UNIVERSITY OF TWENTE.

BIG DATA:

ANALYSING PUBLIC BIKE SYSTEM USE

CASE STUDY ZHONGSHAN, CHINA

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A PUBLIC BIKE SYSTEM

(a) Bike station (b) Service terminal (c) Bike racks

Figure 2-1 Bike sharing system in Nice, France.

Figure 2-3 Bike Sharing World Map
(Source: (BSB, 2009)& Google)

ROLE OF PUBLIC BIKES

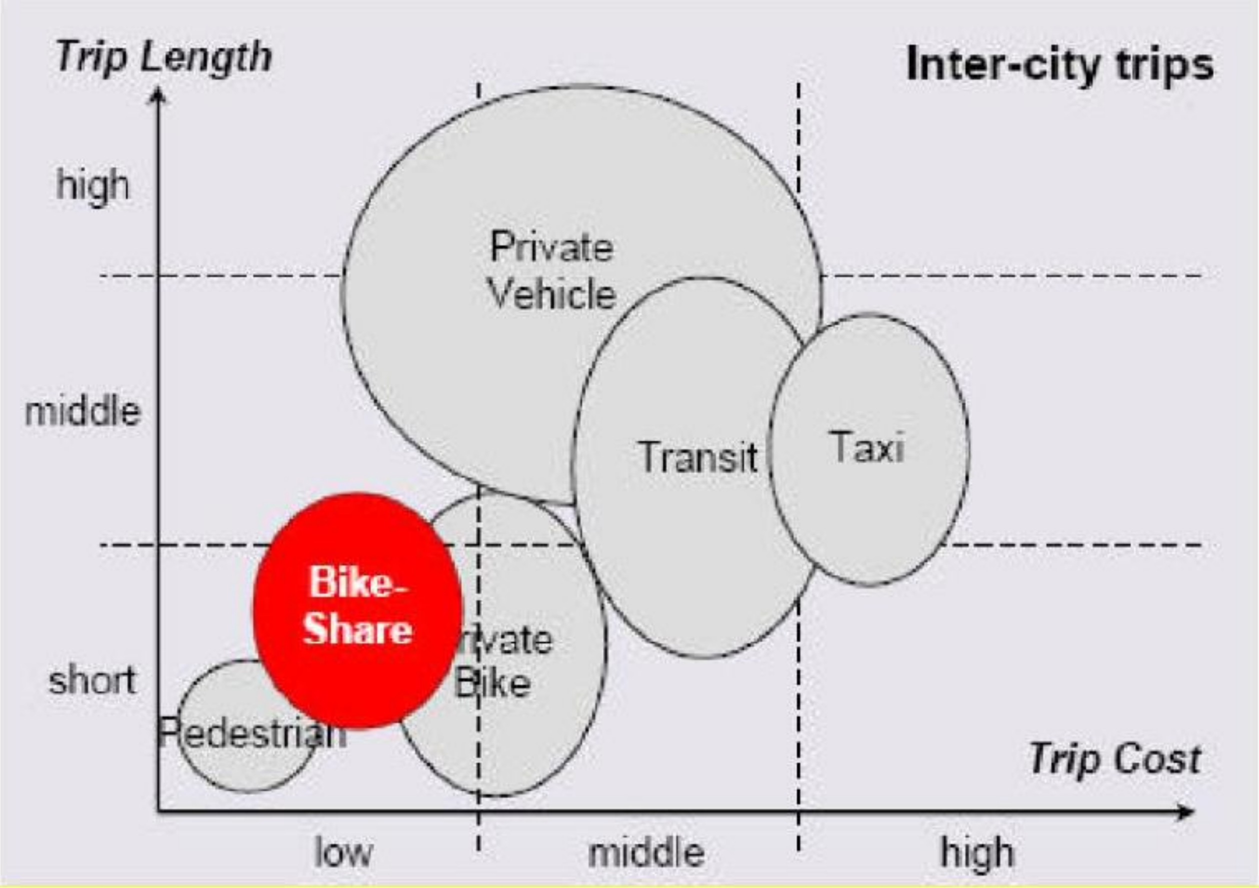


Figure 2-2 The role of public bicycles
(source:(CSD, 2011))

4TH GENERATION PUBLIC BIKE SYSTEMS

Characteristics:

- Demand responsive
- Multimodal setup
- Use of ICT
    - ✓ Electronically locking racks or bike locks
    - ✓ Telecommunication systems
    - ✓ Smart cards
    - ✓ Mobile phone access
    - ✓ On-board computers
    - ✓ Access to real time data

TYPES OF PBS DEMAND ANALYSIS

- User-based survey studies
- Trip-based analysis
- Station-based analysis
- Transition activities-based analysis
- Longitudinal analysis

USER-BASED SURVEY STUDIES (LITERATURE)

- Focus on users’ profile, perceptions and travel behaviour
- Travel behaviour: bike-sharing trips are mainly substitutes for walking and public transport, rather than for private vehicle use
- Primary mode differs for cities: walking (Dublin), public transport (Beijing, Shanghai, Hangzhou)

ZHONGSHAN, CHINA

Characteristics bike-sharing system:

- Launched in 2011
- 4th generation PBS
- 24/7 service
- Smart membership card
- Each trip: first hour free, incremental price of 1CNY for every additional hour (e.g. local bus is 2CNY per trip)
- Gradual expansion of the system
- June 2014: 296 bike stations, 7855 parking docks, 4072 bikes
- Average distance between neighbouring stations is 377m

DATABASE PBS ZHONGSHAN

Items (for each trip):

- Person ID
- Bike ID
- Pick up time
- Pick up station
- Return time
- Return station

Available database 2014 (February-June): 1,820,954 trips

RESEARCH OBJECTIVE

What kind of information on PBS use can be derived

from the operational PBS database,

that might be relevant for a trip behaviour analysis,

in particular for the system in Zhongshan?

