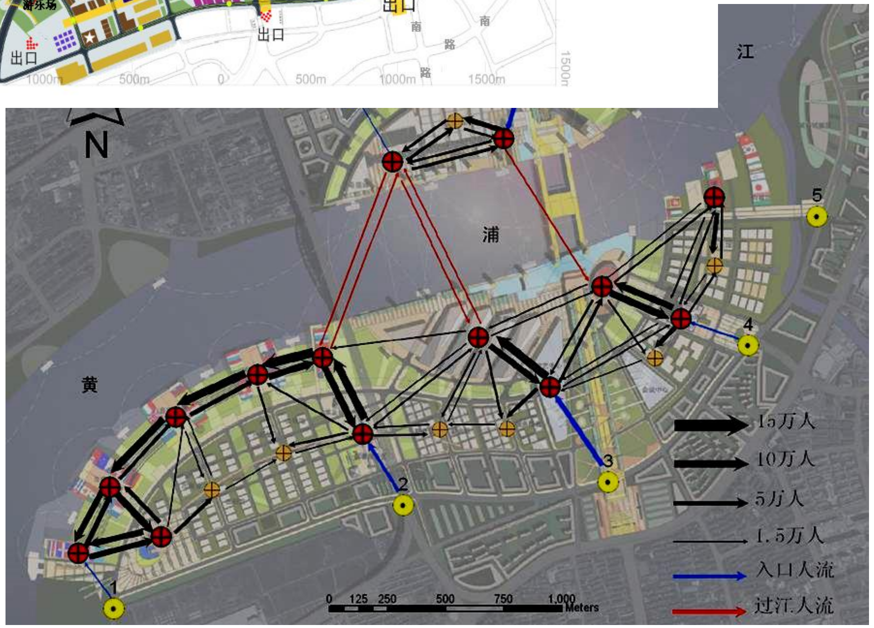


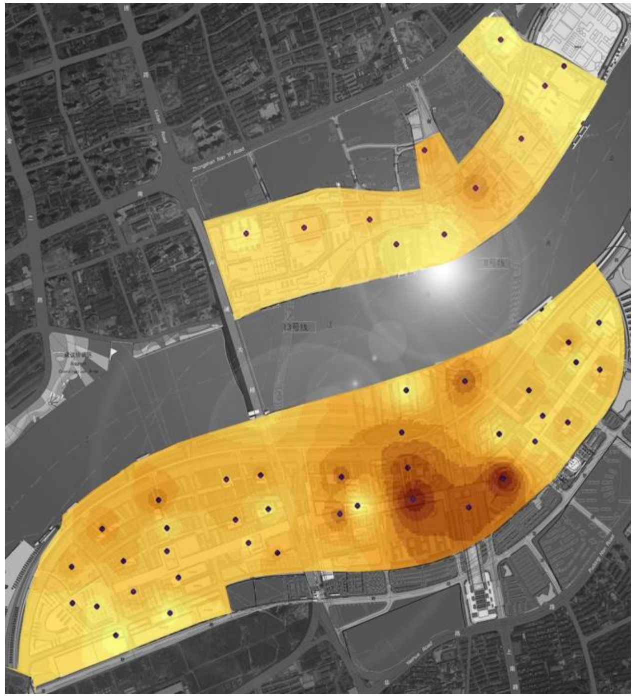
$$P_{ij} = \frac{\exp(V_{ij})}{\sum_{j} \exp(V_{ij})}$$

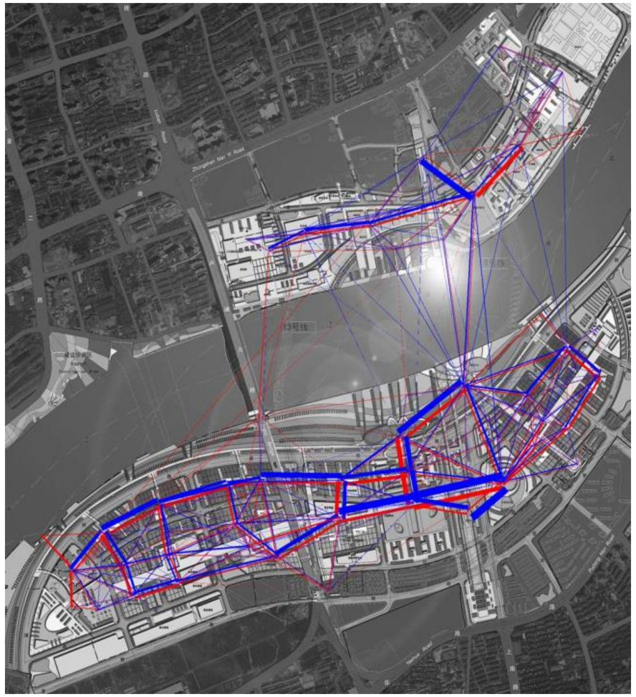
88

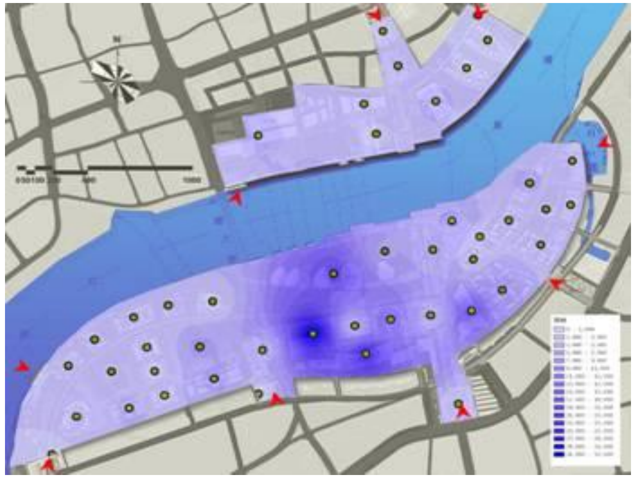
Visitation simulation and facility planning for the finalized planning

