

# 城市模型及其规划设计响应

Applied Urban Models and Their Applications in Urban Planning & Design

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# 城市模型及其规划设计响应

## 1 城市模型与规划支持系统

- 1.1 规划支持系统在城市规划中的应用探索
- 1.2 多尺度的北京城市空间发展模型
- 1.3 规划师主体模型：一项低碳城市形态规划支持的工具
- 1.4 囊括方法、软件和模型的规划支持系统框架体系
- 1.5 面向空间规划的微观模拟

## 2 大模型与定量城市研究

- 2.1 大模型及中国应用案例
- 2.2 基于OpenStreetMap和兴趣点数据的地块特征自动识别
- 2.3 地块尺度中国所有城市的空间扩张模拟
- 2.4 中国PM<sub>2.5</sub>的人口暴露评估
- 2.5 利用北京公共交通刷卡数据的若干定量城市研究**
- 2.6 当前定量城市研究的四项变革

## 3 规划设计响应

- 3.1 数据增强设计：新数据环境下的规划设计回应与改变
- 3.2 街道城市主义
- 3.3 城市规划实施评价：针对中国城市的分析框架
- 3.4 基于人类活动和移动数据的城市增长边界实施评价
- 3.5 中国收缩城市及其研究框架
- 3.6 历史上的北京规划



# Applied Urban Models and Their Applications in Urban Planning & Design

## 1 Urban Models and Planning Support Systems

- 1.1 Planning support systems in urban planning
- 1.2 Beijing urban spatial development model families
- 1.3 Planner Agents: A toolkit for support planning a low carbon urban form
- 1.4 An applied planning support toolkit including quantitative methods, software and models in China
- 1.5 Urban micro-simulation for spatial planning

## 2 Big Models and Quantitative Urban Studies

- 2.1 Big models: Several fine-scale urban studies for the whole China
- 2.2 Automated identification and characterization of parcels (AICP) with OpenStreetMap and points of interest
- 2.3 Simulating urban expansion at the parcel level for all Chinese cities
- 2.4 Estimating population exposure to PM<sub>2.5</sub> in China
- 2.5 Bus landscapes: Analyzing commuting pattern using bus/metro smartcard data in Beijing**
- 2.6 Four changes on quantitative urban studies in the big data era

## 3 Applications in Urban Planning & Design

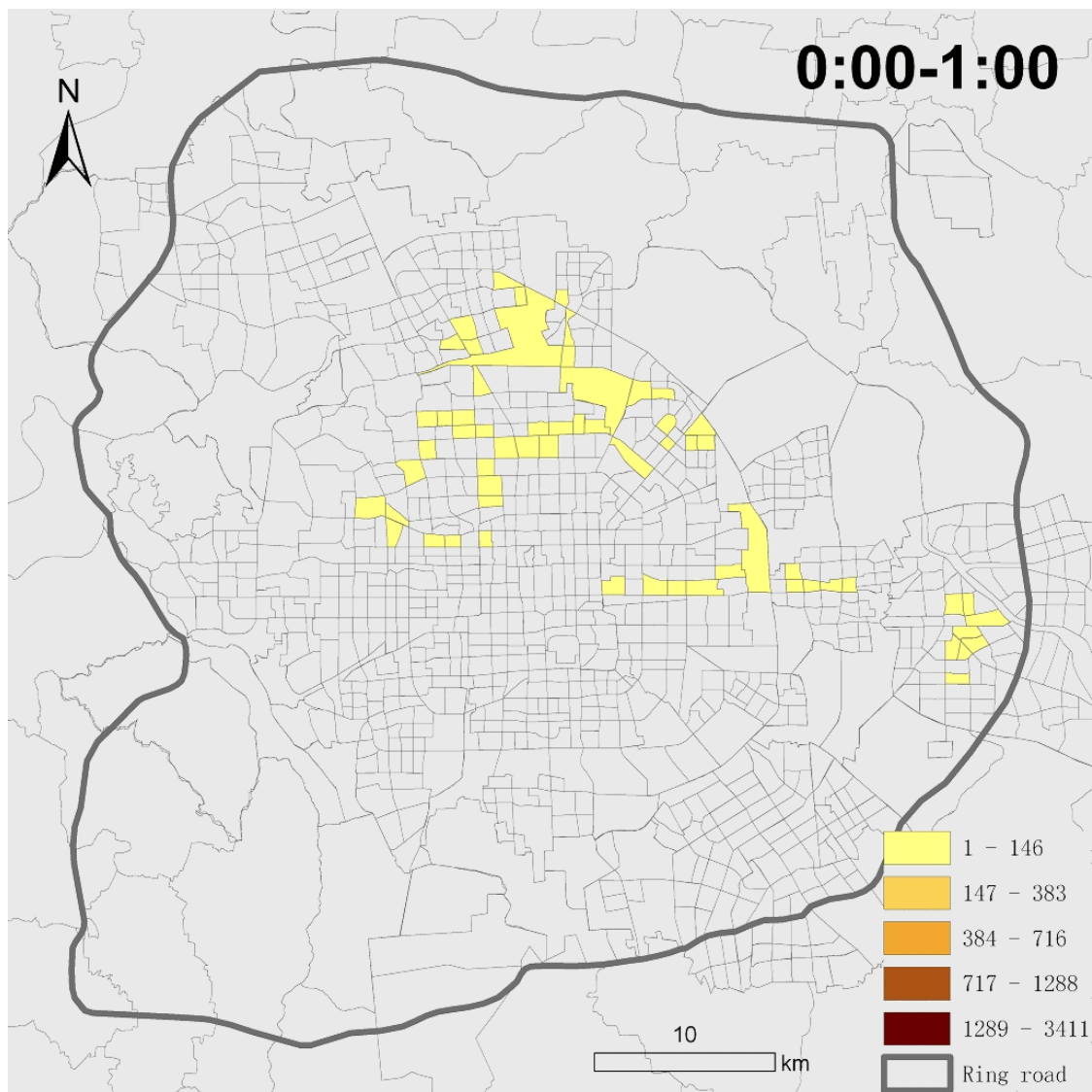
- 3.1 Data augmented design (DAD): Planning & design in new data environment
- 3.2 Street urbanism
- 3.3 Evaluation of urban planning implementation: An analytical framework for Chinese cities and case study of Beijing
- 3.4 Evaluating the effectiveness of urban growth boundaries with human mobility data
- 3.5 Shrinking cities in China and the research agenda
- 3.6 Historical city plans in Beijing