SUPPLY CHARACTERISTICS

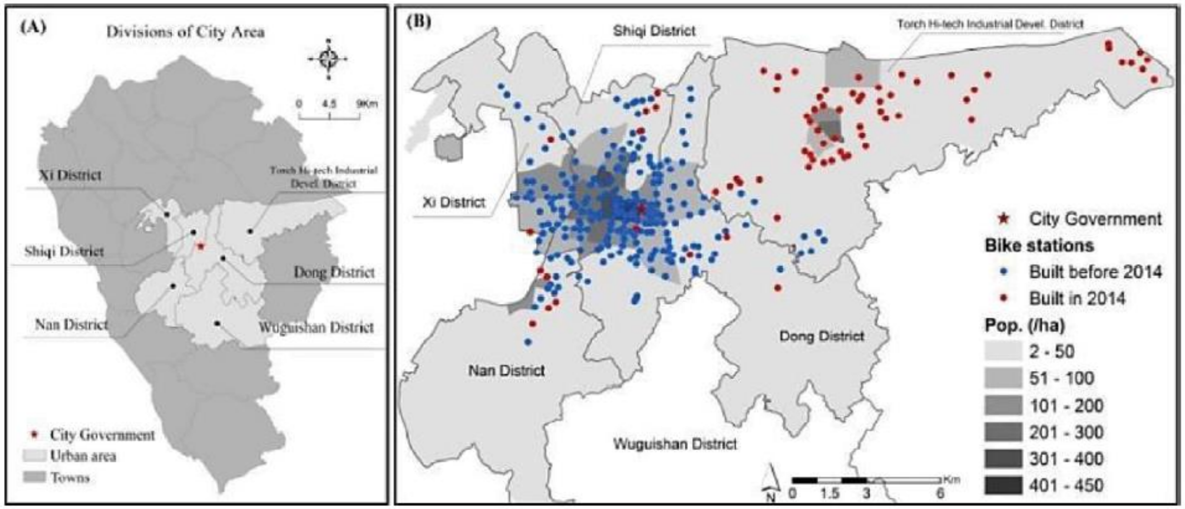


Figure 1: (A) Map of city area, (B) spatial distribution of bike stations and population density in the urban area.

Table 1: System metrics.

	Whole system	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6
Stations	296	33	54	54	63	47	45
Bikes	4,072	424	742	765	870	660	611
Slots/bike	1.9	1.9	1.9	1.9	1.9	1.9	1.9
Station density (/km^2)	1.24	11	6	3.6	1.8	0.42	0.71
Slots/station	27	25	27	27	27	27	26
Bike/1,000 inhabitants	5.4	6.3	6.7	6.4	7.8	3.5	3.8

BIKE-SHARING SYSTEM DESIGN GUIDELINES

	preferred	Zhongshan
Slot/bike ratio:	2-2.5	(1.9)
Stations/km2:	10-16	(1.2; 11 in zone 1)
Bikes/1000 inhabitants :	10-30	(5.4)
Trips/bike per day:	4-8	(3.2)
Daily trips/1000 inhabitants:	25-50	(17; 68,62,40 in zones 1,2, and 3)

Source: ITDP Bike-Share Planning Guide, 2013

TRIP-BASED ANALYSIS

TRIP DURATION CHARACTERISTICS

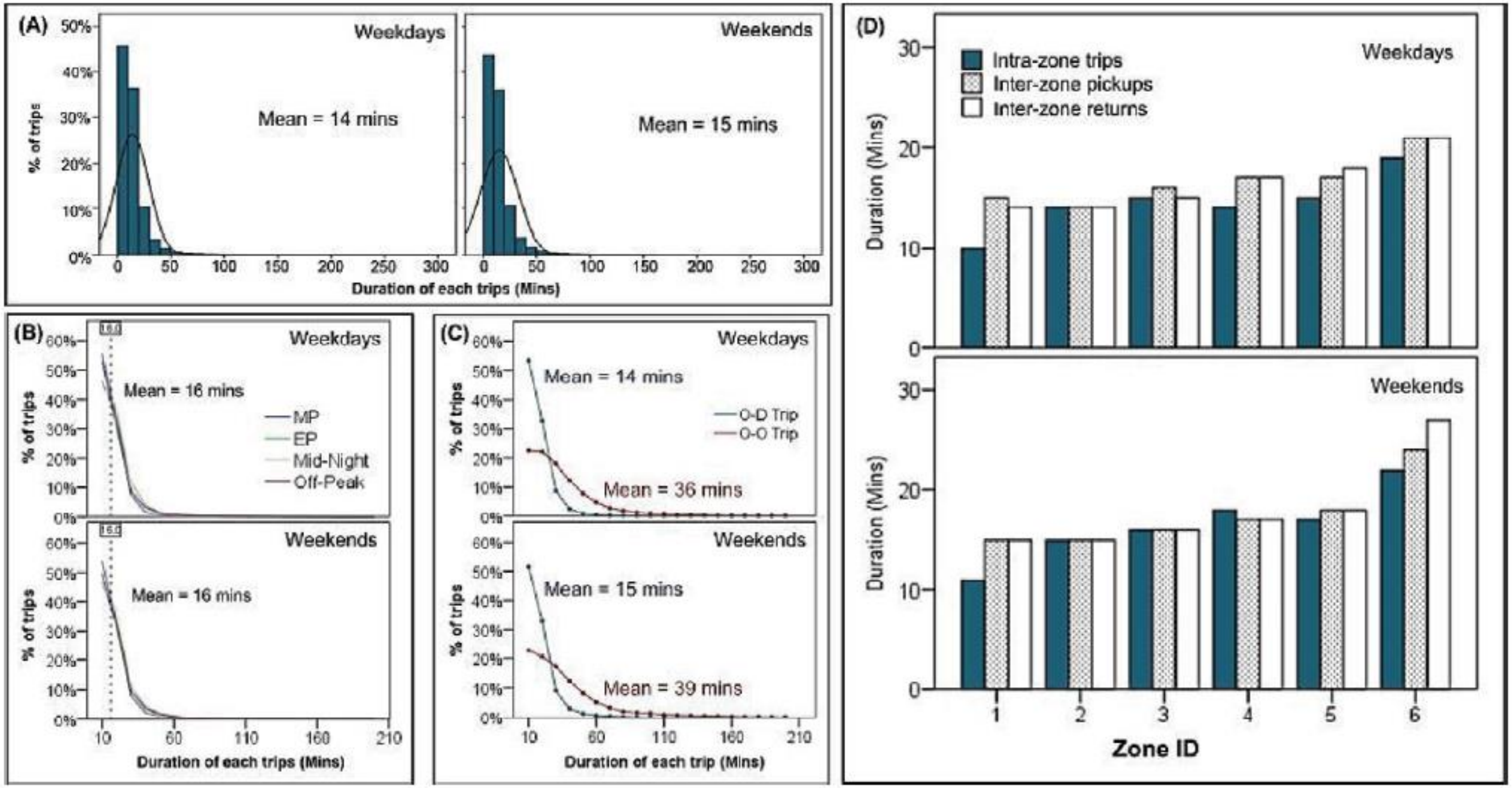
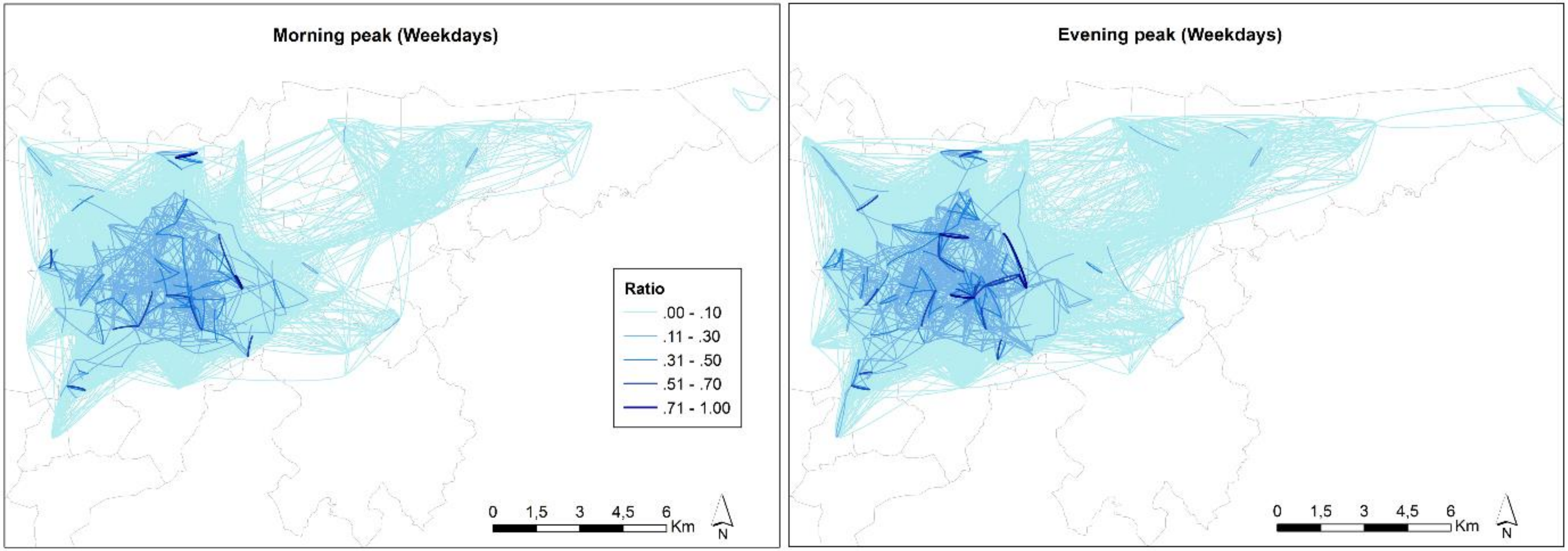