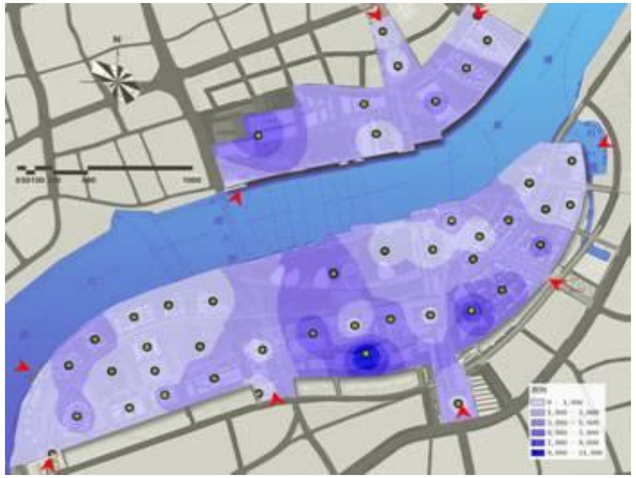












Big Data Behavior Modeling: Agent-based mixed logit model

AMXL framework

Dynamic DCM

$$U_{ijt} = x_{ijt}\beta_{jt} + \varepsilon_{ijt} + \mu_t EV(i,j,t)\,, \qquad \forall i \in P, \forall j \in J, \forall t \in T$$

$$P_{ijt} = \frac{e^{x_{ijt}\beta_{jt}+\varepsilon_{ijt}+\mu EV(i,j,t)}}{\sum_{j' \in J} e^{x_{ij't}\beta_{jt}+\varepsilon_{ij't}+\mu EV(i,j',t)}}\,, \quad \forall i \in P, \forall j \in J, \forall t \in T$$

j: index of alternatives, t: index of time periods

Individual parameter logit (IPL)

$$U_{ij} = x_{ij}\beta + \varepsilon_{ij}\,, \qquad \forall i \in P, \qquad \forall j \in J$$

$$P_{ij} = \int \frac{e^{x_{ij}\beta}}{\sum_{j' \in J} e^{x_{ij'}\beta}} g(\beta|\Omega)\, d\beta, \quad \forall i \in P, \qquad \forall j \in J$$

i: index of individuals, j: index of alternatives

Agent-based Mixed Logit

$$\min_{\theta_{0m},\theta_{im}} \sum_{i\in P} (\beta_{0m} - \beta_{im})^2$$

Subject to

$$V_{ijm^*}(\beta_{im}) + \varepsilon_{ijm^*} \geq V_{ijm}(\beta_{im}) + \varepsilon_{ijm} + b, \qquad j \neq j^*, \forall j \in J, i \in P, m \in M$$

$$\beta_{0m} = \frac{1}{|P|} \sum_{i\in P} \beta_{im}\,, \qquad \forall m \in M$$

$$\beta_{ims} = \beta_{im's}, \qquad \forall i \in P, s \in S_0, m, m' \in M$$

i: index of individuals, j: index of alternatives, **m (t): index of sub-choices**

$$\min_{\theta_0^k,\theta_i} \sum_{k\in K} \sum_{i\in I^k} (\beta_0^k - \beta_i^k)^2$$

$s.t.$

$$\beta_i(X_{nj} - X_{nj^*}) \geq \ln(S_{ij}) - \ln(S_{ij^*}) - tol, \qquad \forall i \in I, j, j^* \in J, j \neq j^*$$

$$\beta_i(X_{nj} - X_{nj^*}) \leq \ln(S_{ij}) - \ln(S_{ij^*}) + tol, \qquad \forall i \in I, j, j^* \in J, j \neq j^*$$

$$\beta_0^k = \frac{1}{|I^k|} \sum_{i\in I^k} \beta_i\,, \qquad \forall k \in K$$

i: index of individuals, j: index of alternatives, **k: index of latent classes**