# BCL开展的一系列定量城市研究项目 (传统数据、大数据、开放数据、大的开放数据)

## Projects

- 1 BUDEM
- 2 Urban Growth Boundaries
- 3 Bus Landscapes
- 4 Population China
- 5 Planning Support Systems
- 6 Urban Form
- 7 Population Synthesis
- 8 Social Network Mining
- 9 Big Model
- 10 Beijing Parking
- 11 Urban Network Analysis
- 12 AM10:00
- 13 PM2.5
- 14 SinoGrids
- 15 Shrinking Cities



北京一日24小时的城市脉动（基于公交刷卡数据）

# Bus Landscapes

利用公共交通刷卡数据开展城市研究

**最早：2009**

**最大：每周一日**

**目的：提高居民生活质量**

# Smart card data from public transportation

智能交通卡、一卡通、八达通...

- Smart card data collected by automated fare collection systems
  - Bus
  - Subway
- Since 1990's the use of smart card has become significant (Blythe, 2004)
- Overwhelmingly adopted by Chinese cities
  - Over 100 cities in 2007
- With precise bus trip information
  - (both boarding and getting off)
  - A spatial resolution of bus stop
  - A temporal resolution of second



# Bus SCD in Beijing



- Anonymous card
- Over 90% bus riders use smart cards till April 2007

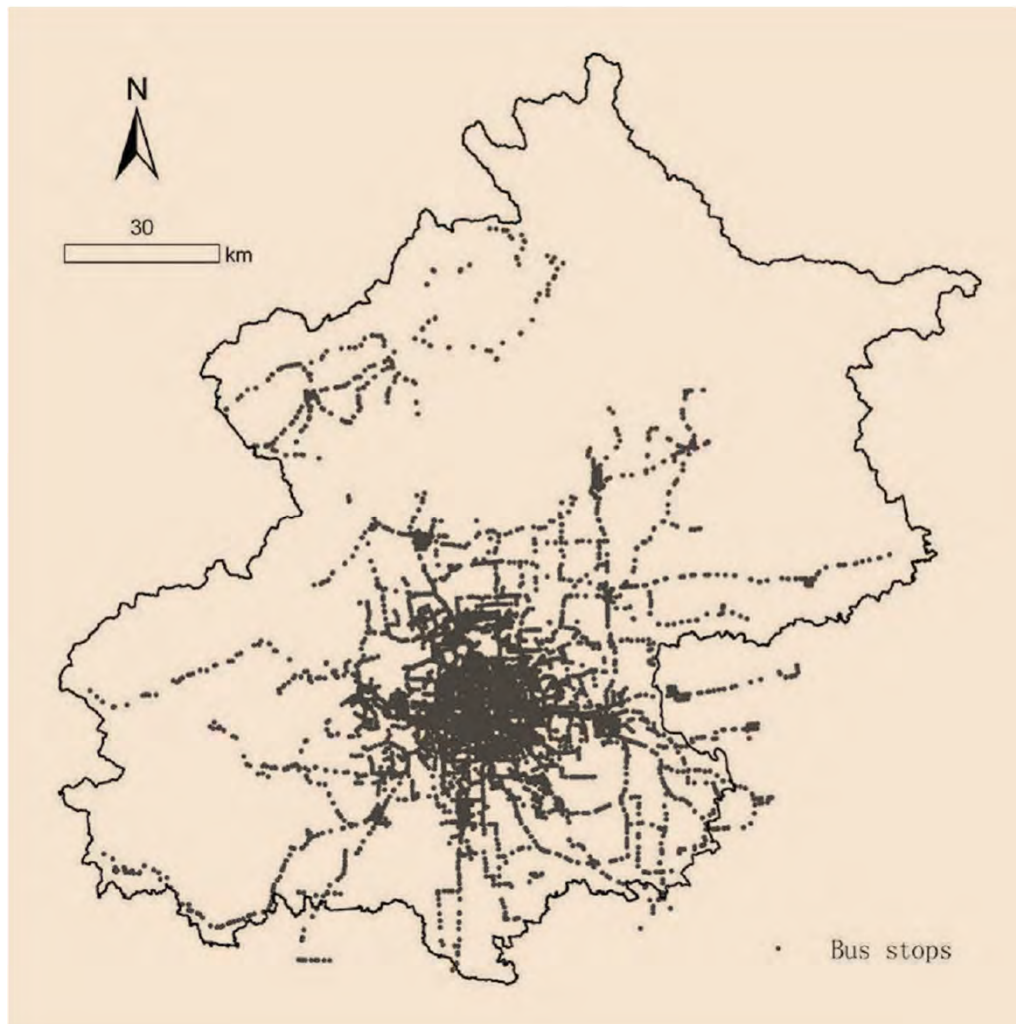
- One week in April 2008 from
  - Monday to Sunday
  - Subway not included
- 80 million records for **8.5 million cardholders**
  - One record for a bus riding of a cardholder
  - 1.3 daily bus ridings per person
- One week bus/metro SCD in 2010, 2013 and 2014
  - 100 m records for 10 m cardholders
- The largest scale in the world
  - Singapore, London, Seoul