Figure 3: Distribution functions and averages of trip durations.

SPATIAL VISUALISATION OF TRIPS



ORIGIN-DESTINATION PATTERNS

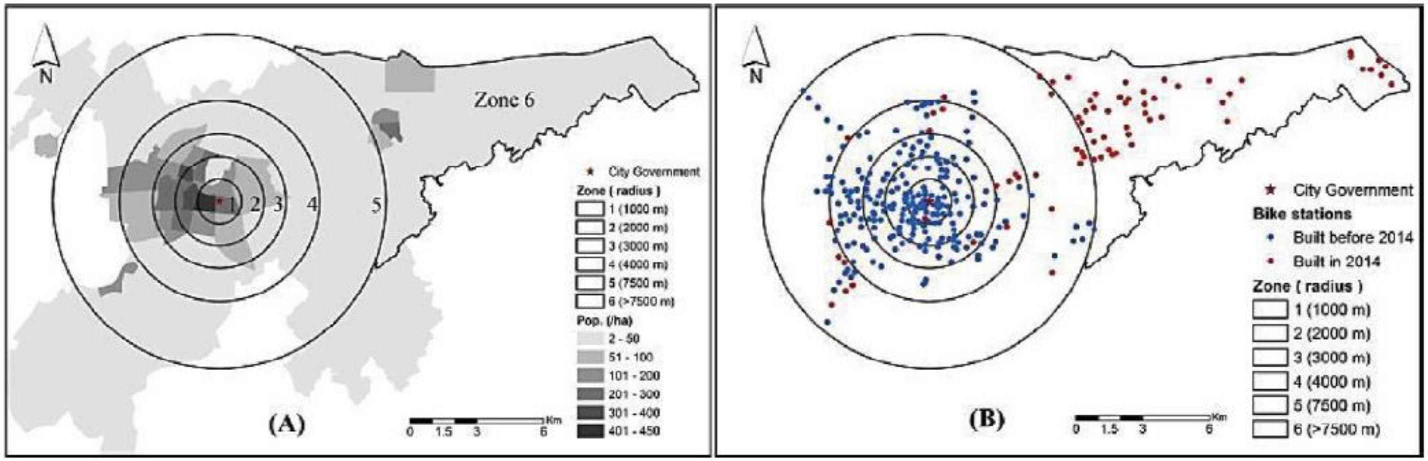


Figure 2 : Six spatial zones with (A) population density and (B) bike stations in the urban

Table 3: O–D matrix of public bike trips (weekdays).

O \ D	Zone 1 (%)	Zone 2 (%)	Zone 3 (%)	Zone 4 (%)	Zone 5 (%)	Zone 6 (%)	Total (%)
Zone 1	49.89	38.59	9.45	1.76	0.31	0.01	100
Zone 2	25.74	46.19	23.12	4.40	0.53	0.01	100
Zone 3	9.39	32.77	42.04	14.28	1.50	0.03	100
Zone 4	3.01	11.62	26.31	47.87	11.10	0.08	100
Zone 5	1.41	2.87	6.41	30.80	55.60	2.91	100
Zone 6	0.17	0.56	0.56	0.67	11.93	86.10	100