Big Data Behavior Modeling: Agent-based mixed logit model

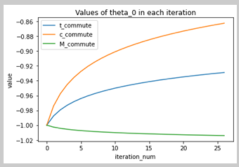
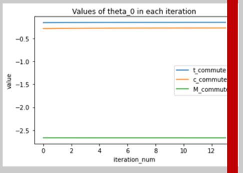
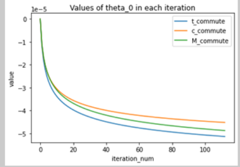
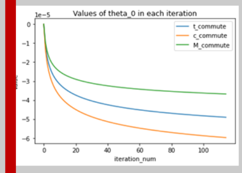
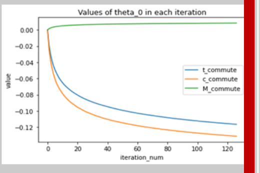
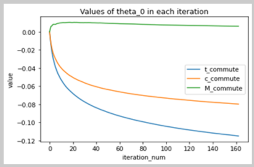
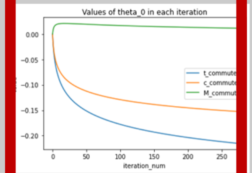
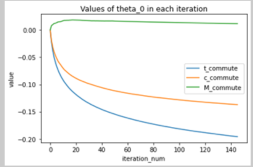
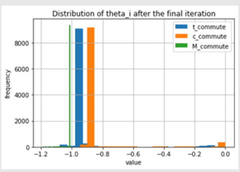
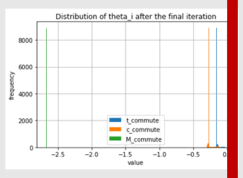
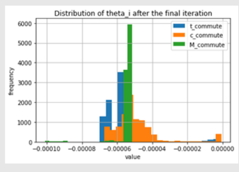
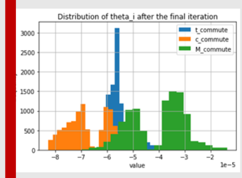
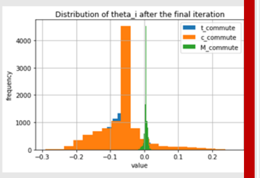
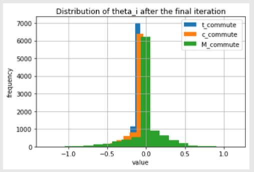
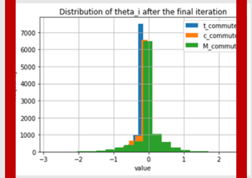
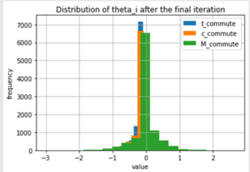
AMXL framework

Multiagent inverse utility maximization (MIUM)

$$\min_{\theta_0,\theta_i}\{(\theta_0-\theta_i)^2: V_{ij^*}+\varepsilon_{ij^*}\geq V_{ij}+\varepsilon_{ij}+b, \quad j\neq j^*, \forall j\in S\}, \quad \forall i\in P$$

$$\text{subject to } \theta_0 = \frac{1}{|P|}\sum_{i\in P}\theta_i$$

- *Setting the initial to [0,0,…,0]*
- *Normalize the variable*
- *Add random utilities ε_{ij}*
- *Add safe boundary b*

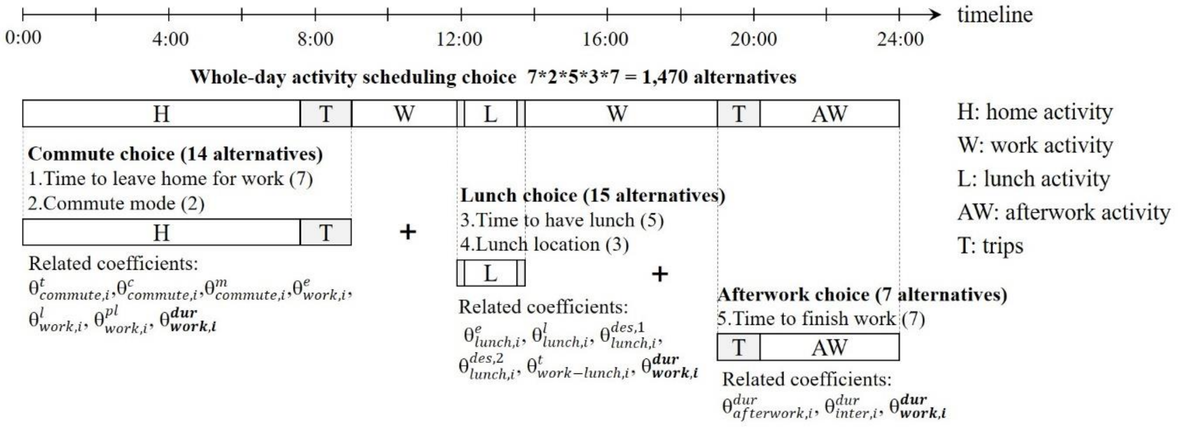
	IO_10k [-1,-1,-1]	IO_10k [MNL_coef	IO_10k [0,0,0]	IO_N_10k [0,0,0]	IO_R_10k [0,0,0]	IO_NR_10k [0,0,0]	$V_{j^*} - V_j \geq \varepsilon_{ij}$-$\varepsilon_{ij^*}$	$V_{j^*} - V_j \geq \varepsilon + b$
Time to converge	728 s	361 s	3032 s	3072	3467 s	4309 s	9864 s	3905 s
Number of iterations	26	13	112	114	126	162	272	145
Plot of θ_0^n								
Distribution of $\theta_i^{n\_final}$								