# SCD data structure

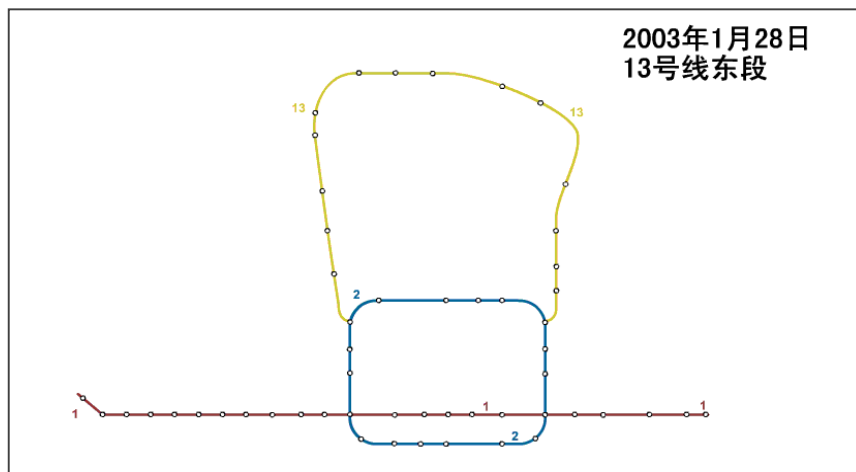
Variable	Exemplified Values
Card ID	“10007510038259911”, “10007510150830716”
Card Type	1, 2, 3, 4
Line ID	602, 40, 102
Line Type	0, 1
Driver ID	11032, 332
Vehicle ID	111223, 89763
Departure Data	2008-04-08
Departure Time	“06-22-30”, “11-12-09”
Departure Stop	11, 5, 14
Arrival Time	“09-52-05”, “19-07-20”
Arrival Stop	3, 14, 9

# Bus stops



- 8691 bus stops
- The spatial resolution of identification
- The average distance between two stops
  - 231 m

# Subway



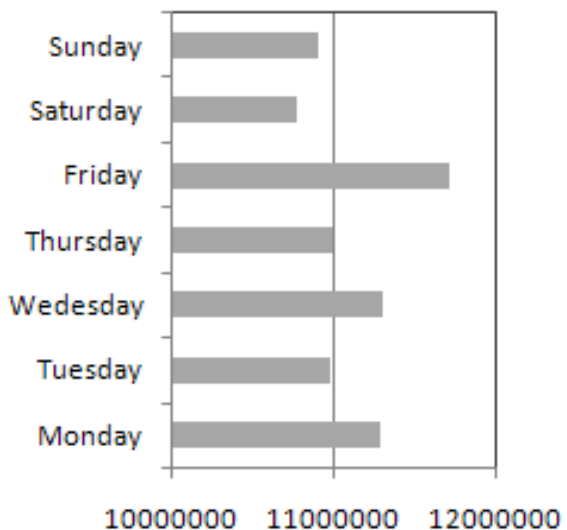
- 1969年10月1日全长23.6公里的北京地铁1号线一期工程（苹果园—北京站）建成通车，到2003年12月27日地铁八通线的开通，北京地铁运营里程突破100公里用了34年
- 截至2014年1月，北京地铁共有17条运营线路。它包含16条地铁线路、1条机场轨道，组成覆盖北京市11个市辖区，拥有273座运营车站、总长465千米运营线路的轨道交通系统。
- 2013年1—11月，北京地铁全网日均客运量达876万人次，同比增长30.5%，最高单日客运量达1106万人次，在公共交通客运总量中所占比重接近40%

# The Beijing Household Travel Survey

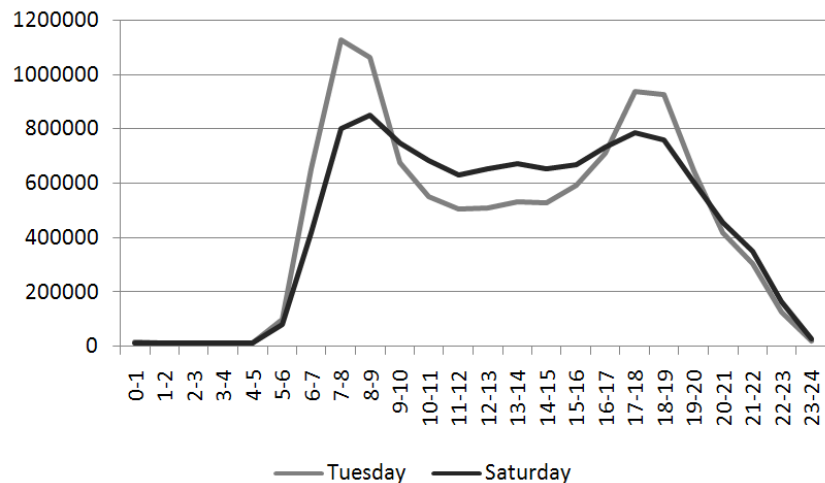
(The 2005 survey)

- Conducted in 2005 for the whole BMA
- 81,760 households/208,290 persons, with 1.36% sampling rate
  - 800 thousand trips
- Information included:
  - Socio-economic attributes of household and persons
  - One-day travel diary of each person
    - Mode, purpose (e.g. **commute**), OD, departure and arrival time, etc.
- For setting rules for identifying jobs-housing places and commuting trips

