Forum THNS2024: TRANSFORMING TRANSPORT

Evaluation system for urban traffic intelligence based on travel experiences: A sentiment analysis approach

Speaker：Sa Gao

Supervisor：Prof. Wanjing Ma

School：Tongji University

2024-11-7

Table of Contents

Introduction

Background & Significance

Traffic congestion

Traffic safety

Traffic pollution

✓ The issues of urban traffic are becoming increasingly prominent, with the most common problems including **traffic congestion, traffic safety, and traffic pollution**.

✓ With the urgent need for addressing these challenges, urban road traffic is rapidly advancing towards **intelligent development**.

✓ enhance the efficiency of transportation systems

✓ significantly impact the travel experiences of individuals

Introduction

Background & Significance

❑ **Establish a precise and comprehensive evaluation system for urban traffic intelligence**

CRUCIAL

Mainly relying on indicators based on **physical measurements**

Coverage rate of parking guidance systems

congestion delay index

Death rate per 10,000 vehicles

✓ The existing systems mainly rely on indicators based on physical measurements, while neglecting the crucial factor of travel experience.

Introduction

Background & Significance

❑ **Therefore, there is a** **notable discrepancy** **between the intended effects of transportation design and the actual travel experiences perceived by traffic participants.**

Give two small examples

Increasing the maximum carrying capacity of the bus system can improve its transportation efficiency, but this often comes at **the cost of reducing passenger comfort**.

Bus capacity

The two-stage design during the journey crossing aims to **minimize** the overall waiting time and improve the safety of pedestrians and vehicles. However, some people may find this design inconvenient because they need to wait twice when crossing the intersection.

Pedestrian second crossing

✓ Fundamentally, intelligent transportation serves travelers. In the process of developing and constructing intelligent transportation, physical work and service functions are equally important, and the latter is becoming increasingly important.

Main challenges

❑ **It is urgently necessary to fill the gap by evaluating the quality of urban transportation services based on actual travel experiences, achieving the effect of "promoting construction through evaluation".**

Three main challenges

1

How to establish a comprehensive indicator library for the evaluation system

One commonly employed approach is to extract suitable indicators through literature research.

2

How to collect data related to the travel experiences of traffic participants

Traditional data collection methods primarily rely on surveys

3

How to build an effective evaluation system based on travel experiences

Main challenges

Three main challenges

1

How to establish a comprehensive indicator library for the evaluation system

2

How to collect data related to the travel experiences of traffic participants
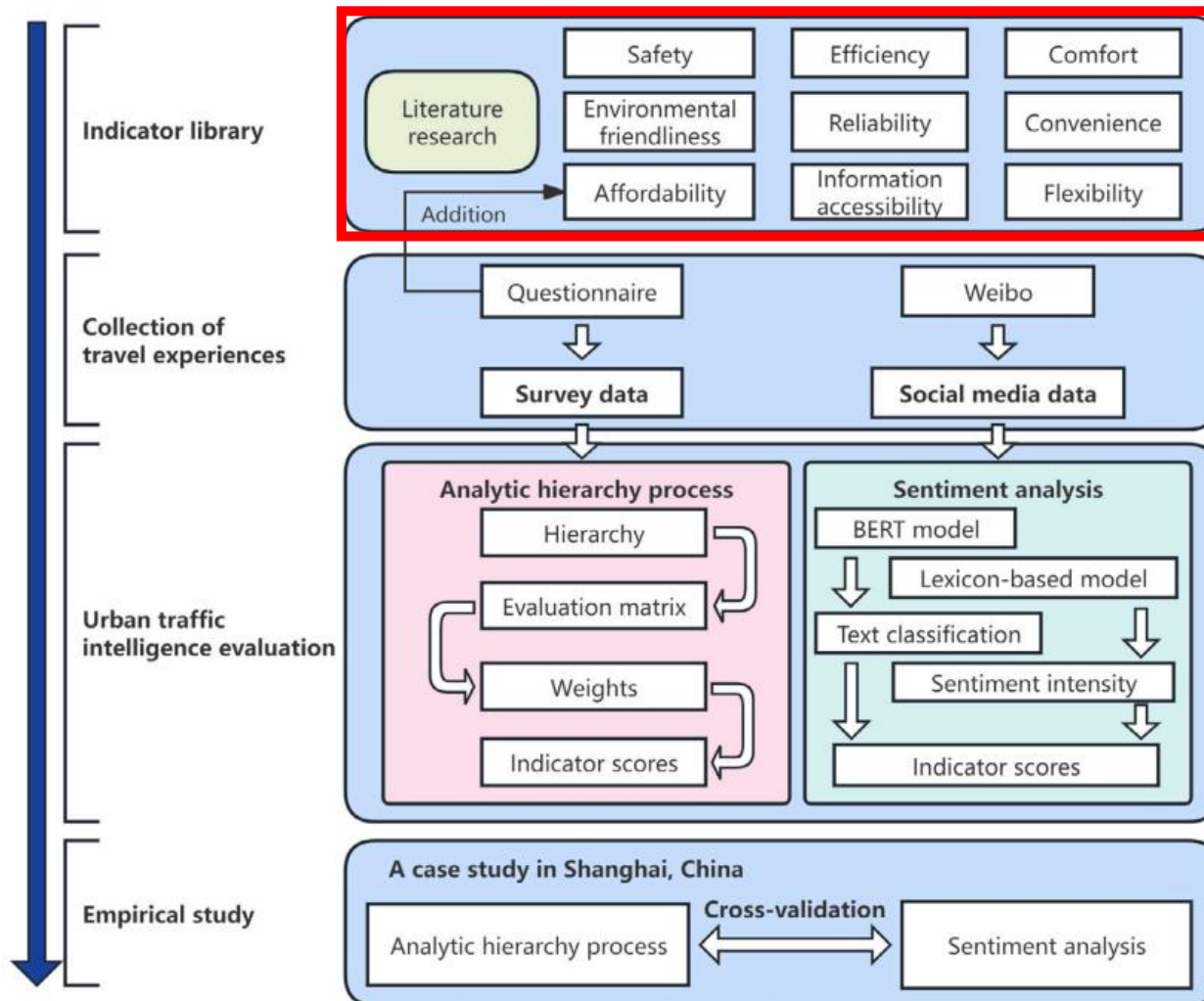
3

How to build an effective evaluation system based on travel experiences

To address the above challenges, we propose a **data-driven evaluation system** for urban traffic intelligence **based on travel experiences** through sentiment analysis, and the evaluation framework is shown in next page.
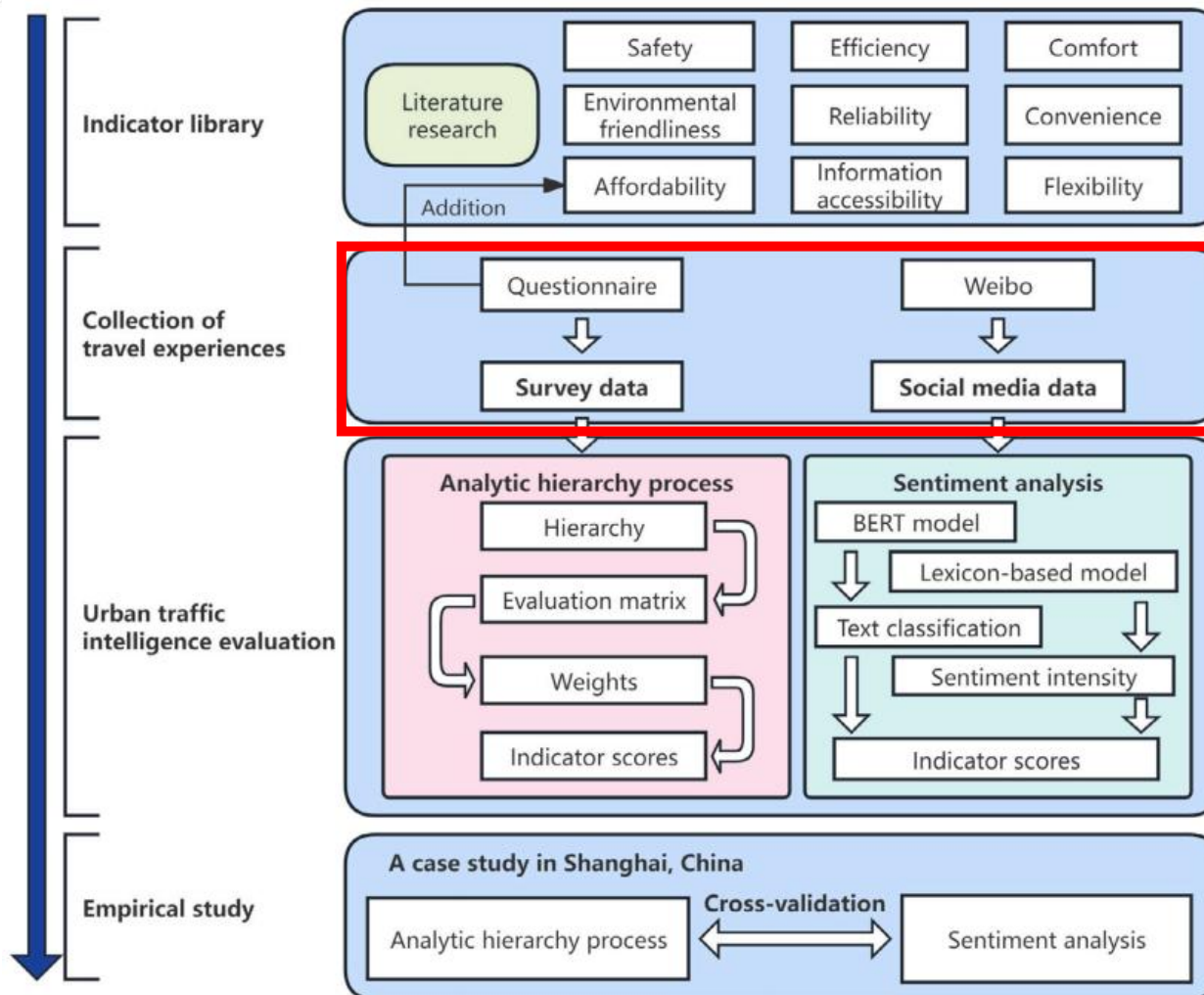
Model Framework