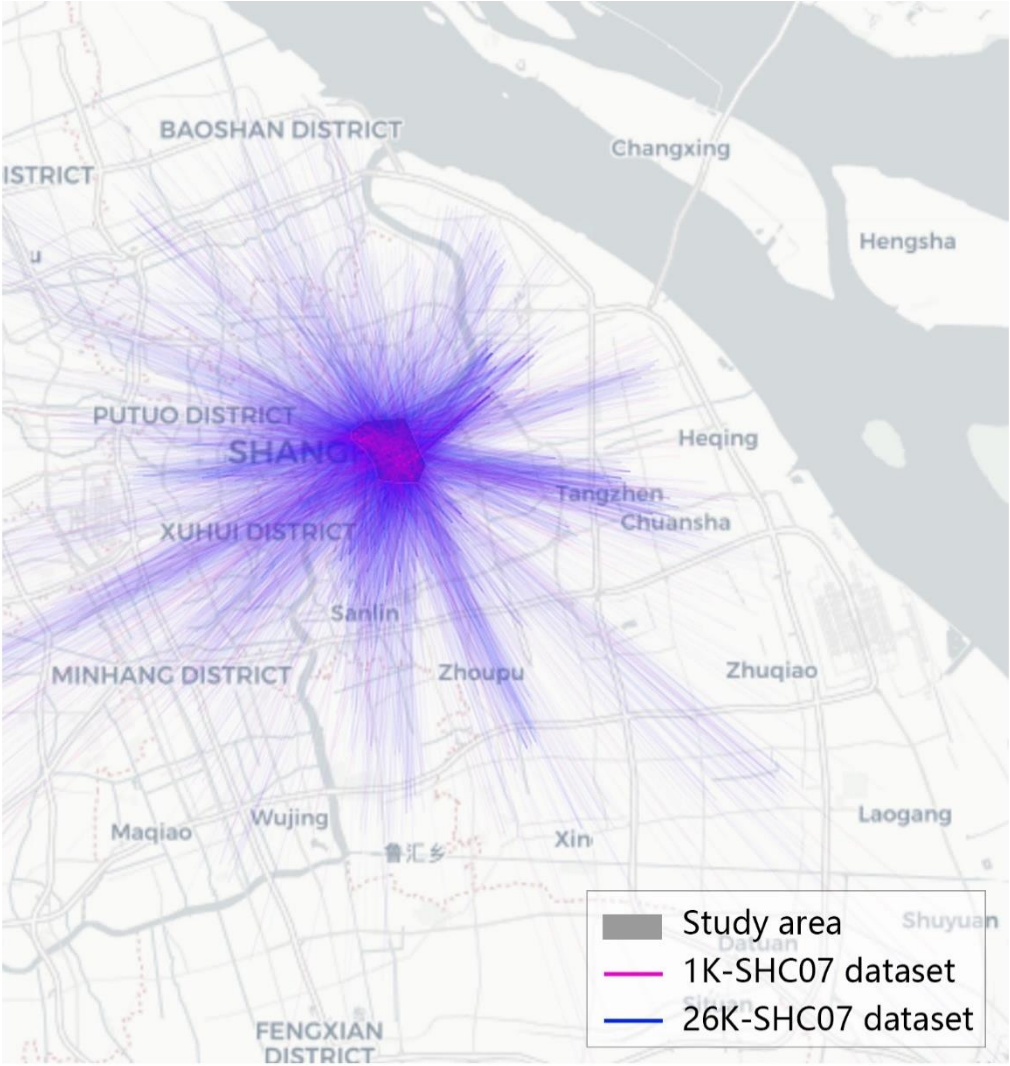
* Chow, J. Y. J., & Recker, W. W. (2012). Inverse optimization with endogenous arrival time constraints to calibrate the household activity pattern problem. Transportation Research Part B: Methodological, 46(3), 463–479.

Big Data Behavior Modeling in the practice of Lujia Zhui, Shanghai

26,149 commuter samples in two weekdays, containing information of five choice dimensions