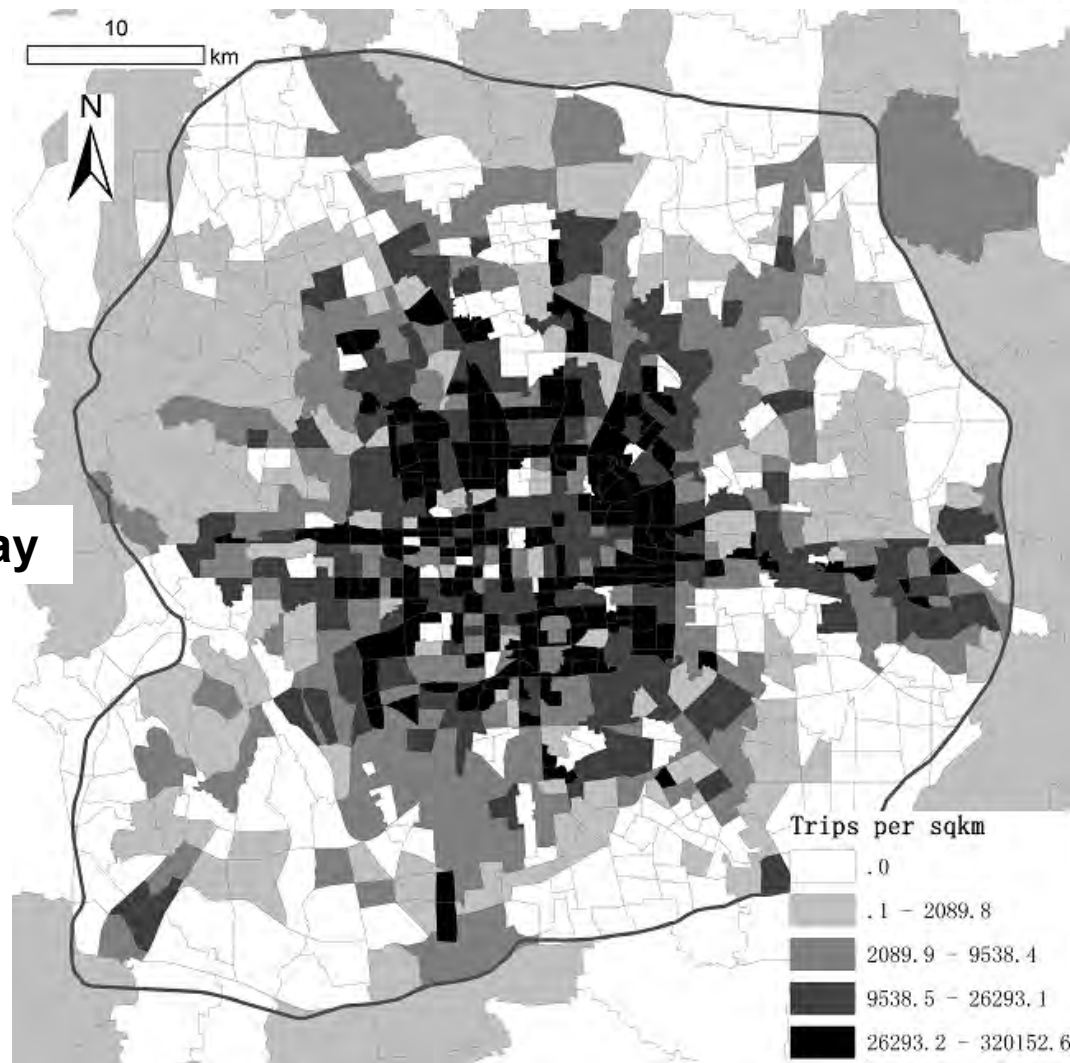
# 数据一览



■ Trip count  
**Trip count (bus riding) for each day**



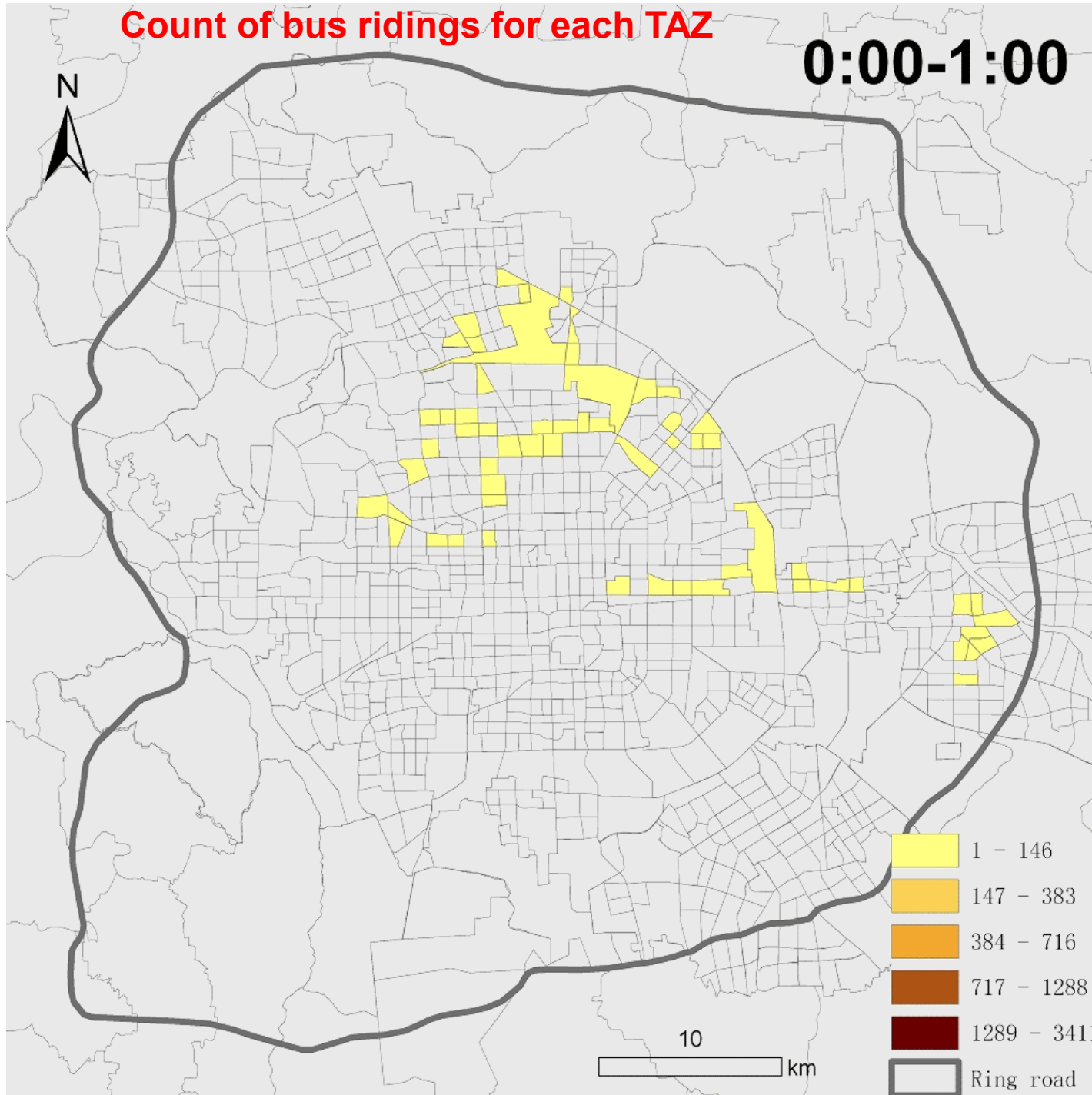
— Tuesday — Saturday  
**Trip count in each hour on Tue and Sat**