The framework is designed in an end-to-end manner, which can seamlessly and automatically handle tasks from data collection to evaluation.

✓ For the first challenge of indicator library construction, we combine literature retrieval and survey to establish a comprehensive indicator library.
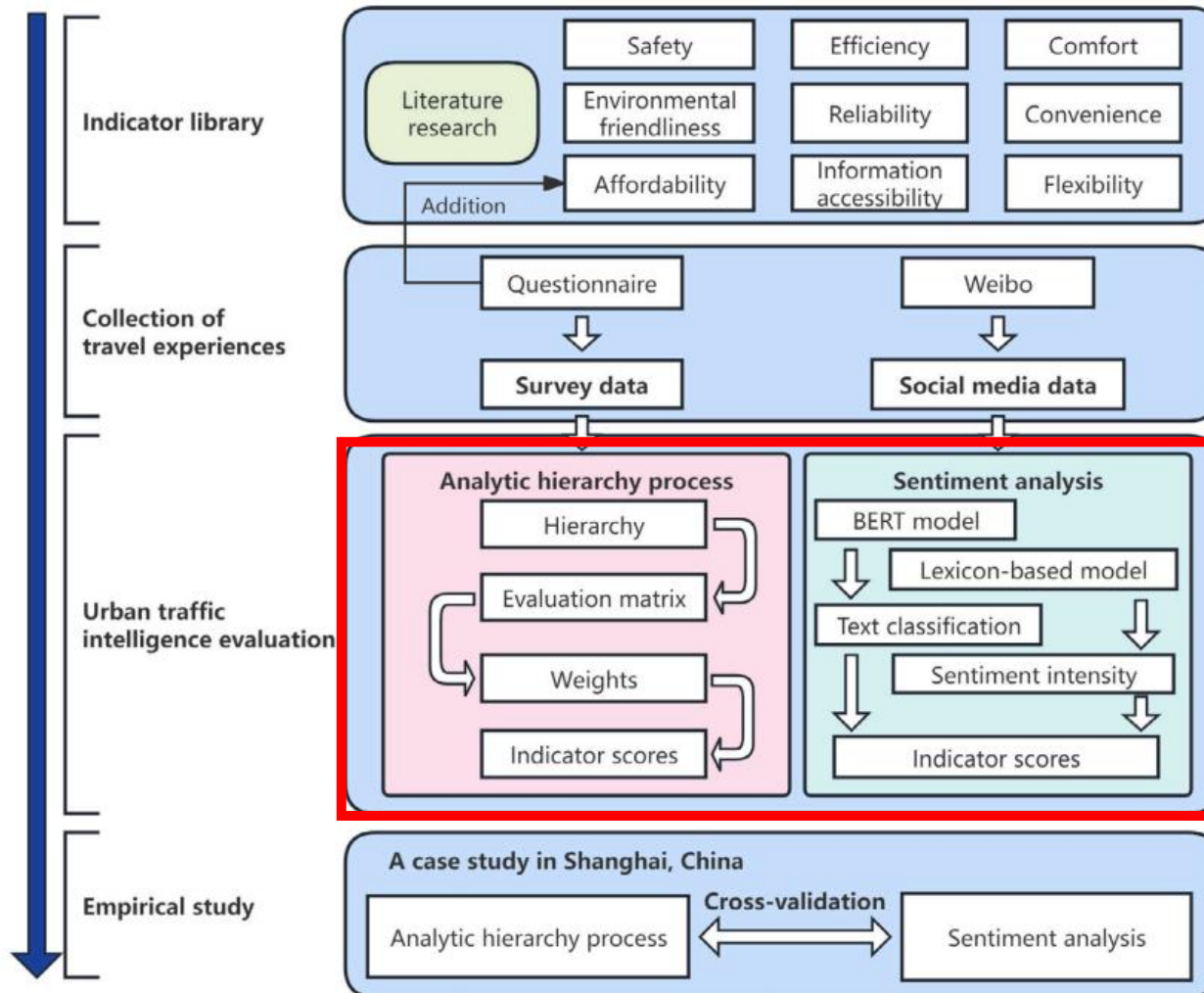
Model Framework

The framework is designed in an end-to-end manner, which can seamlessly and automatically handle tasks from data collection to evaluation.

✓ For the second challenge of travel experiences extraction, we collect travel experiences from two data sources: questionnaire and social media posts.

Model Framework

The framework is designed in an end-to-end manner, which can seamlessly and automatically handle tasks from data collection to evaluation.

✓ For the third challenge of evaluation system design, we conduct sentiment analysis on social media posts and Analytic Hierarchy Process on survey data. The evaluation results based on these two data sources are then cross-validated.
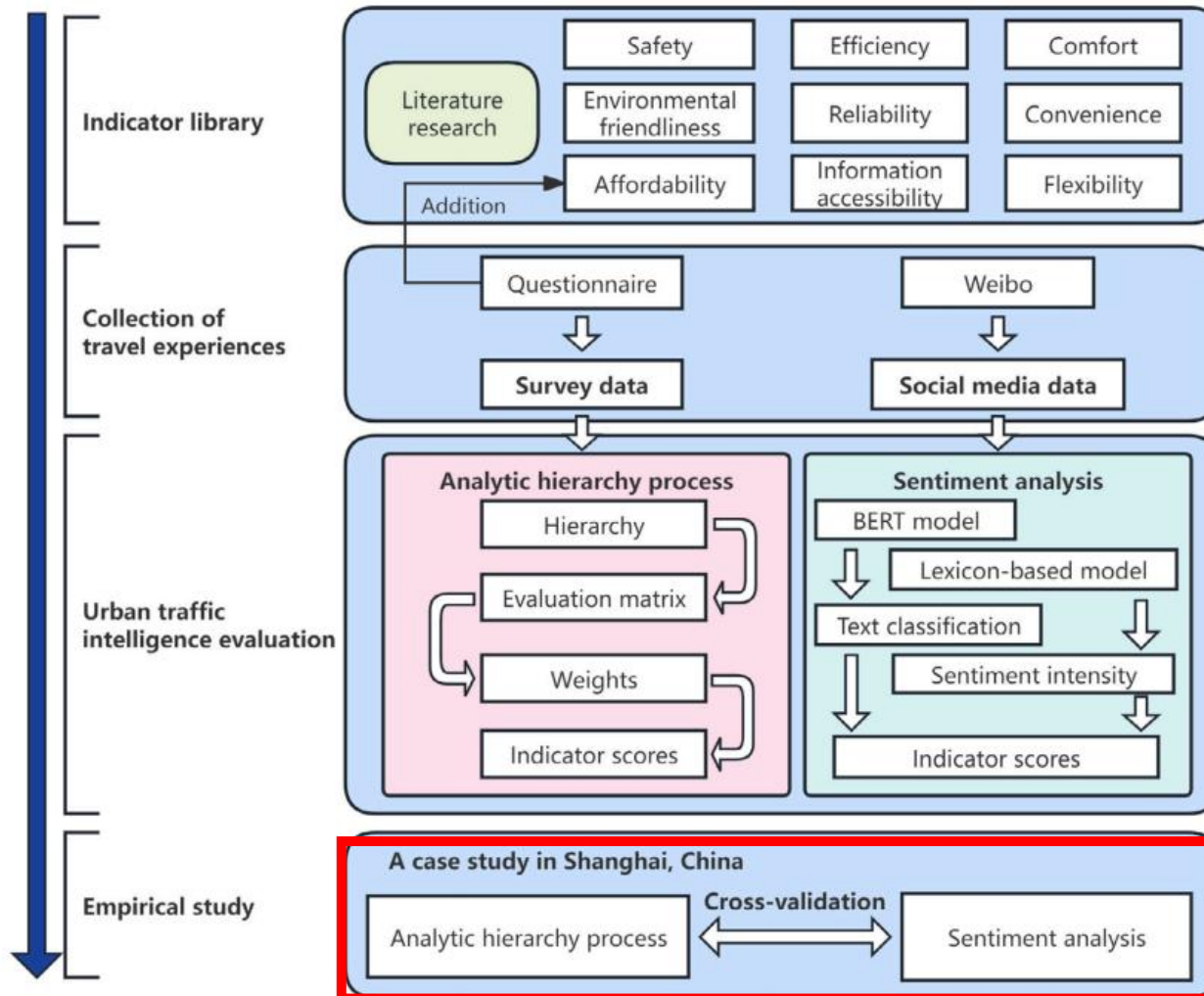
Model Framework