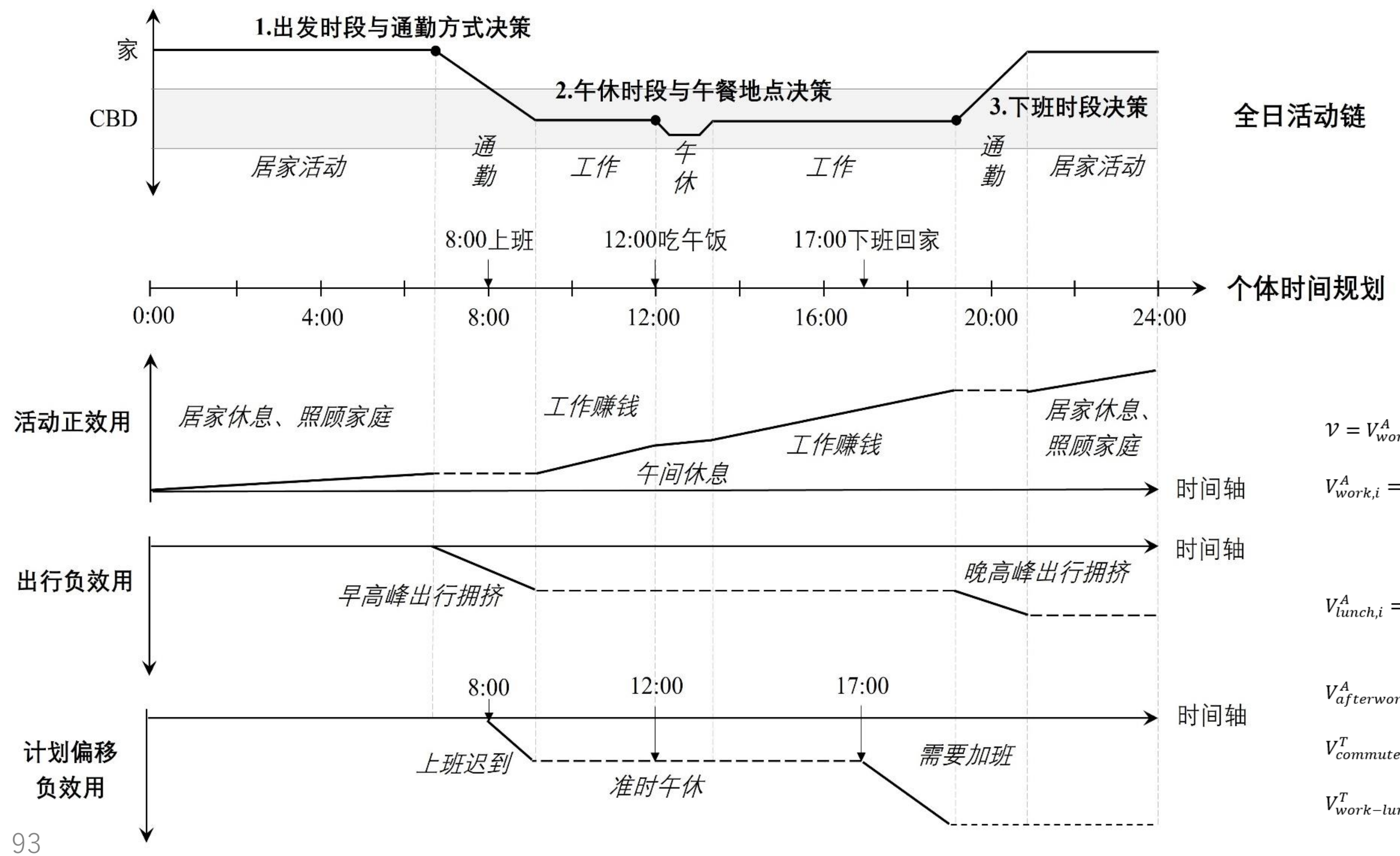
iid	S_work	S_lunch	S_afterwork	M_commute	K_lunch
693	7:30-8:00	14.0:00-14.0:30	14:00-14:30	Transit	Inside the CBD
694	7:30-8:00	11.0:00-11.0:30	17:30-18:00	Transit	Workplace
695	7:30-8:00	11.0:30-12.0:00	19:00-19:30	Driving	Workplace

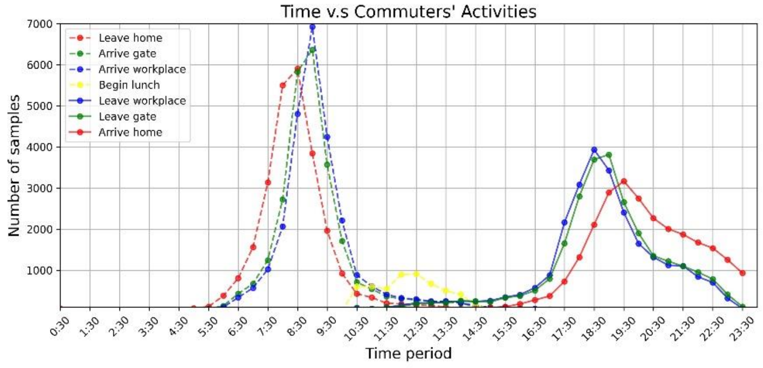




92

Big Data Behavior Modeling in the practice of Lujia Zhui, Shanghai





$$\mathcal{V} = V^{A}_{work,i} + V^{A}_{lunch,i} + V^{A}_{afterwork,i} + V^{T}_{commute,i} + V^{T}_{work-lunch,i}, \qquad \forall i \in P$$

$$\begin{aligned} V^{A}_{work,i} &= V^{SD}_{work,i} + V^{Dur}_{work,i} \\ &= \theta^{e}_{work,i} SDE_{work,i} + \theta^{l}_{work,i} SDL_{work,i} + \theta^{pl}_{work,i} PL_{work,i} \\ &\quad + \theta^{dur}_{work,i} \ln\left(D_{work,i}\right), \qquad \forall i \in P \end{aligned}$$

$$V^{A}_{lunch,i} = \theta^{e}_{lunch,i} SDE_{lunch,i} + \theta^{l}_{lunch,i} SDL_{lunch,i} + \theta^{des,1}_{lunch,i} des^{1}_{lunch,i} + \theta^{des,2}_{lunch,i} des^{2}_{lunch,i}, \quad \forall i \in P$$

$$V^{A}_{afterwork,i} = \theta^{dur}_{afterwork,i} \ln\left(D_{afterwork,i}\right) + \theta^{dur}_{inter,i} \ln\left(D_{work,i}\right) \ln\left(D_{afterwork,i}\right), \qquad \forall i \in P$$