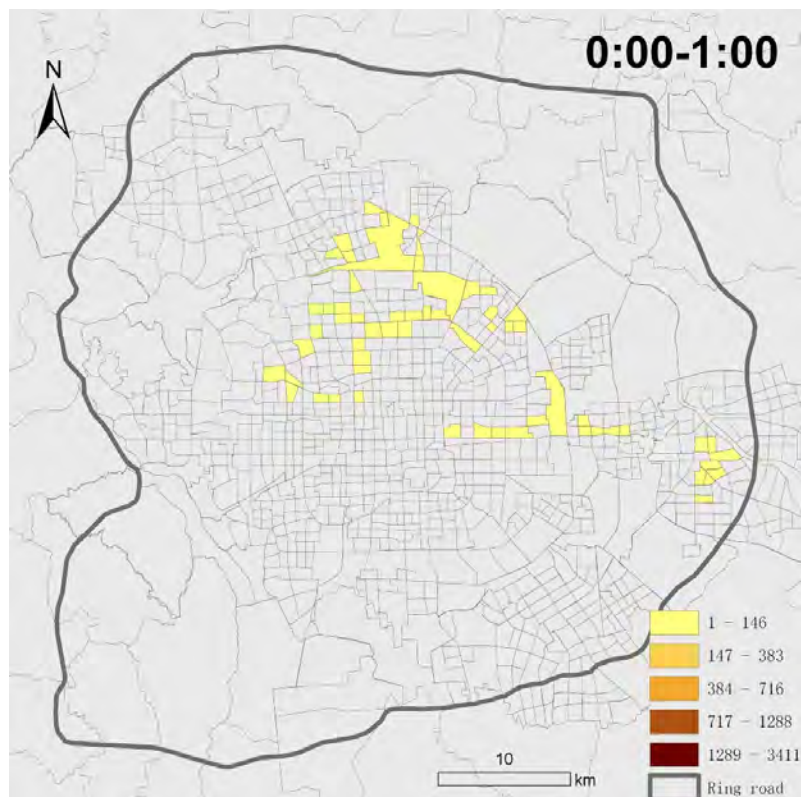


**Trip density in the TAZ level in the whole week**

# Count of bus ridings for each TAZ

0:00-1:00





地理学报(首篇)、Computers, Environment and Urban Systems

# 通勤出行



# Identification of housing places using one-day data

- The departure bus stop of the first trip (TRIP1) will be the housing place of a cardholder.
- Grounded on:
  - In the 2005 survey, **99.5%** person's first trips start from home
- Note that a person is assumed to live around the identified stop with a maximum distance of 750 m
  - Retrieved from walking trips in the 2005 survey
  - This could be the spatial resolution of our identification results

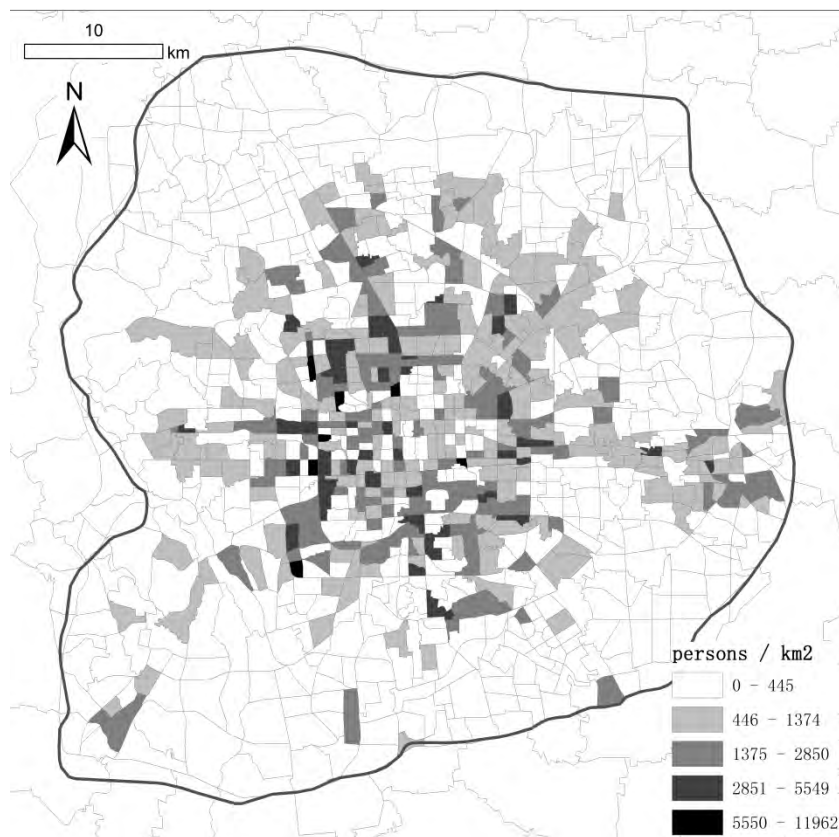
# Identification of job places using one-day data

- An activity of a non-student (except at home) with a duration longer than 6 hours is assumed to be working.
  - *If:*
    - *Condition 1:* The card type is not the student card
    - *Condition 2:*  $D_k > 360$
    - *Condition 3:*  $k \neq 1$ 
      - he/she is sleeping at home when  $k=1$
  - *Then:*
    - the  $k_{th}$  place  $P_k$  will be regarded as the job place of this cardholder
- Grounded on:
  - In the 2005 survey, **96%** persons work over 6 hours per day.