The framework is designed in an end-to-end manner, which can seamlessly and automatically handle tasks from data collection to evaluation.

✓ The proposed method is tested in Shanghai, China, to evaluate the level of urban traffic intelligence.In conclusion, this research presents a novel approach to evaluating urban traffic intelligence. The obtained evaluation outcomes can provide scientific guidance for the development of intelligent transportation systems.

Research Object

☐ China's **second-largest** city

☐ **Diverse** transportation modes

☐ **Rapid** development of intelligent transportation

Shanghai

The map of Shanghai

Shanghai subway network map
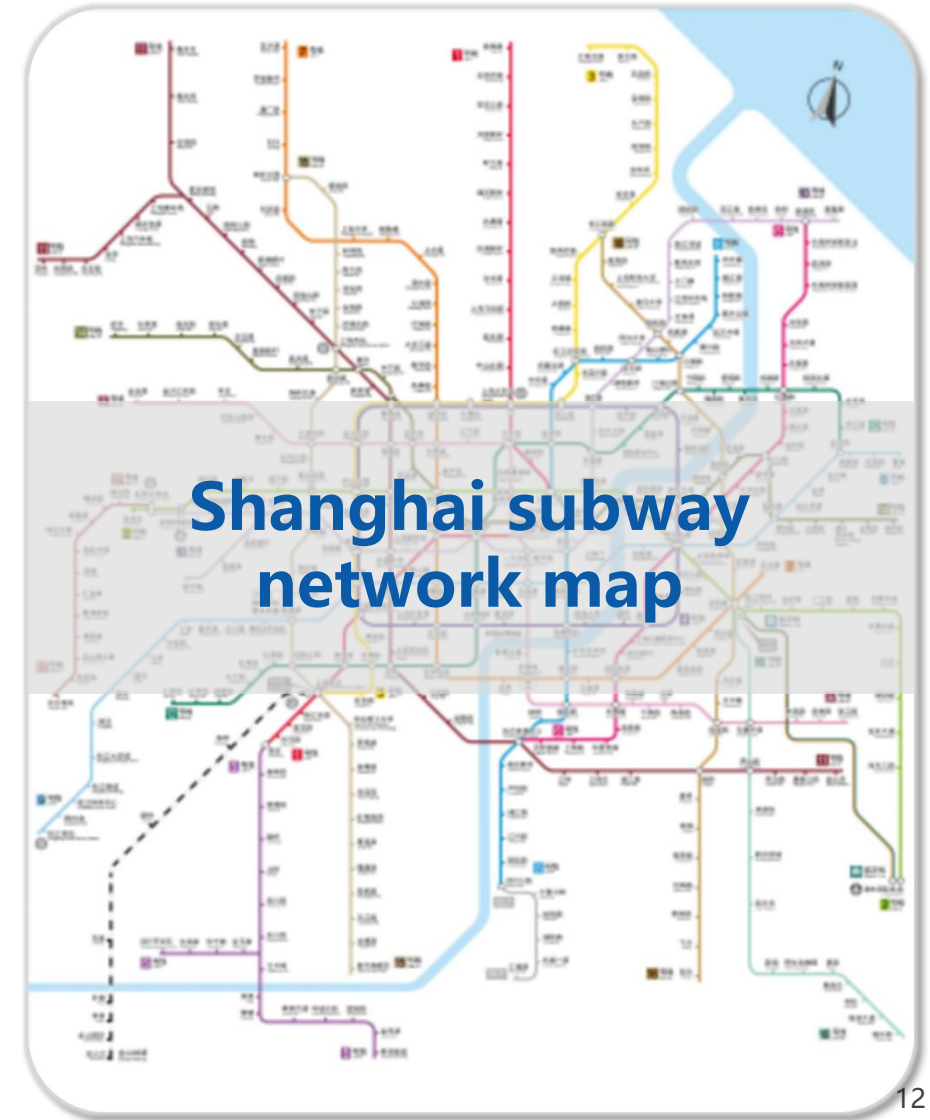
Research Method

Stage 1 Construction of indicator library based on literature research

❑ In this work, we obtain the indicator library through meta-analysis，which is to retrieve indicators from existing literature.

Papers published after the year 2010

Meta-analysis

17 closely related papers

• We focus on papers that proposed evaluation systems related to ITS, and we limit our analysis to papers published after the year 2010. After conducting a thorough search, a total of 17 closely related papers are identified

Included papers in the literature research.

Research subject	Author	Country	Method	Number of primary indicators	Number of secondary indicators
Public transport system	Velasco and Gerike (2024)	USA	LR	5	49
	Zhang et al. (2019)	China	Delphi	10	25
	Barbosa et al. (2017)	Brazil	Delphi	10	30
	Nassereddine and Eskandari (2017)	Iran	LR+Delphi	6	/
	Mouwen (2015)	NL	Survey	15	/
	Zak (2011)	USA	LR	9	/
Transit system	Weng et al. (2018)	China	LR	6	21
	Hassan et al. (2013)	UAE	Delphi	5	/
	Eboli and Mazzulla (2011)	Italy	LR	11	26
	El-Geneidy et al. (2011)	USA	Delphi	3	/
Rail transit system	Huang et al. (2018)	China	NS+Delphi	8	40
	Aydin et al. (2015)	Turkey	Delphi	9	23
Urban mobility	Lyons (2018)	/	LR	4	/
	Awasthi et al. (2018)	LUX	LR+Delphi	4	31
Sustainable transport system	Sdoukopoulos et al. (2019)	Greece	LR	4	47
	Mitropoulos and Prevedouros (2016)	USA	LR+Delphi	5	/
	Ramani et al. (2011)	USA	LR+Delphi	5	/

Country: UAE: The United Arab Emirates; NL: Netherlands; LUX: Grand Duchy of Luxembourg

Method: LR: Literature Research; NS: National Standard

Research Method

Included papers in the literature research.