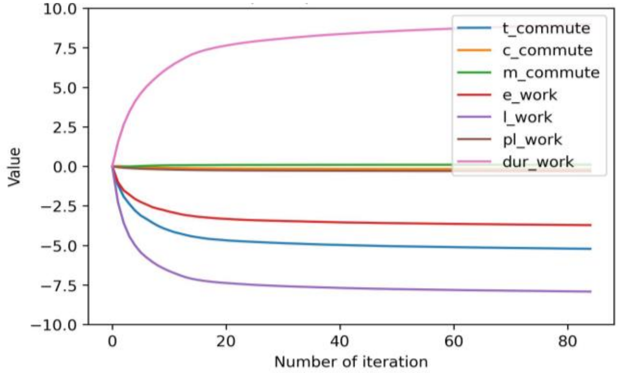
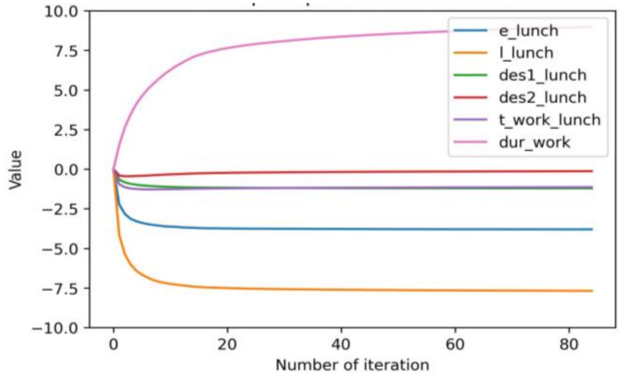
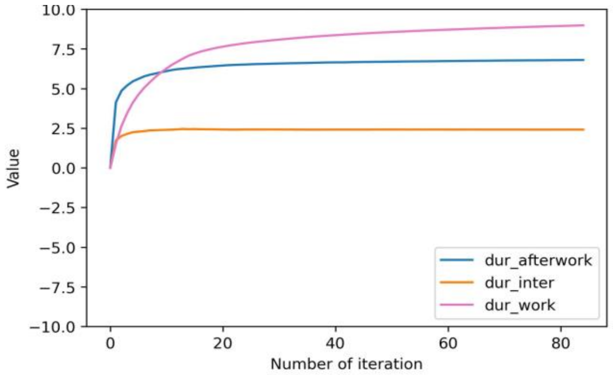
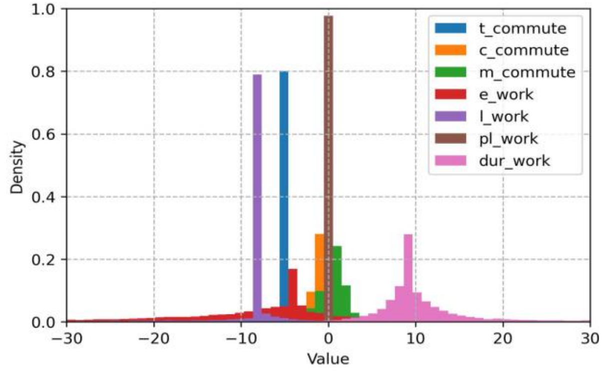
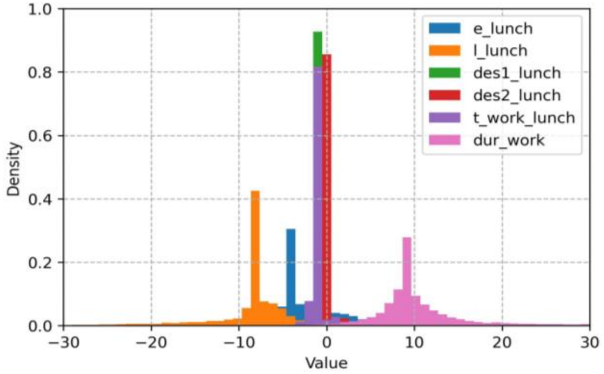
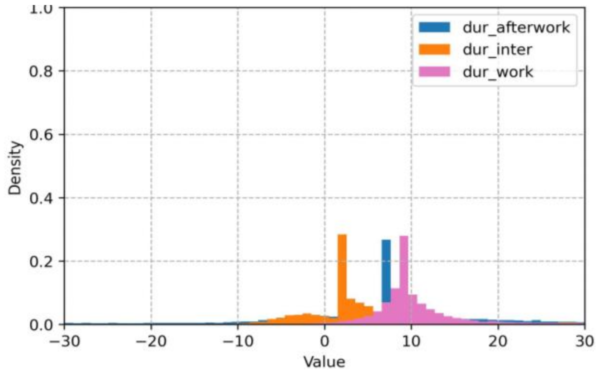
$$V^{T}_{commute,i} = \theta^{t}_{commute,i} t_{commute,i} + \theta^{c}_{commute,i} c_{commute,i} + \theta^{m}_{commute,i} m_{commute,i}, \qquad \forall i \in P$$

$$V^{T}_{work-lunch,i} = \theta^{t}_{work-lunch,i} t_{work-lunch,i}, \qquad \forall i \in P$$