ITC

STATION-BASED ANALYSIS

CLUSTERING OF STATIONS
BASED ON DAILY TEMPORAL PATTERNS OF BICYCLE ACTIVITY

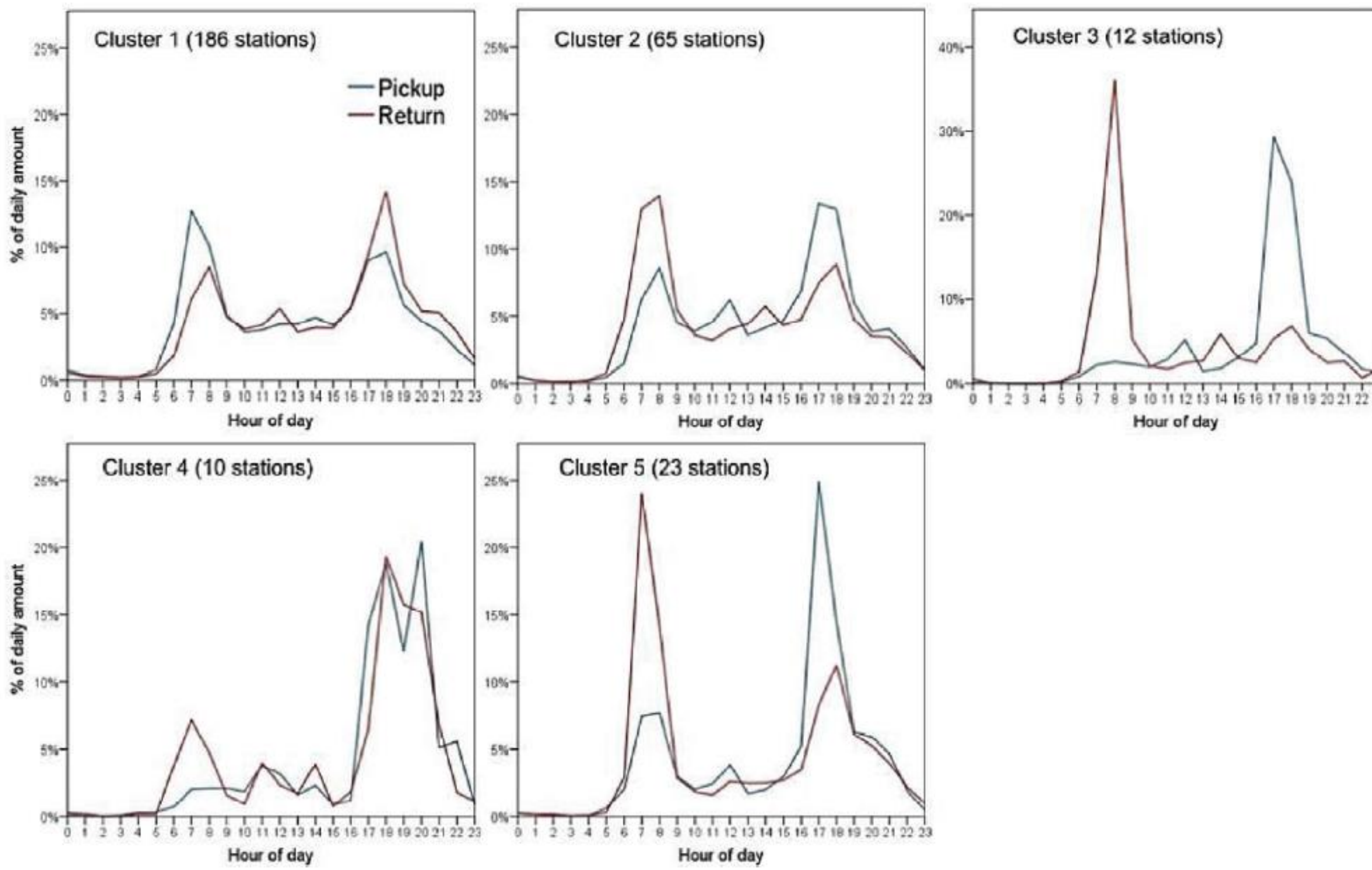


Figure 4: Weekday patterns of bicycle activity at stations.

SPATIAL DISTRIBUTION OF STATION CLUSTERS

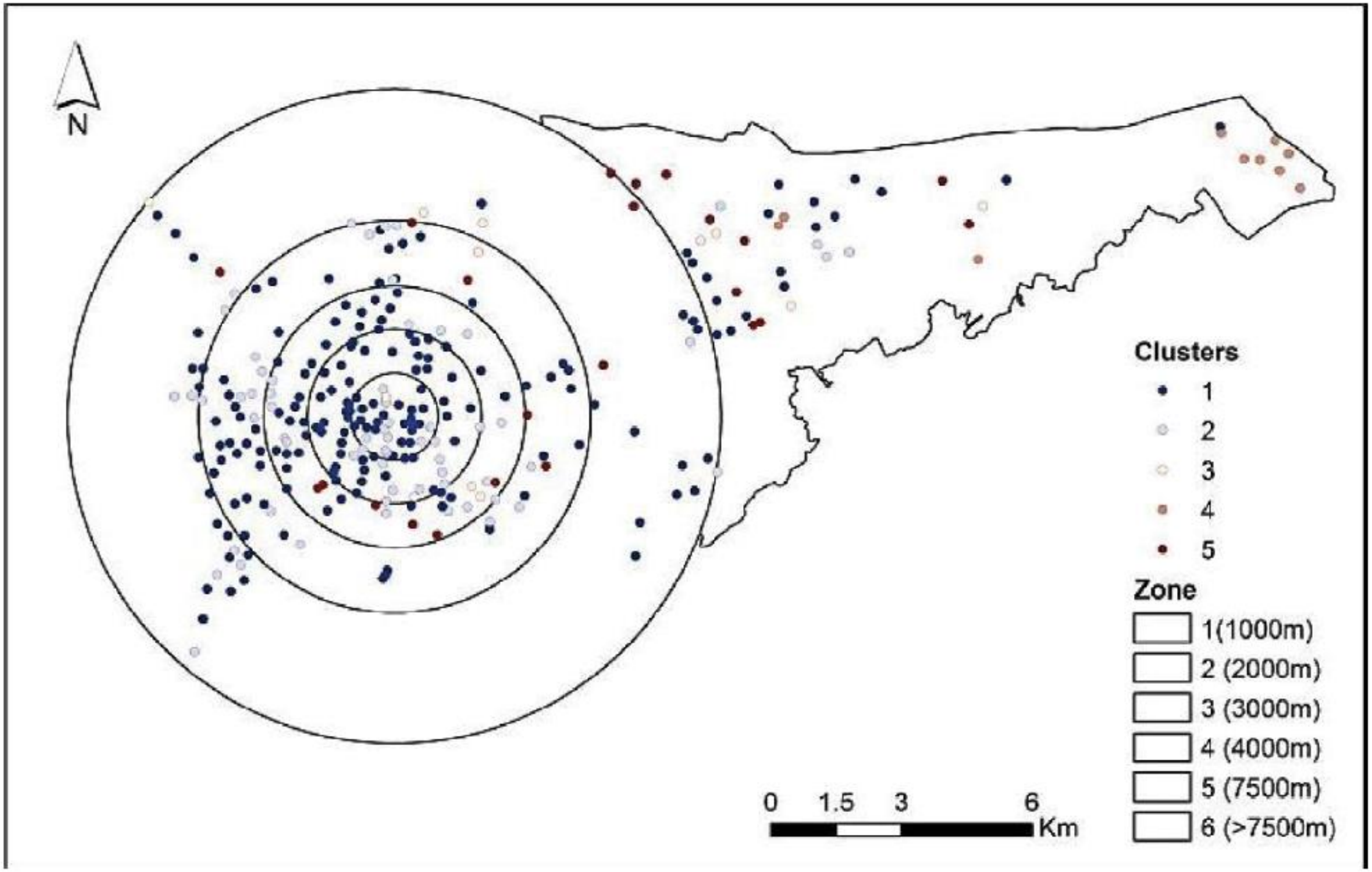


Figure 5: Spatial distribution of station clusters.

DESCRIPTIVE STATISTICS OF EXPLANATORY VARIABLES

Table 1
Descriptive statistics of explanatory variables and daily and hourly usage at stations.