Research subject	Author	Country	Method	Number of primary indicators	Number of secondary indicators
Public transport system	Velasco and Gerike (2024)	USA	LR	5	49
	Zhang et al. (2019)	China	Delphi	10	25
	Barbosa et al. (2017)	Brazil	Delphi	10	30
	Nassereddine and Eskandari (2017)	Iran	LR+Delphi	6	/
	Mouwen (2015)	NL	Survey	15	/
	Zak (2011)	USA	LR	9	/
Transit system	Weng et al. (2018)	China	LR	6	21
	Hassan et al. (2013)	UAE	Delphi	5	/
	Eboli and Mazzulla (2011)	Italy	LR	11	26
	El-Geneidy et al. (2011)	USA	Delphi	3	/
Rail transit system	Huang et al. (2018)	China	NS+Delphi	8	40
	Aydin et al. (2015)	Turkey	Delphi	9	23
Urban mobility	Lyons (2018)	/	LR	4	/
	Awasthi et al. (2018)	LUX	LR+Delphi	4	31
Sustainable transport system	Sdoukopoulos et al. (2019)	Greece	LR	4	47
	Mitropoulos and Prevedouros (2016)	USA	LR+Delphi	5	/
	Ramani et al. (2011)	USA	LR+Delphi	5	/

Country: UAE: The United Arab Emirates; NL: Netherlands; LUX: Grand Duchy of Luxembourg

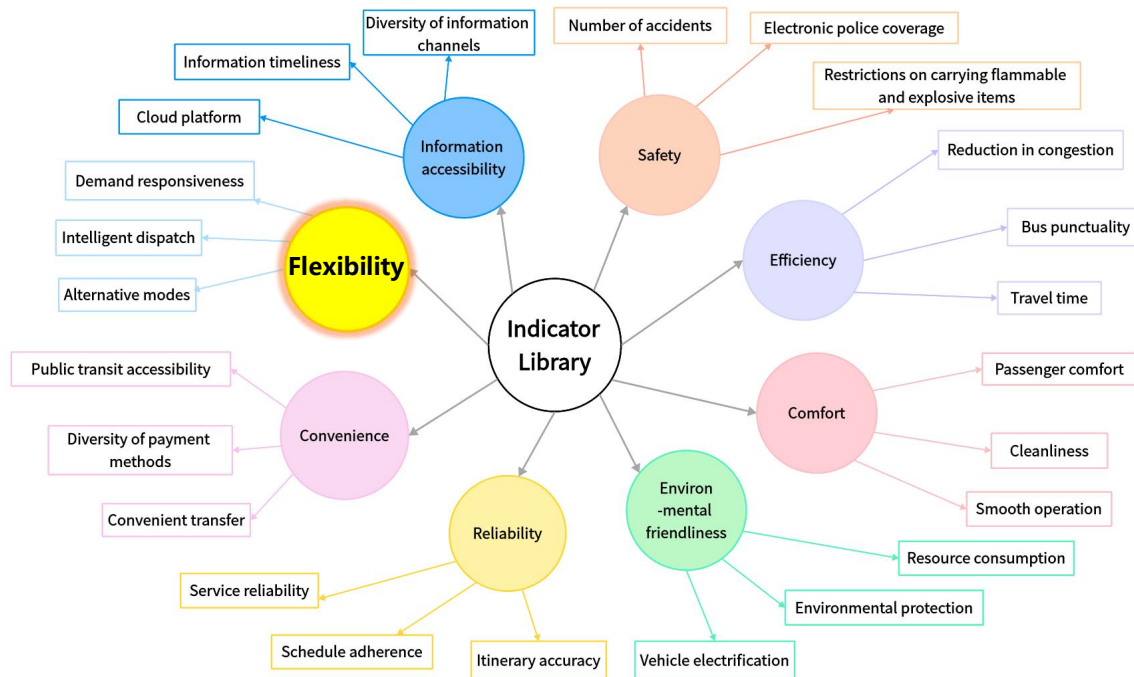*Method:* LR: Literature Research; NS: National Standard

✓ Filter the preliminary indicators that are closely related to travel experiences and perform cluster analysis
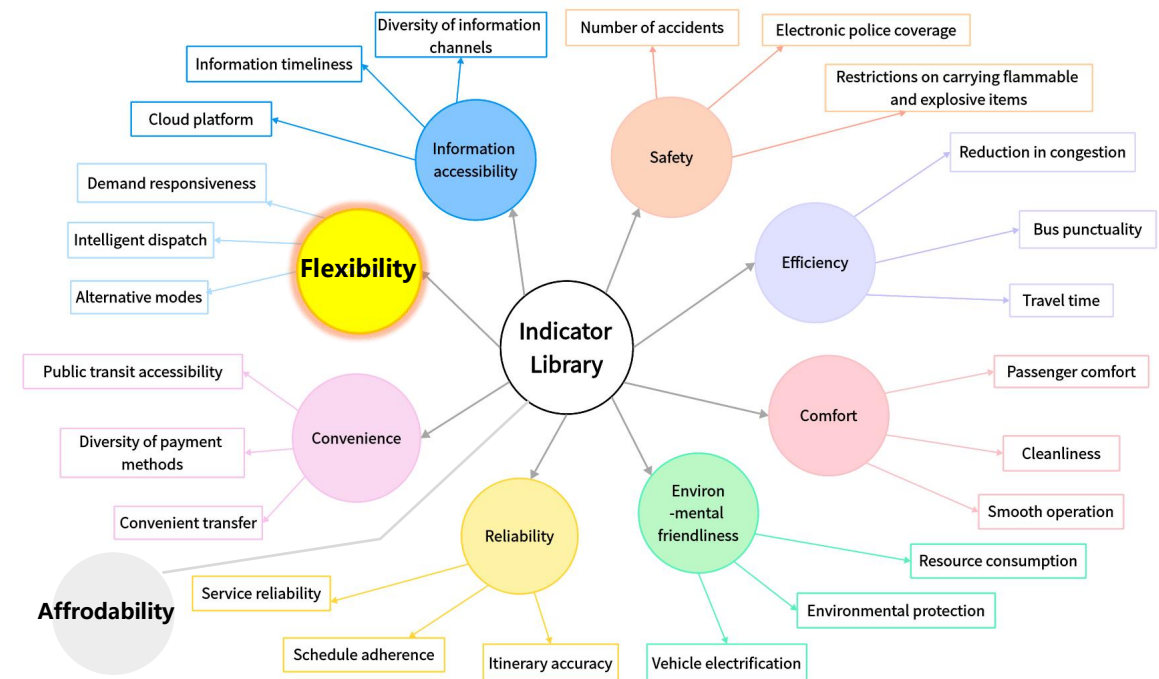
Representative indicators that can be used to evaluate urban traffic intelligence

Research Method

✓ Flexibility refers to the responsiveness of a transportation system to different travel needs and the capability of providing personalized travel suggestions

Representative indicators that can be used to evaluate urban traffic intelligence

Research Method

Stage 2 Data collection for travel experiences

❑ This section introduces the data collection process for obtaining travel experiences from two data sources:
(1) survey data collected through questionnaires
(2) social media data scraped from Sina Weibo.

01 **survey data collected through questionnaires**

02

- ☐ the background characteristics of the respondents
- ☐ assess the overall understanding and perceptions of the respondents regarding ITS
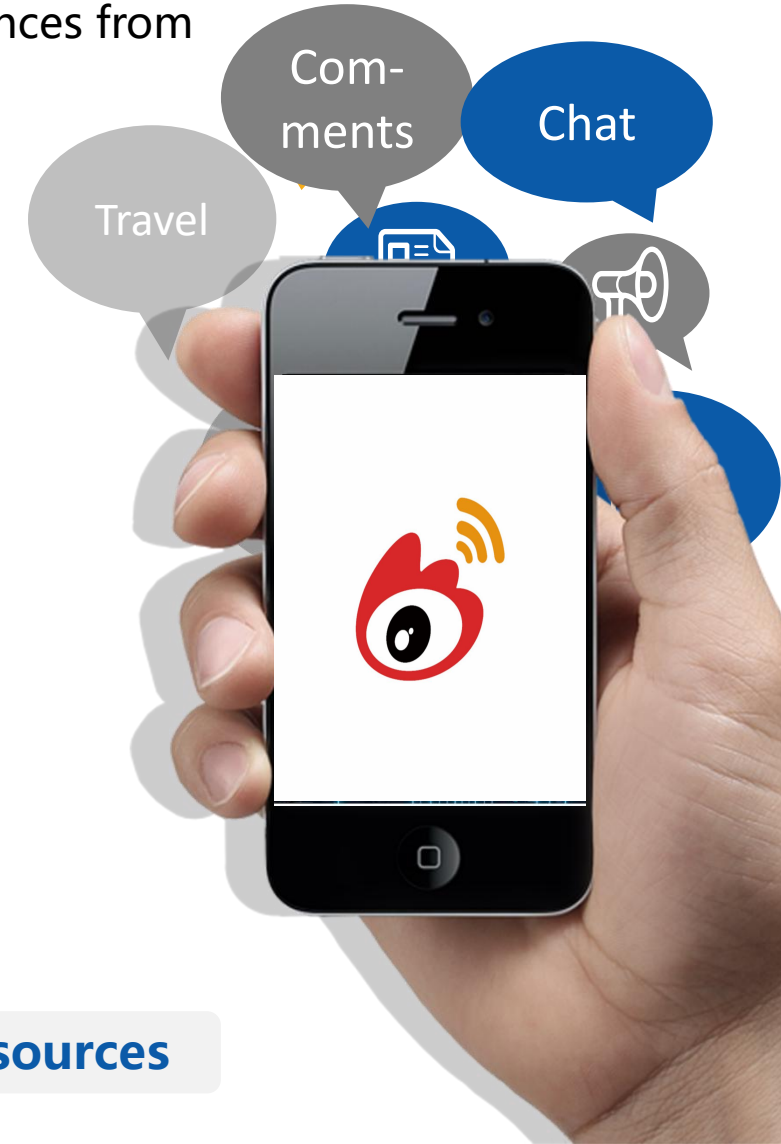- ☐ information from respondents to evaluate the indicators