93

Big Data Behavior Modeling in the practice of Lujia Zhui, Shanghai

26,149 samples: coverage after 28.9 hours after 82 iterations

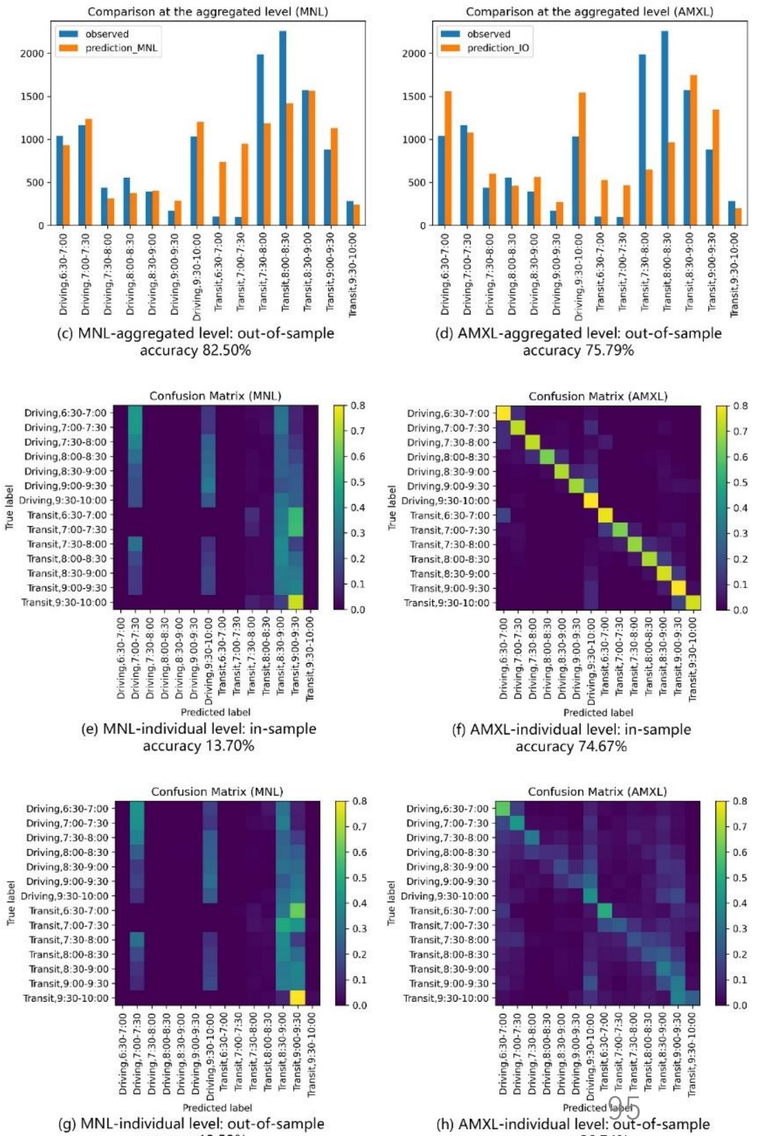
	Commute Choice	Lunchtime Choice	Afternoon Choice
Fixed-point prior in each iteration			
Distribution of estimated coefficients			

94

Big Data Behavior Modeling in the practice of Lujia Zhui, Shanghai

In-sample and out-of-sample accuracy

	Commute choice (14 alternatives)	Lunch choice (15 alternatives)	Afterwork choice (7 alternatives)	Whole-day schedule (1,470 alternatives)
In-sample accuracy (26K-SHC07 dataset)				
MNL-aggregated level	81.40%	85.53%	92.88%	7.50%
AMXL-aggregated level	89.61%	86.71%	98.87%	**80.89%**
MNL-individual level	13.70%	31.16%	35.76%	1.37%
AMXL-individual level	74.67%	78.43%	80.93%	**47.18%**
Out-of-sample accuracy (SHC14 dataset)				
MNL-aggregated level	82.50%	89.92%	89.75%	5.21%
AMXL-aggregated level	75.79%	86.73%	96.07%	**61.68%**
MNL-individual level	13.53%	27.93%	28.99%	1.06%
AMXL-individual level	30.74%	24.25%	37.71%	4.33%