	Description	Mean	Std. Deviation
Station attributes and accessibility			
Capacity of the bike station	Number of parking slots of a station	26.59	6.91
Number of other bike stations within 300 m buffer	Number of other bike stations within a 300 m buffer of a station	1.13	1.28
Distance to city government (m)	The shortest network distance from a station to city government	3340.02	1929.15
Population within 300 m buffer	The size of population within 300 m buffer of a station based on the distance decay	16.32	15.91
Cycling infrastructure			
Bike lane within 1000 m buffer (m)	The length of bike lane within 1000 m buffer of a station	8702.95	4483.42
Main road within 300 m buffer (m)	The length of main road within 300 m buffer of a station	563.51	362.50
Secondary road within 300 m buffer (m)	The length of secondary road within 300 m buffer of a station	550.70	396.71
Branch road within 300 m buffer (m)	The length of branch road within 300 m buffer of a station	1275.41	921.49
Public transport facilities			
Public bus stops within 300 m buffer	Number of public bus stops within 300 m buffer of a station	1.83	1.02
Distance to the closest public bus stop(m)	The shortest network distance from a station to the closest public bus stop	165.47	166.01
Closest stop is a bus terminal (0 or 1)	The closest public bus stop is a bus terminal or not	0.058	0.234
Closest stop is a transport hub (0 or 1)	The closest public bus stop is a transport hub or not	0.058	0.234
Land use characteristics			
Land use types within 300 m buffer	Number of different land use types within 300 m buffer of a station	3.21	1.13
Near a shopping mall (0 or 1)	The station located nearby a shopping mall or not	0.28	0.45
Near a residential community (0 or 1)	The station located nearby a residential community or not	0.49	0.50
Near a recreational place (0 or 1)	The station located nearby a recreational place or not	0.045	0.21
Near a park (0 or 1)	The station located nearby a park or not	0.090	0.29

SPATIAL REGRESSION ANALYSIS

$$\ln Y_s = \beta_0 + \beta' X_{s[Dis\_Govt]} + \sum \beta_i \ln X_{si} + \sum \beta_j X_{sj} + \rho W \ln Y + \rho\prime W \ln X_{slot}$$

Two spatially lagged variables, i.e. the spatially lagged dependent variables and the spatially lagged parking slots:

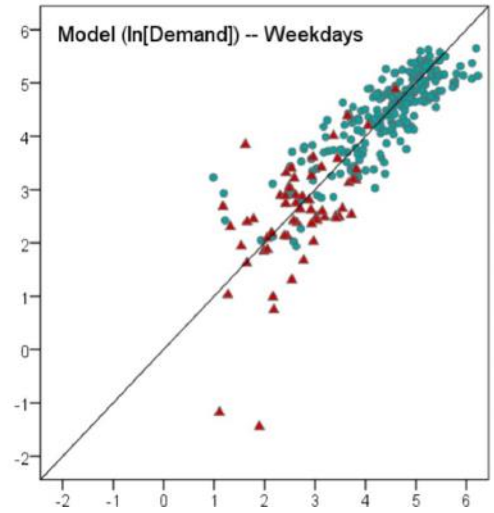
Spatial correlation implies that the demand of one station is correlated with the demand of nearby stations, simply because they are in close proximity. Moreover, the demand of a station may also be associated with the number of parking slots at neighbouring stations

REGRESSION RESULTS FOR WEEKDAY TRIPS

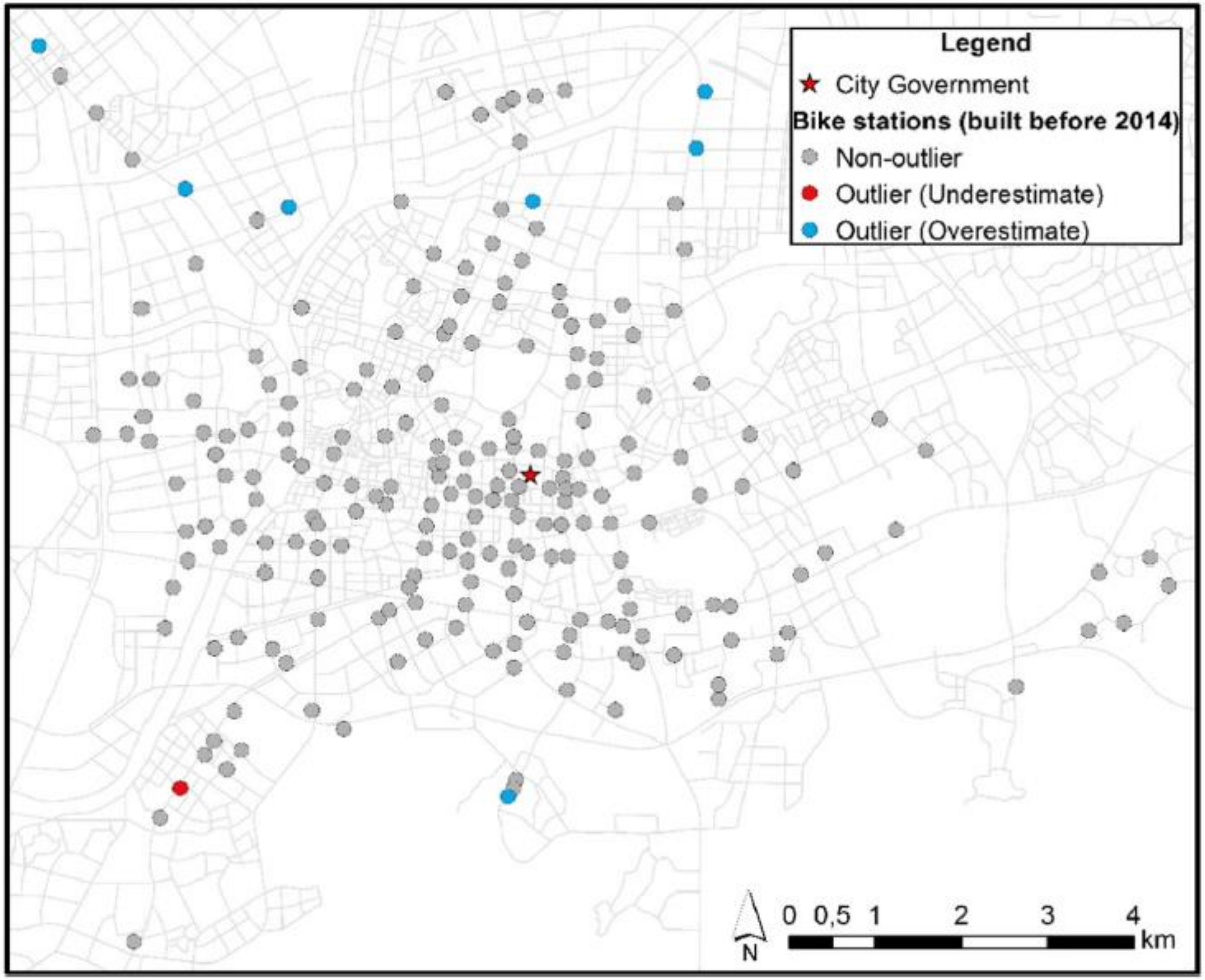
Ln[D]	Weekdays[a] Coefficient	t-Stat
(Constant)	2.621	6.525
Capacity of the station	–	–
Number of other bike stations within 300 m buffer	−0.582***	−4.531
Number of population within 300 m buffer	0.226***	5.325
Network distance to city government	−0.000163***	−4.834
Length of bike lane within 1000 m buffer	0.0727**	3.279
Length of branch road within 300 m buffer	0.0826***	3.355
Number of land use types within 300 m buffer	0.544***	3.802
Spatially lagged dependent variable	0.1006***	3.358