14 Qs

social media data collected from Sina Weibo

Com-ments

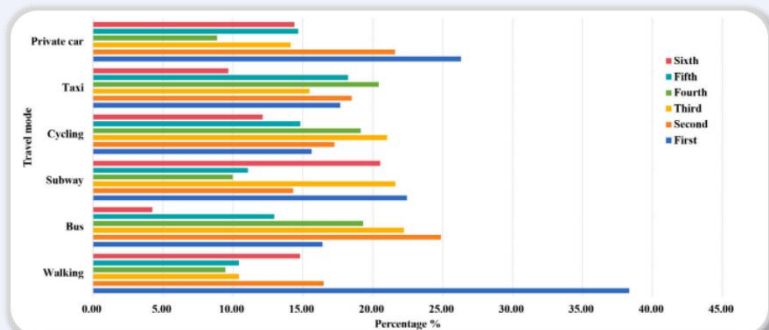Chat

Travel

Multiple data sources

Research Method

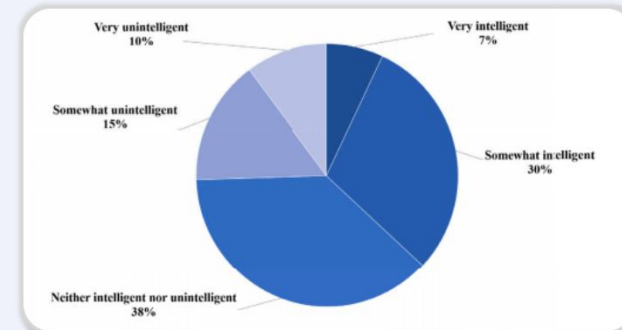## Stage 2 Data collection for travel experiences

❑ This section introduces the data collection process for obtaining travel experiences from two data sources:

(1) survey data collected through questionnaires

(2) social media data scraped from Sina Weibo.

Distribution of travel modes among survey respondents

Overall understanding and perceptions of the survey respondents regarding ITS

Background information	Options	Number observed	Percentage (%)
Gender	Male	274	57.44
	Female	203	42.56
Age (years)	15–24	55	11.53
	25–34	246	51.57
	34–49	136	28.51
	50–69	35	7.34
	70+	5	1.05
Education level	Primary or junior high school	84	17.61
	High school	68	14.26
	College and University	220	46.12
	Post graduate +	105	22.01
Occupation	Student	165	34.59
	Employee	75	15.73
	Civil servant	52	10.90
	Self-employed	78	16.35
	Teacher or doctor	76	15.93
	Others	31	6.50

✓ a total of 477 valid questionnaires were obtained after conducting an integrity check and filtering out invalid responses.
✓ travel mode
✓ Overall understanding and perceptions of the survey respondents regarding ITS
✓ Participants are required to rank the satisfaction of the indicators from last chapter based on their travel experiences.

Research Method
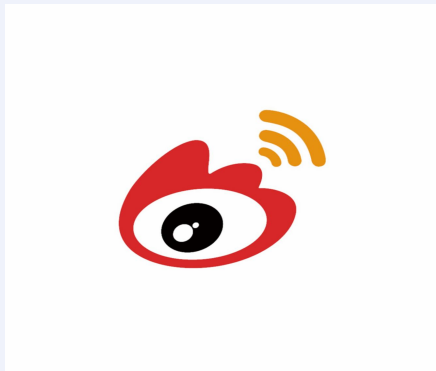
Stage 2 Data collection for travel experiences

❑ This section introduces the data collection process for obtaining travel experiences from two data sources:

(1) survey data collected through questionnaires

(2) social media data scraped from Sina Weibo.

✓ Weibo is the Chinese version of Twitter, which has over 250 million daily active users according to the data at the end of 2022.

✓ our web scraping efforts are focused on gathering posts from **Shanghai**

✓ conduct data filtering
✓ obtain a dataset with a total of 3266 valid Weibo data entries

	A	B	C	D	E	F	G	H	I
1	页码	微博ID	微博BID	微博作者	发布时间	微博内容	转发数	评论数	点赞数
2	1	['4898342624826743',	['MFg18kfEH'	['石犀客2018']	['Sat May 06 10:15:51 +0800	['上海这条高速入口堵上天了，该改	[12]	[9]	[35]
3	1	'4898134289028906',	['MFaV6BSPw'	['上海发布'，'上	['Fri May 05 20:28:00 +0800	['【#上海公交6月1日起将开启冷空	[27]	[51]	[153]
4	1	'4885405918567437',	['MzPNtzWMt'	['今日闵行'，'上	['Fri May 31 17:30:00 +0800	['【上海地铁最新四线换乘、三线拍	[55]	[1]	[3]
5	1	'4902070316438258',	['N0RRdr0SS'	['乐行上海']	['Tue May 16 17:08:22 +0800	['"【公交】接通知：受天气影响，1(	[0]	[0]	[0]
6	1	'4901979228997288',	['N0PuiBKBy'	['昆明国家高新区'	['Tue May 16 11:06:25 +0800	['#昆明高新动态# 为学习借鉴先进	[0]	[1]	[1]
7	1	'4901582728334179',	['N0FaMyY6f'	['love浦江'，'上'	['Mon May 15 08:50:52 +0800	['#上海这些地铁站和公交站有母	[17]	[0]	[1]
8	1	'4901401396512452',	['N0Asjrkby'	['种纬raullinoux'	['Sun May 14 20:50:19 +0800	['北京上海交通之初体验。']	[0]	[0]	[1]
9	1	'4901034457301020',	['N0qUtuDko'	['乐行上海'，'乐(	['Sat May 13 20:32:13 +0800	['"【突发】20时30分，G1503外圈近	[0, 1]	[0, 0]	[0, 0]
10	1	'4900972537320571',	['N0piBuIpJ'	['glen-happy']	['Sat May 13 16:26:11 +0800	['华为钱包PAY，上海交通联合卡，	[0]	[0]	[0]
11	1	'4900843562207362',	['N01WA9geC'	['刺杀三明治_']	['Sat May 13 07:53:41 +0800	['上海交通让人很痛苦']	[0]	[0]	[0]
12	1	'4900719587230131',	['N0iICukT1'	['你就是我的小星!	['Fri May 12 23:41:02 +0800	['上海这座城的交通， 半夜路上都	[0]	[0]	[0]
13	2	'4900675739456457',	['N0hzTDG3v'	['长三角之声'，'_	['Fri May 12 20:46:49 +0800	['【#71路中运量公交西延伸工程专	[1]	[0]	[0]
14	2	'4900659659280915',	['N0h9XCWob'	['乐行上海'，'乐彳	['Fri May 12 19:42:55 +0800	['【路况】#车流量大# 19时41分，(	[0, 1]	[0, 0]	[0, 0]
15	2	'4900627337449233',	['N0gjPvfSV'	['glen-happy']	['Fri May 12 17:34:29 +0800	['华为钱包PAY，上海交通联合卡，	[0]	[0]	[0]
16	2	'4900619929780681',	['N0g7SF2oV'	['吴泾家园'，'上	['Fri May 12 17:05:02 +0800	['【空中漫步即可直达商圈！上海边	[0]	[0]	[0]
17	2	'4900576946558252',	['N0f0yrw6g'	['文博圈官微']	['Fri May 12 14:14:15 +0800	['上海交通大学校史博物馆 科教兴	[2]	[1]	[1]
18	2	'4900520752318657',	['N0dxV9JbH'	['中国经济时报']	['Fri May 12 10:30:57 +0800	['【"科技+政策"共推公交领域自	[0]	[0]	[0]
19	2	'4900280334816134',	['N07i9kcTA'	['顺位第一']	['Thu May 11 18:35:37 +0800	['上海交通联合卡充值成功！下月服	[0]	[0]	[0]
20	2	'4900264925202940',	['N06TilPwo'	['大闸蟹的文言文'	['Thu May 11 17:34:23 +0800	['青浦这个公交我真的不想说啥了 ;	[0]	[1]	[0]
21	3	'4900184012884106',	['N04MNc6hQ'	['乐行上海']	['Thu May 11 12:12:52 +0800	['【路况】#车流量大# 12时10分，;	[2]	[0]	[0]