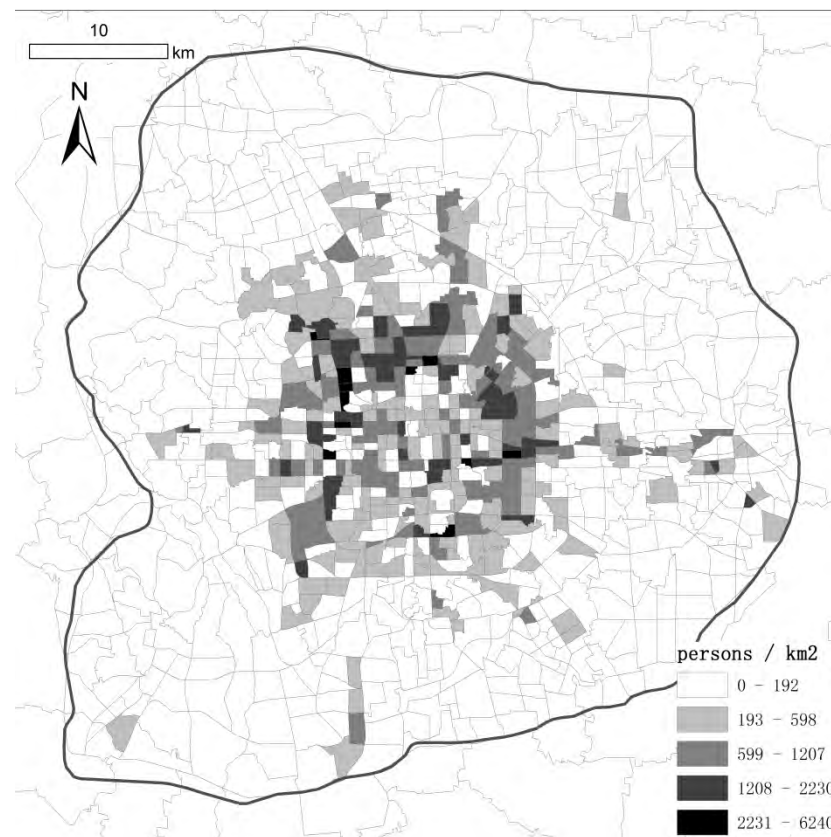
# Combining each day's result to get more solid housing-jobs places

- One day result might not be stable, e.g.
  - A shopping, hospital, or creation activity longer than 6 h
  - One night sleeping at a friend's home
- Periodic pattern of cardholders with identified housing-jobs results like
  - **M T W T F S S**
  - a a a b a a a (Person 1)
  - a a a b b b c (Person 2)
  - a a b b c c d (Person 3)

1,045,785 cardholders (12.2% of all 8549072 cardholders) are identified with housing places, and 362,882 cardholders (4.2% of all) are identified with job places.



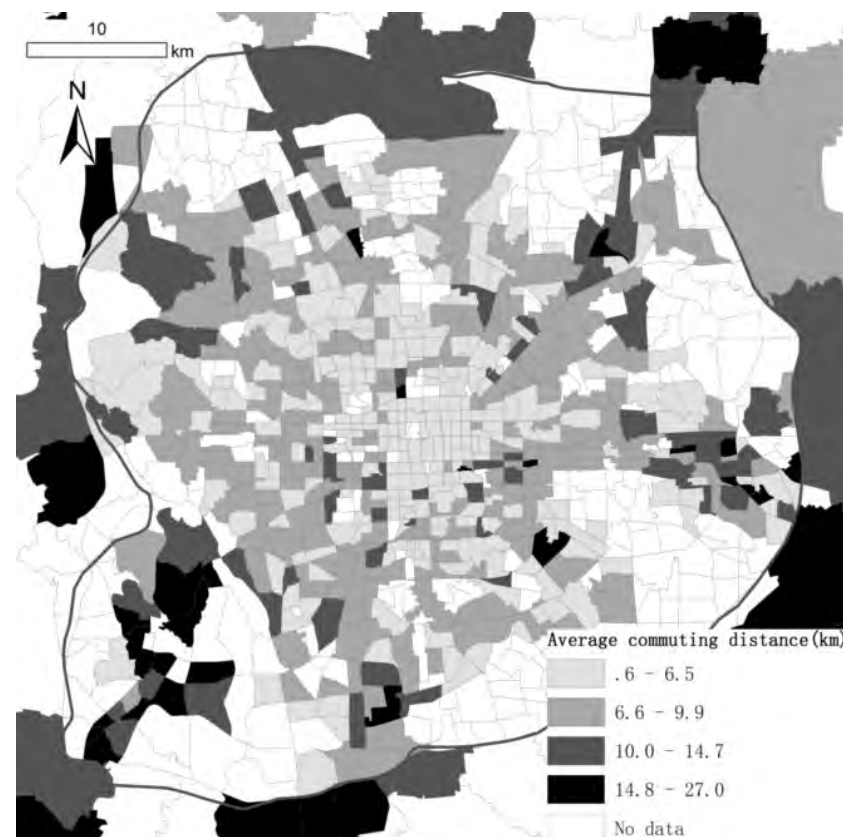
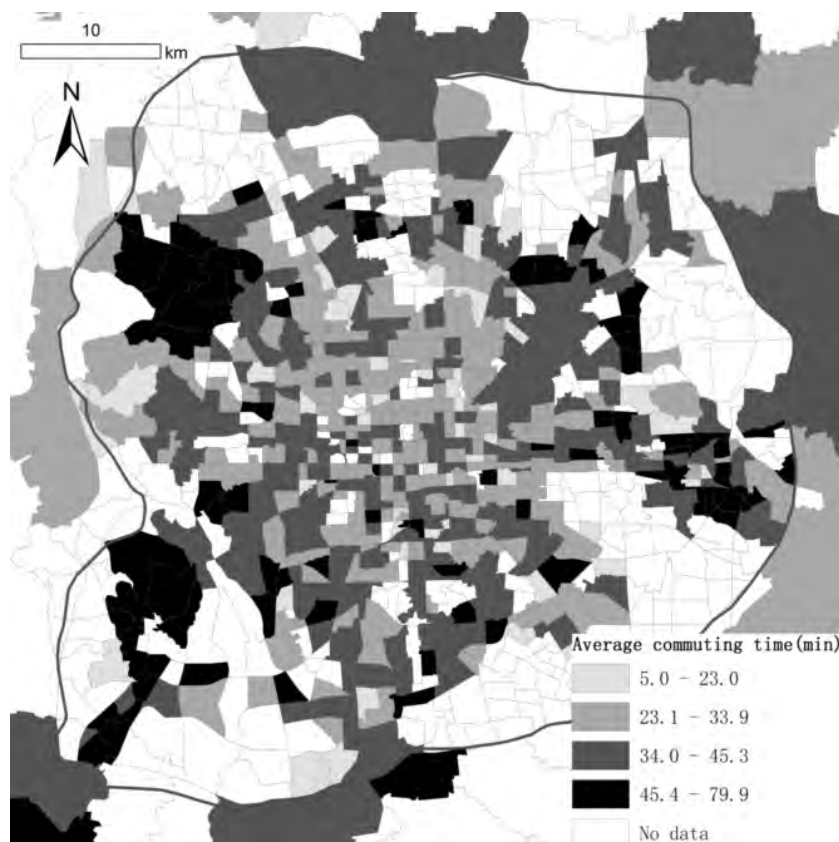
Cardholder density with an identified **housing** place