$R^2 = 0.697$

*** $p<0.001$; ** $p<0.01$

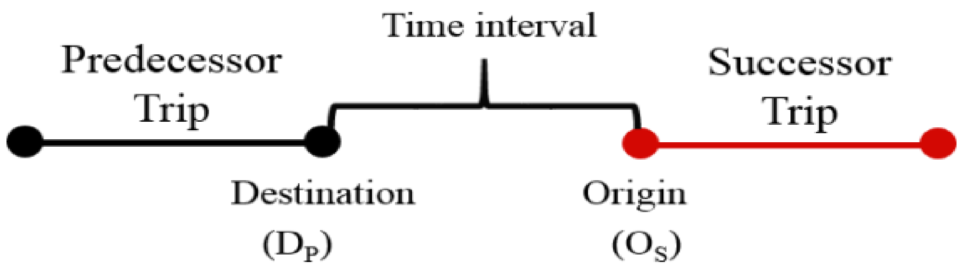


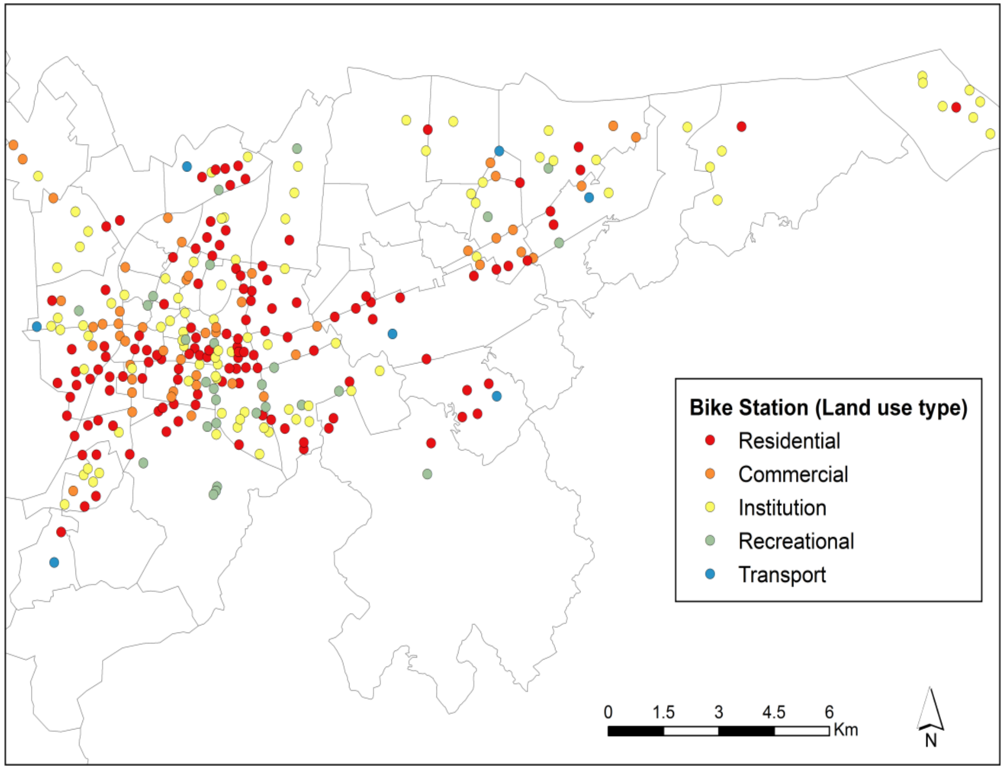
SPATIAL DISTRIBUTION OF OUTLIERS



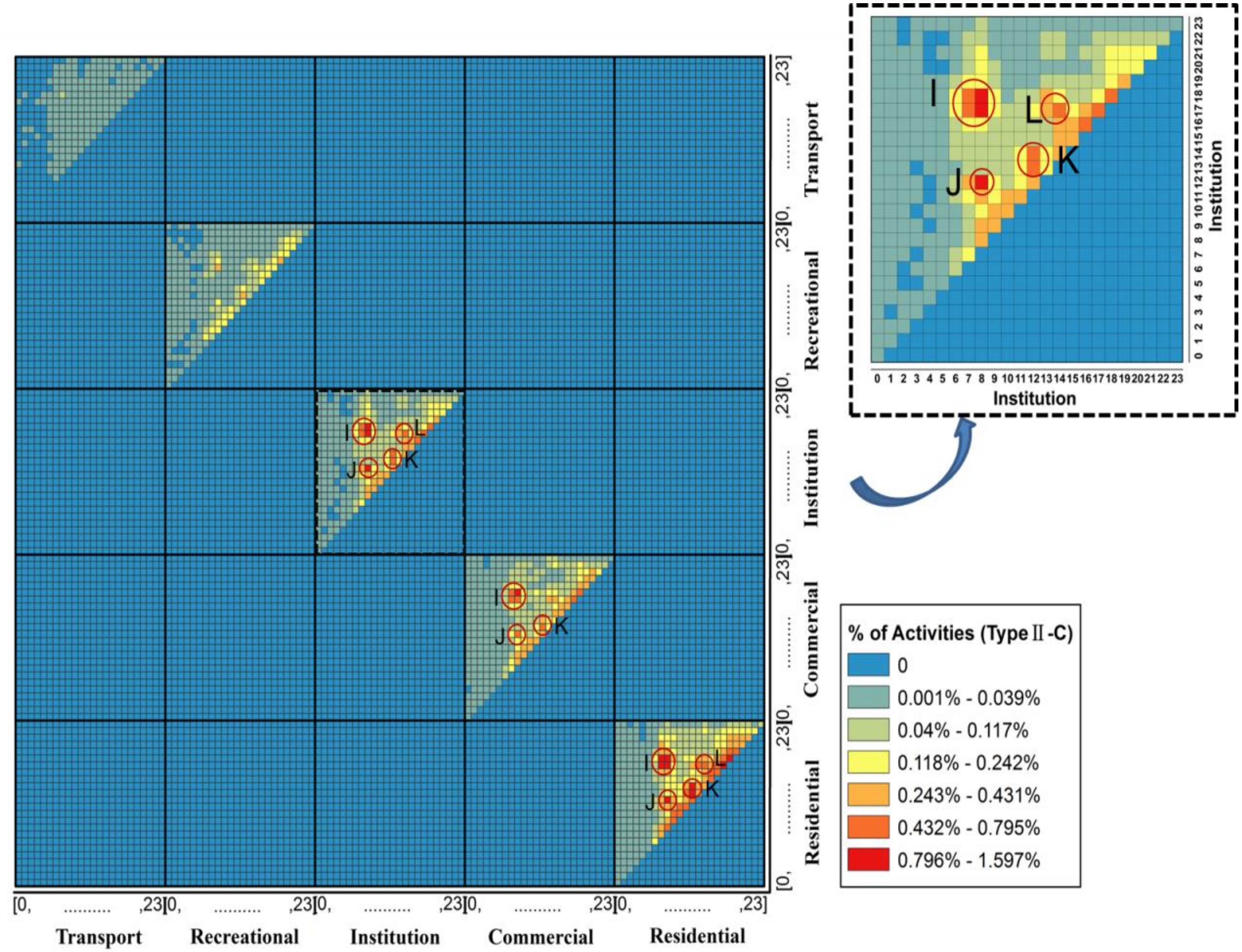
TRANSITION ACTIVITY-BASED ANALYSIS

TRANSITION ACTIVITY PATTERN AND LAND USE





TRANSITION ACTIVITY PATTERN



LONGITUDINAL ANALYSIS

SPATIAL DISTRIBUTION OF BIKE STATIONS