Research Method

Stage 3 Evaluation system design

❑ Because the data are collected from two data sources, which are different data types, so this part use two approaches to design evaluation.
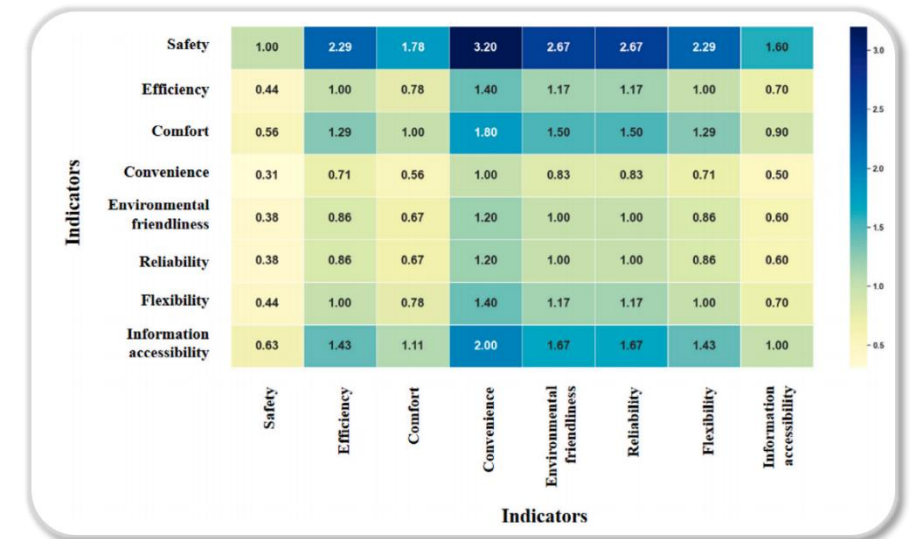
For survey data

✓ a preliminary rating of urban traffic intelligence can be derived. This rating can be used as a benchmark to cross-validate with the evaluations derived from the social media data. The rating derived from the survey data can be calculated as follows:

$$I_1 = \sum_{i=1}^{n} w_i r_i$$

weight ⟸

rating from Likert scale ranking in Q8

✓ use AHP method
✓ The heat map highlights the relative importance of row and column factors
✓ the consistency check pass
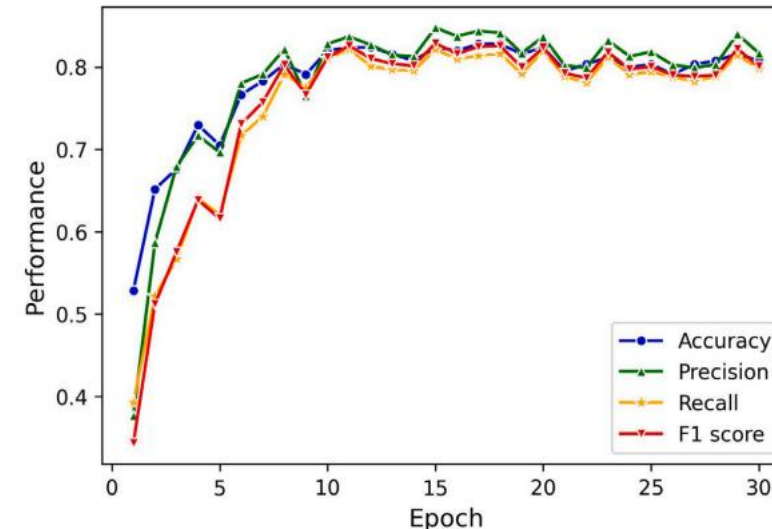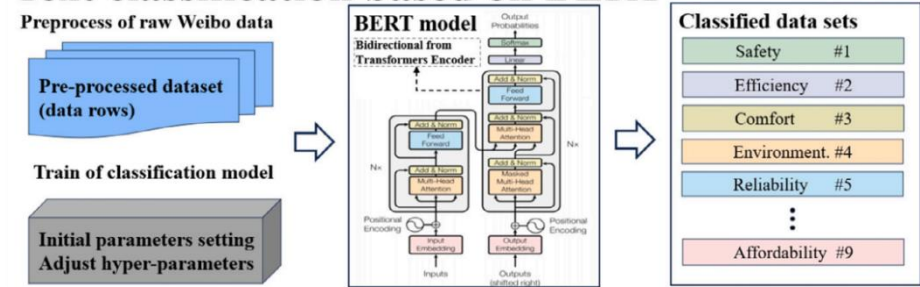✓ obtain weights of every indicator

Research Method

Stage 3 Evaluation system design

❑ Because the data are collected from two data sources, which are different data types, so this part use two approaches to design evaluation.

For survey data

Nine-point intensity of importance scale and its description.

Definition	Intensity of importance
Equally important	1
Moderately more important	3
Strongly more important	5
Very strongly more important	7
Extremely more important	9
Intermediate values	2,4,6,8

✓ a preliminary rating of urban traffic intelligence can be derived. This rating can be used as a benchmark to cross-validate with the evaluations derived from the social media data. The rating derived from the survey data can be calculated as follows:

weight

$$I_1 = \sum_{i=1}^{n} w_i r_i$$

rating from Likert scale ranking

The weights are then utilized to perform a weighted sum of the **ratings.** Therefore, the AHP method yields an **evaluation score of 69.64** for urban traffic intelligence in Shanghai.

Research Method

❑ Because the data are collected from two data sources, which are different data types, so this part use two approaches to design evaluation.

For social media data

✓ We first classify the text data collected from Weibo into respective indicators using a pre-trained language model which is named BERT.
✓ The training of the BERT framework involves two steps: pre-training and fine-tuning.
✓ ①trained on a vast amount of data with various pre-training tasks
✓ employ the parameters provided by CUI
✓ fine-tune these parameters using the labeled text data

Text classification based on BERT

✓ labeled a total of 1633 samples
✓ the performance metrics of the BERT model across different epochs in the test data.
✓ the four metrics increase steadily and stabilize after 10 epochs.
✓ select the model from the 10th epoch for the text classification task.

Cui, Y., Che, W., Liu, T., Qin, B., Yang, Z., 2021. Pre-training with whole word masking for Chinese BERT. IEEE/ACM Trans. Audio, Speech, Lang. Process. 29,3504–3514
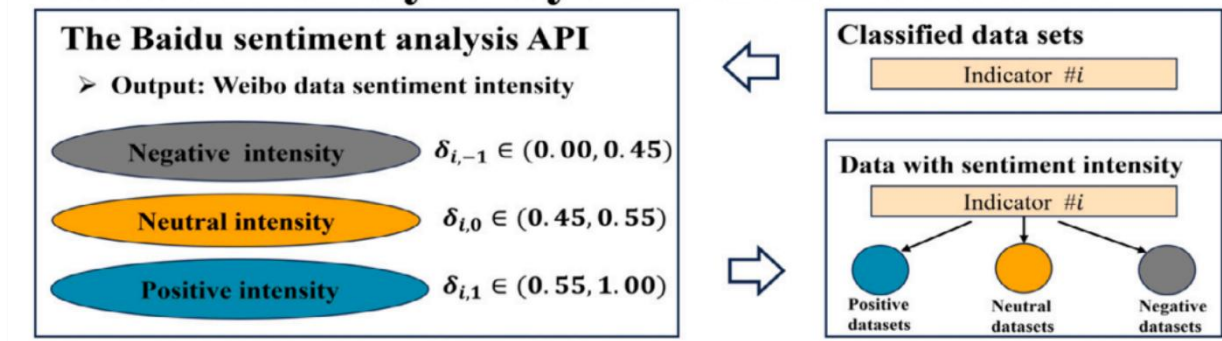
Research Method

Stage 3 Evaluation system design

❑ Because the data are collected from two data sources, which are different data types, so this part use two approaches to design evaluation.

For social media data

✓ After that, we perform sentiment analysis (SA) on the classified text data using a lexicon-based model: baidu API.
✓ The lexical analysis models offered by Baidu have been widely used in recent academic research focusing on text data in Chinese
✓ extract the polarity and the sentiment intensity of text data.

Sentiment analysis by lexicon-based model

The Baidu sentiment analysis API

➤ Output: Weibo data sentiment intensity

Negative intensity	$\delta_{i,-1} \in (0.00, 0.45)$
Neutral intensity	$\delta_{i,0} \in (0.45, 0.55)$
Positive intensity	$\delta_{i,1} \in (0.55, 1.00)$

Classified data sets

Indicator #i

Data with sentiment intensity

Indicator #i

Positive datasets   Neutral datasets   Negative datasets

Stage 3 Evaluation system design

❑ Because the data are collected from two data sources, which are different data types, so this part use two approaches to design evaluation.