Cardholder density with an identified a **job** place

# Commuting trips identification

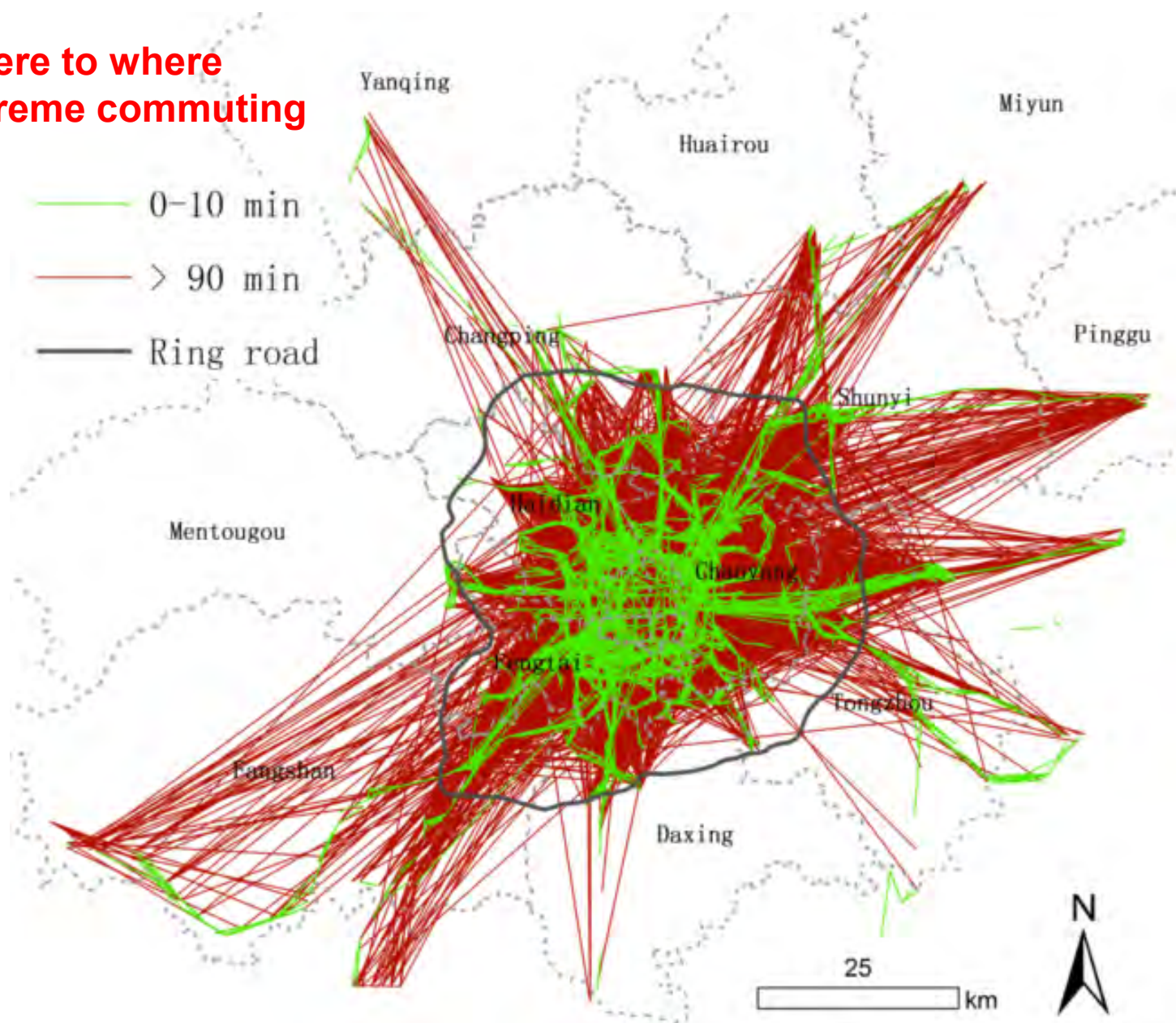
221,773 cardholders identified with commuting trips