(c) MNL-aggregated level: out-of-sample accuracy 82.50%

(d) AMXL-aggregated level: out-of-sample accuracy 75.79%

(e) MNL-individual level: in-sample accuracy 13.70%

(f) AMXL-individual level: in-sample accuracy 74.67%

(g) MNL-individual level: out-of-sample accuracy 13.53%

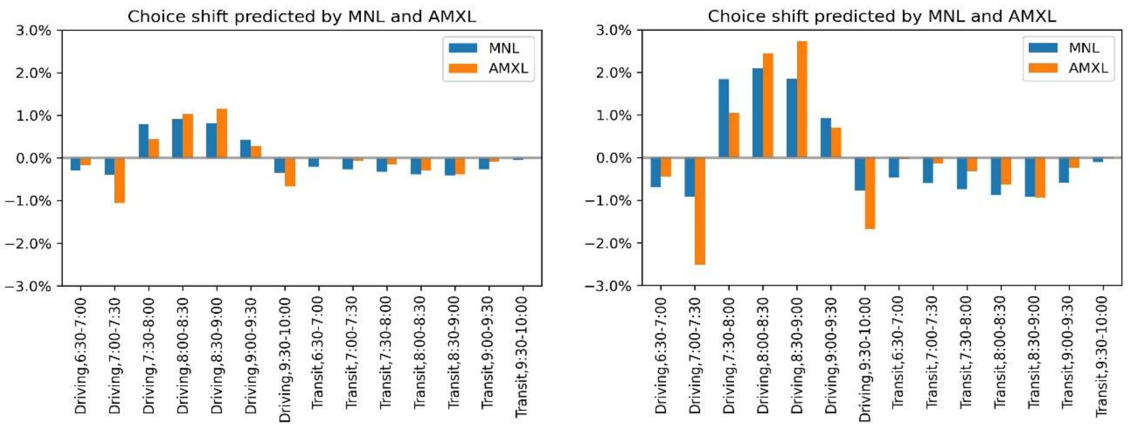
(h) AMXL-individual level: out-of-sample accuracy 30.74%

Compared with DCMs, AMXL considerably improved:

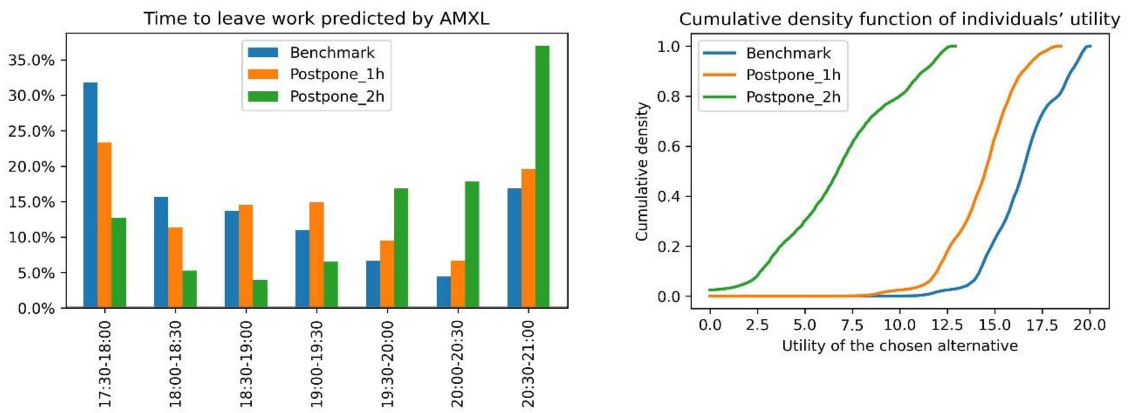
- In-sample accuracy of **individual-level prediction** (from 1.37% to **47.18%**)
- Out-of-sample accuracy of **aggregated-level prediction** (from 5.21% to **61.68%**)

95

Big Data Behavior Modeling in the practice of Lujia Zhui, Shanghai



(a) Peak-hour driving time decreased by 10%   (b) Peak-hour driving time decreased by 20%



(a) Simulation results   (b) CDF of utilities

$$\max Z = c_1 x_1 + c_2 x_2 + \cdots + c_{80} x_{80} \quad (20)$$

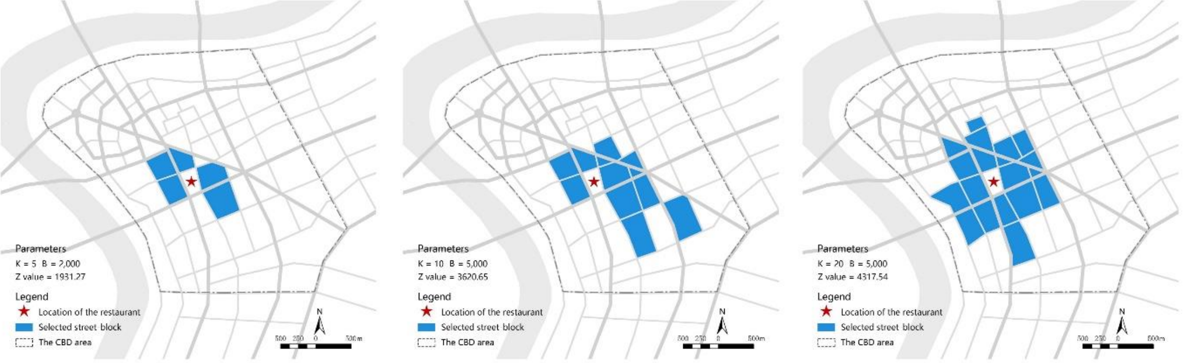
subject to:

$$c_b = \sum_{i \in P_b} (\theta^{t}_{work-lunch,i} \Delta t_{work-lunch,i} + \theta^{des,1}_{lunch,i} \Delta des^{1}_{lunch,i}), \qquad b = 1, \ldots, 80 \quad (21)$$

$$|P_1| x_1 + |P_2| x_2 + \cdots + |P_3| x_{80} \le B \quad (22)$$

$$x_1 + x_2 + \cdots + x_{80} \le K \quad (23)$$

$$x_1, x_2, \ldots, x_{80} \in \{0,1\} \quad (24)$$



(a) K=5, B=2,000   (b) K=10, B=5,000   (c) K=20, B=5,000

96