For social media data
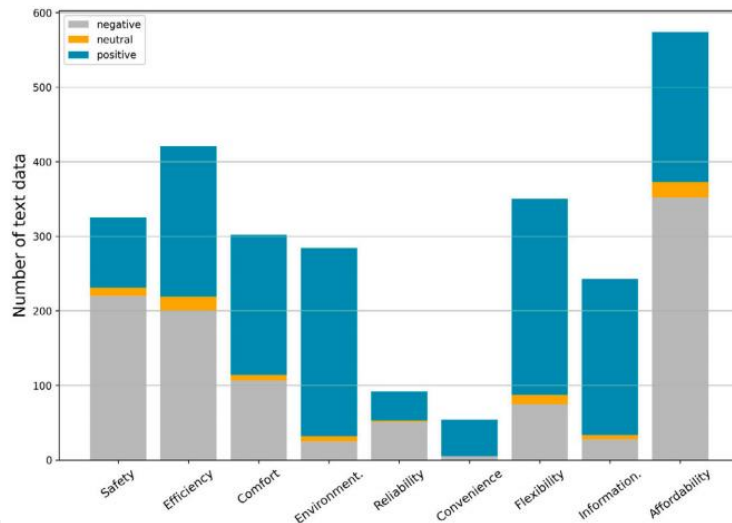
Top three most frequently discussed topics within each indicator.

Indicator	Top three topics		
safety	road accident	road chain conflicts	potential dangers
efficiency	public transportation	traffic congestion	traffic regulations
comfort	user-friendly	noise level	mobile signal
environment friendliness	greenery	cleanliness	weather condition
reliability	on-time arrival	bus punctuality	accurate bus stop sign
convenience	multiple payment access	automation	easily understood
flexibility	shared bikes	transfer distance	alternative travel mode
information accessibility	accurate navigation	real-time traffic conditions	accident notifications
affordability	wallet-friendly	taxi fares	bus fairs and air conditioning

✓ The descriptive statistics of the classification and sentiment distributions for each indicator are presented

✓ presents the distribution of positive, neutral, and negative sentiments for each indicator, which provides insights into the sentiment tendencies of travelers regarding Shanghai's transportation system

✓ the overall rating of urban traffic intelligence in Shanghai is determined to be 68.39 by the sentiment analysis approach.
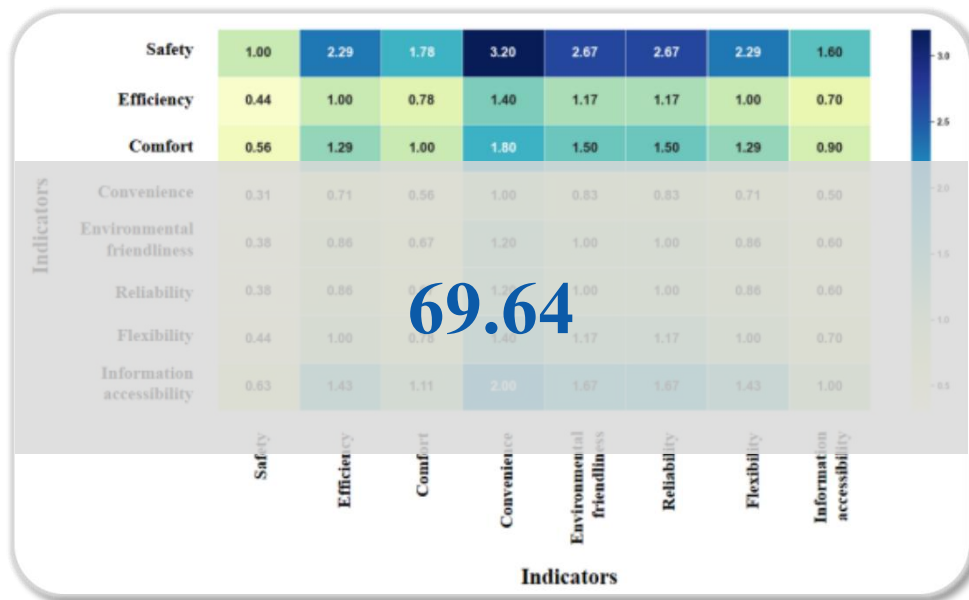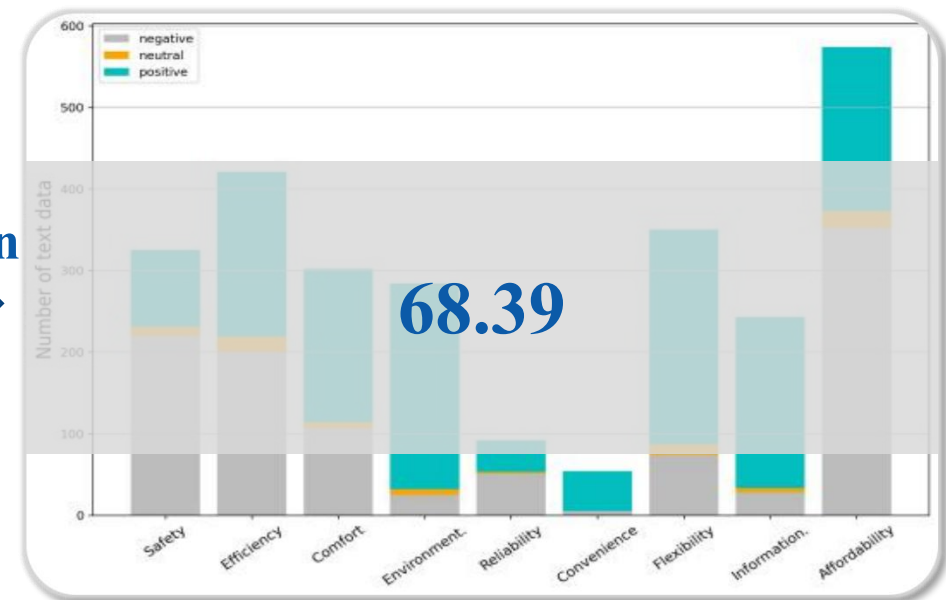
Discussion and Conclusion

Discussion

☐ Results cross-validation

Results of AHP method

69.64

Evaluation Score

Results of sentiment analysis

68.39

✓ These two results were obtained using different datasets (survey data and social media data) from these two different methods (AHP and SA), and the results are very close, indicating the effectiveness of our proposed evaluation system. Therefore, we can prove that the evaluation results of Shanghai's urban transportation intelligence are reliable.