BEFORE AND AFTER SYSTEM EXPANSION

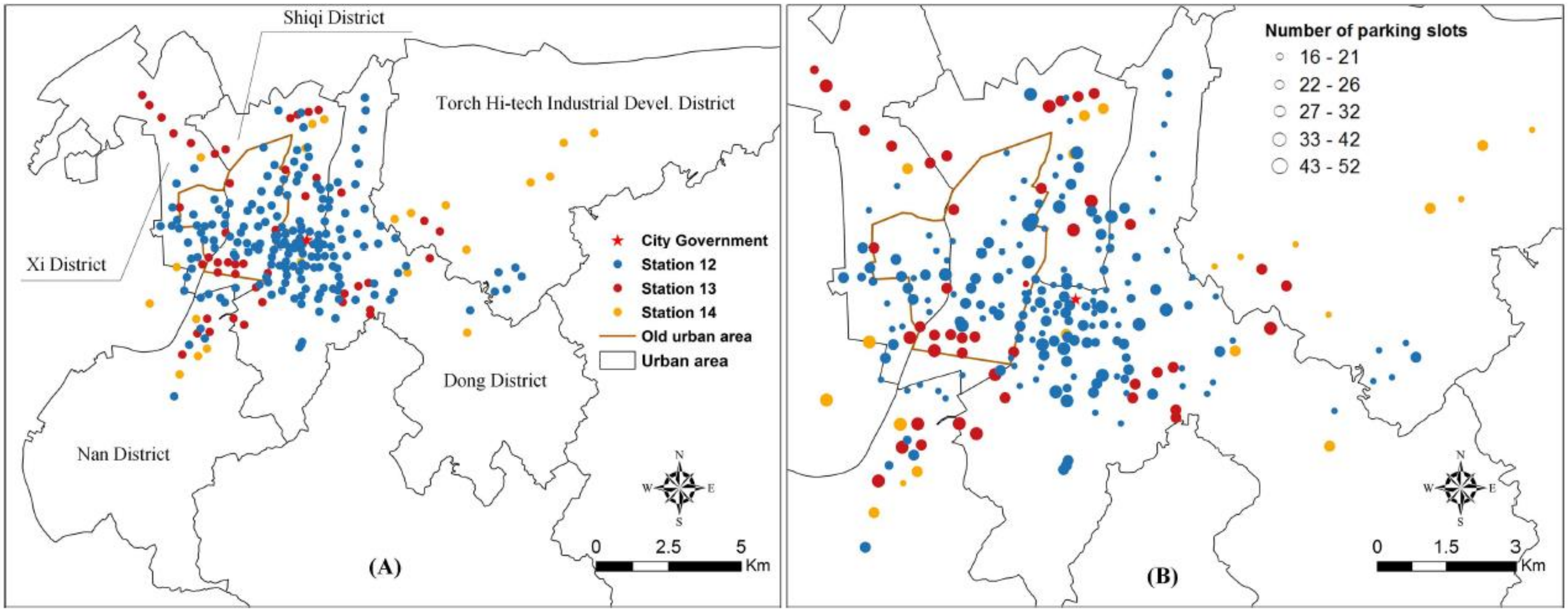


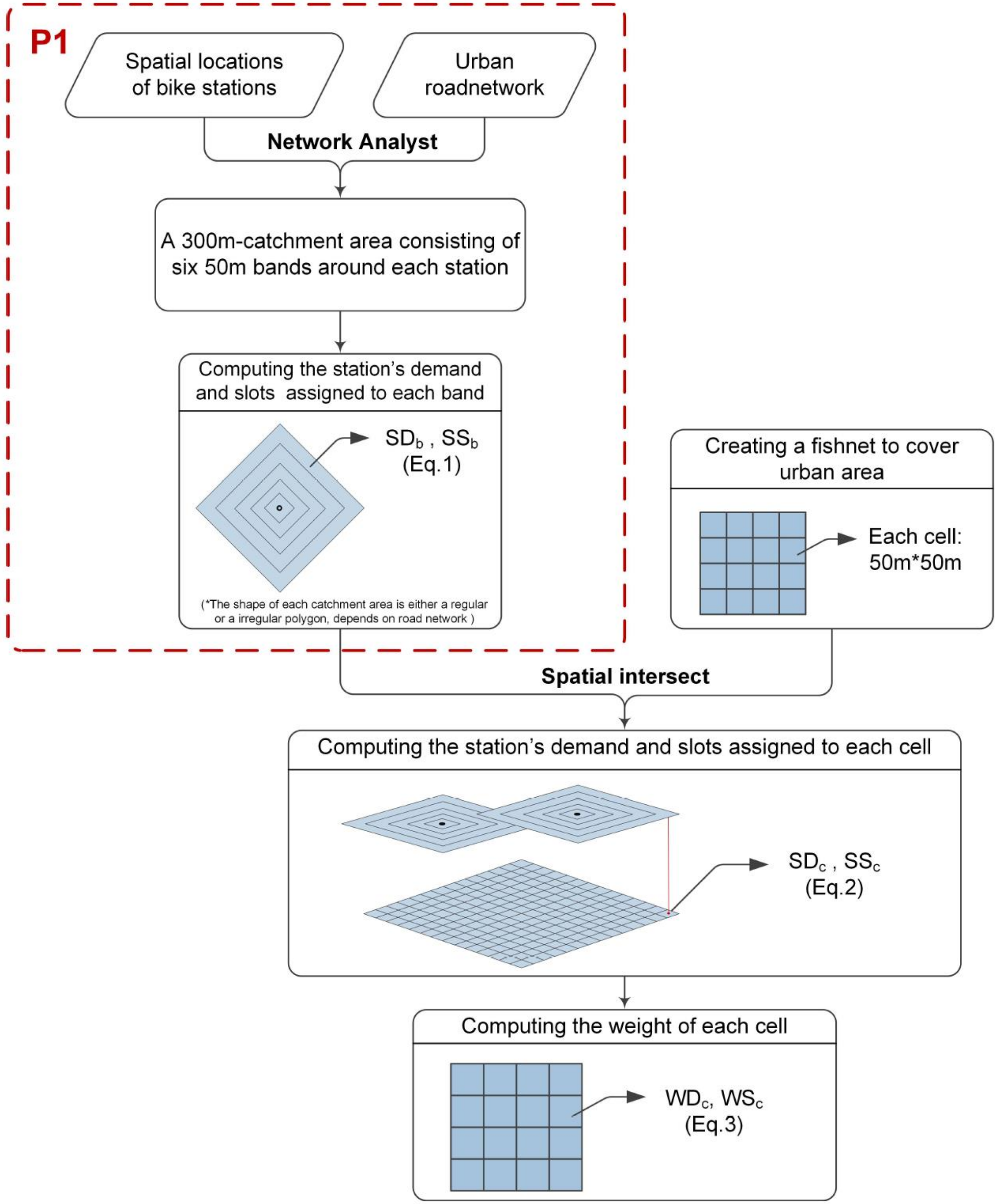
Fig 2. The spatial distribution of bike stations and capacities in the study area. (A) spatial distribution of stations that were built before and after the system expansion. (B) The number of parking slots at each of bike stations.