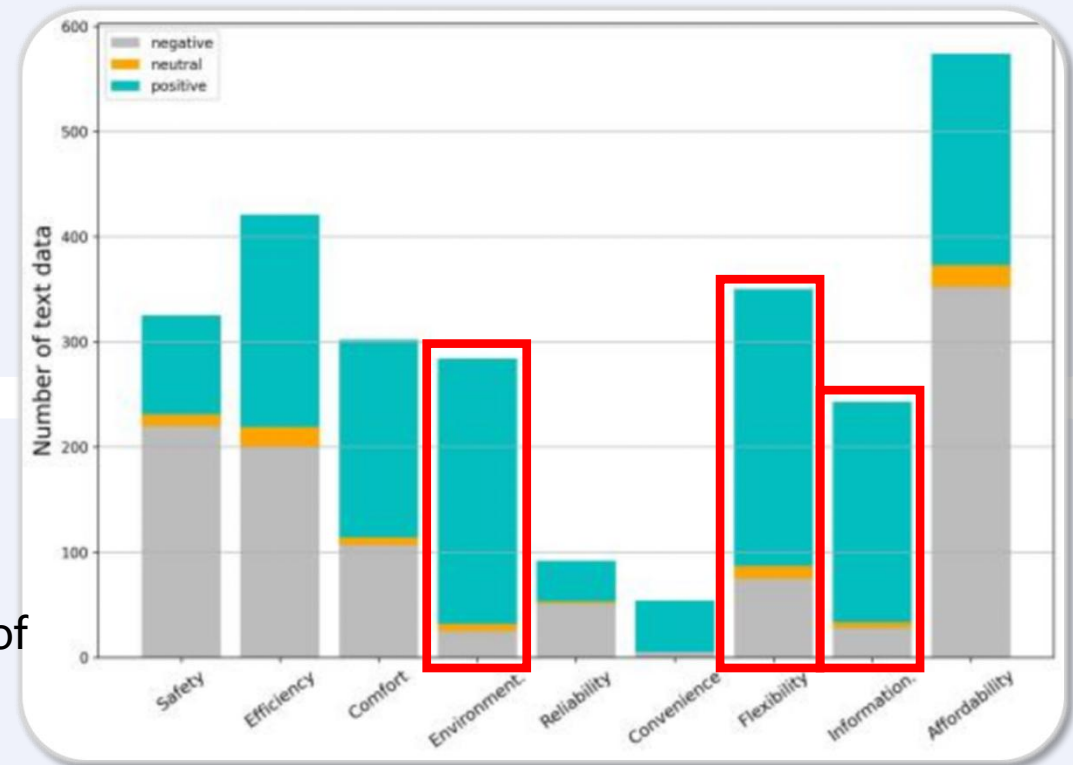# Discussion and Conclusion

Discussion

For Shanghai   by analyzing the obtained evaluation results

- ✓ flexibility
- ✓ environmental friendliness
- ✓ information accessibility

three well-performed aspects of the ITS in Shanghai

- ✓ Shanghai has dense bus and metro system and the integration of shared transport modes.
- ✓ environmental friendliness is largely due to the widespread adoption of electric vehicles. The number of new energy vehicles in Shanghai had reached 1.288 million by the end of 2023, ranking first globally. This milestone marks a significant step forward in the development of environmentally friendly transportation.
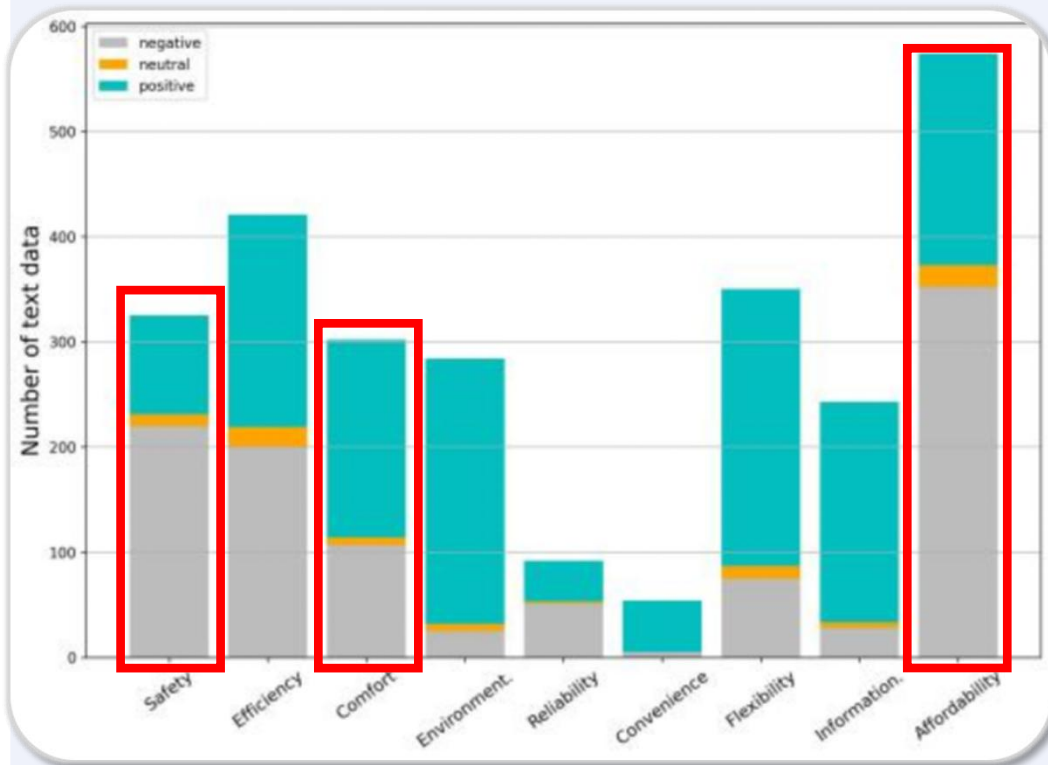
Discussion and Conclusion

Discussion

For Shanghai   by analyzing the obtained evaluation results
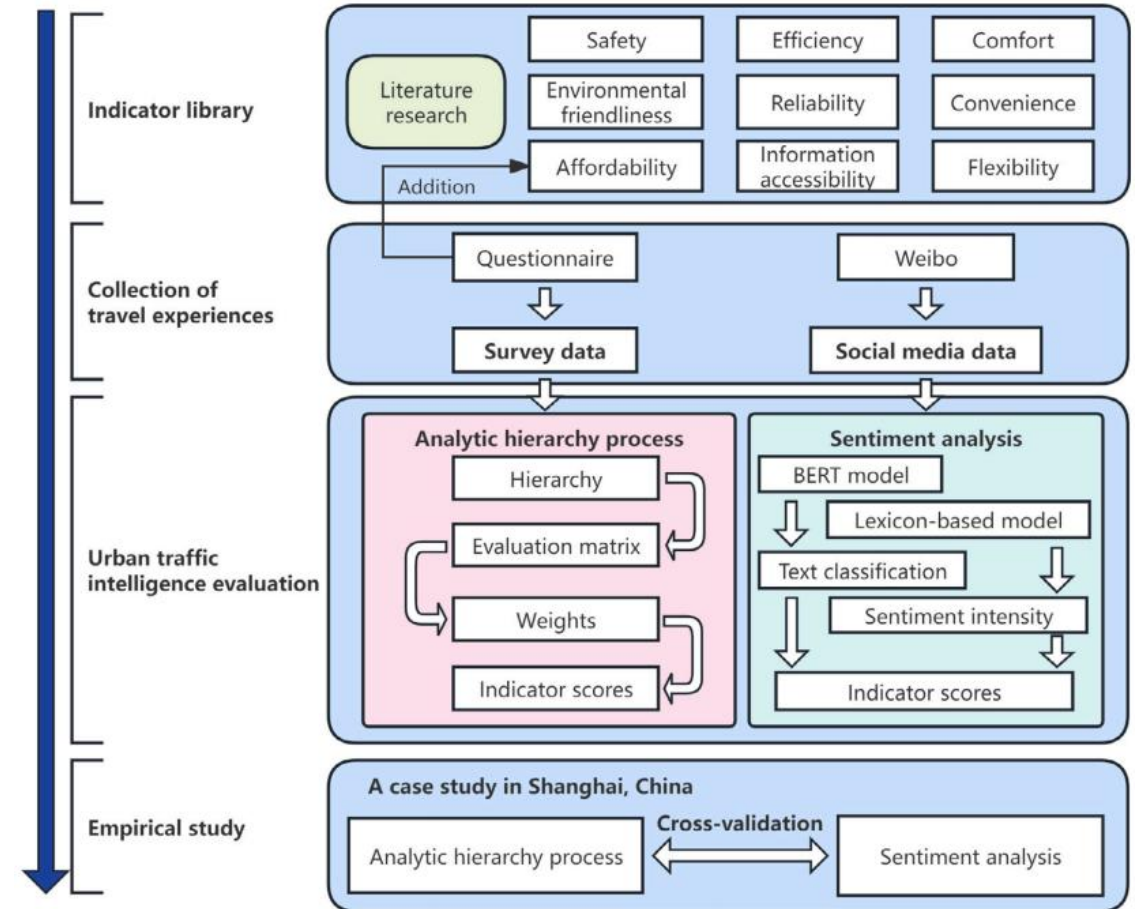

- safety
- comfort
- affordability

the least satisfied factors reported by travelers

✓ affordability receives the most negative comments on Weibo. This is largely because Shanghai has one of the most expensive taxi fares in China. However, Shanghai's public transportation system is relatively affordable compared to similar-sized cities worldwide, owing to subsidies.

✓ as for safety, negative attitudes are not necessarily linked to accidents but rather to incidents of road rage or near accidents.

Discussion and Conclusion

Conclusion

- ✓ In this study, we proposed a novel approach for **evaluating urban traffic intelligence based on travel experiences**. The evaluation system was built on the sentiment analysis approach based on social media data.

- ✓ We employed **two distinct methodologies to** assess urban traffic intelligence based on the established indicator library.

- ✓ Through a careful examination of both questionnaire responses and social media data, we **gained valuable insights into the perceptions and assessments of travelers** regarding urban traffic intelligence of Shanghai.

- ✓ The proposed framework can provide a reliable, scalable, and robust method for evaluating urban traffic intelligence using social media data.

- ✓ Looking forward, our next steps include refining this model for automatic data labeling to reduce manual intervention.