SOME FINDINGS

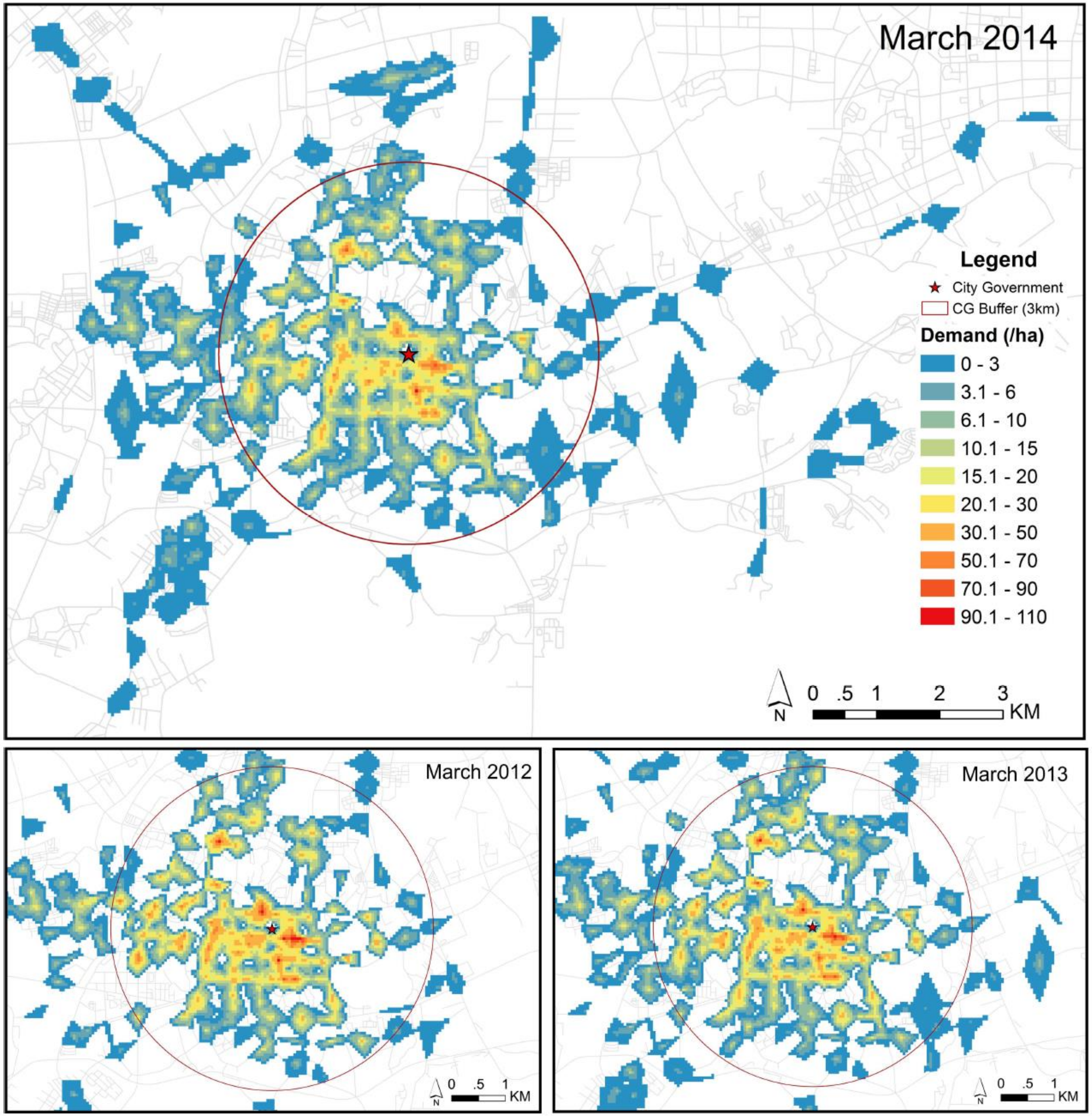
- Strong dynamics in user group over the years
  (March 2012-2013-2014)
  some 45% of users are steady users

- Overall decrease in number of trips, despite the expansion of the system, and for all user groups (steady, former, newer)

- No significant change in the spatial distribution over the years



P1
Spatial locations of bike stations
Urban roadnetwork
Network Analyst
A 300m-catchment area consisting of six 50m bands around each station
Computing the station's demand and slots assigned to each band
SD_b , SS_b (Eq.1)
(*The shape of each catchment area is either a regular or a irregular polygon, depends on road network)
Creating a fishnet to cover urban area
Each cell: 50m*50m
Spatial intersect
Computing the station's demand and slots assigned to each cell
SD_c , SS_c (Eq.2)
Computing the weight of each cell
WD_c, WS_c (Eq.3)



Longitudinal analysis

using a spatial fishnet

CONCLUSIONS

- From the operational PBS database many relevant information items can be derived regarding trip behaviour as well as operational aspects of the system.
- Information on socio-economic characteristics of the users would be very useful, to gain more insight in travel behaviour per user group; in particular, the dynamics in the user group in the years following the launch of the system requires attention
- A user survey is still needed to get a better picture of the perception of the service level of the PBS compared to other modes of transport (e.g. walking, public transport)

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