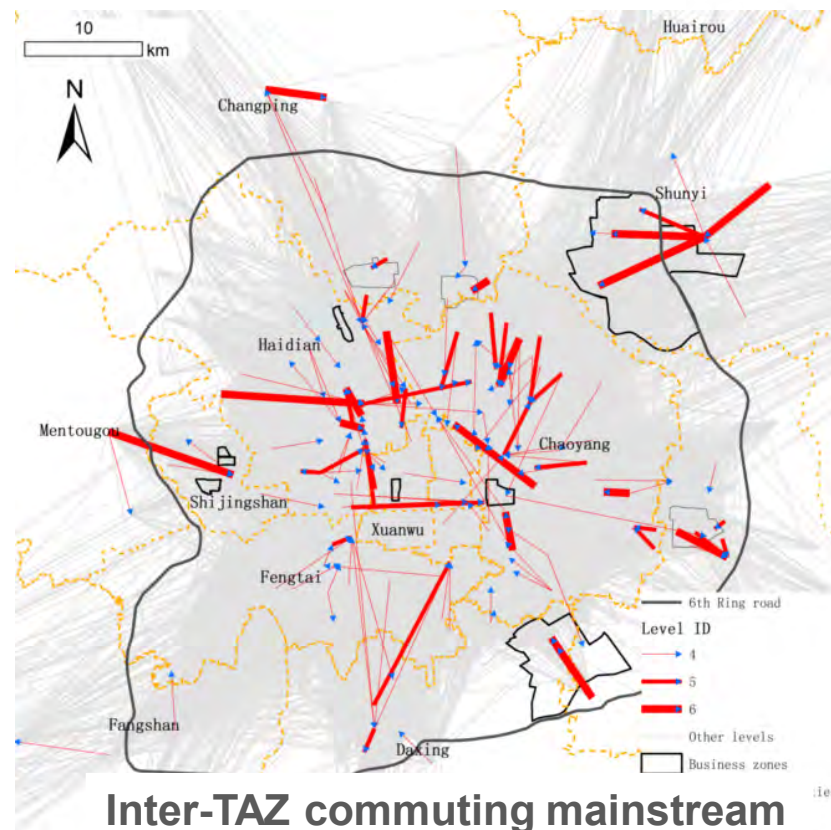
Average commuting **time** and **distance** for each TAZ 24

# Bus commuting pattern

- Where to where
- Extreme commuting



- Aggregated at the TAZ level
- The head/tail division rule used
- Policy suggestion on BRTs



2013年9月开通以来

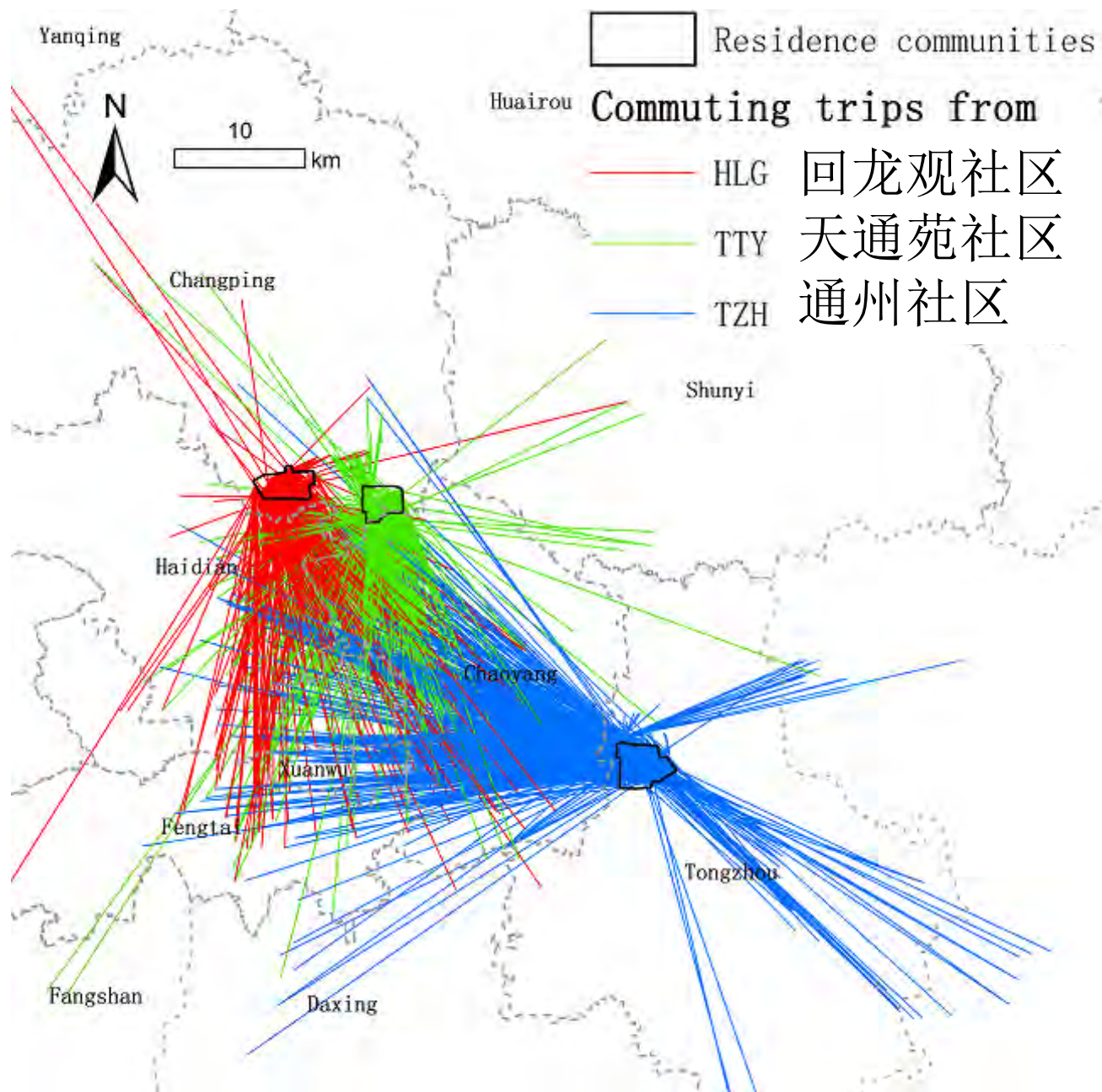
开通45个方向

日发车77个班次

运送乘客10.33万人次

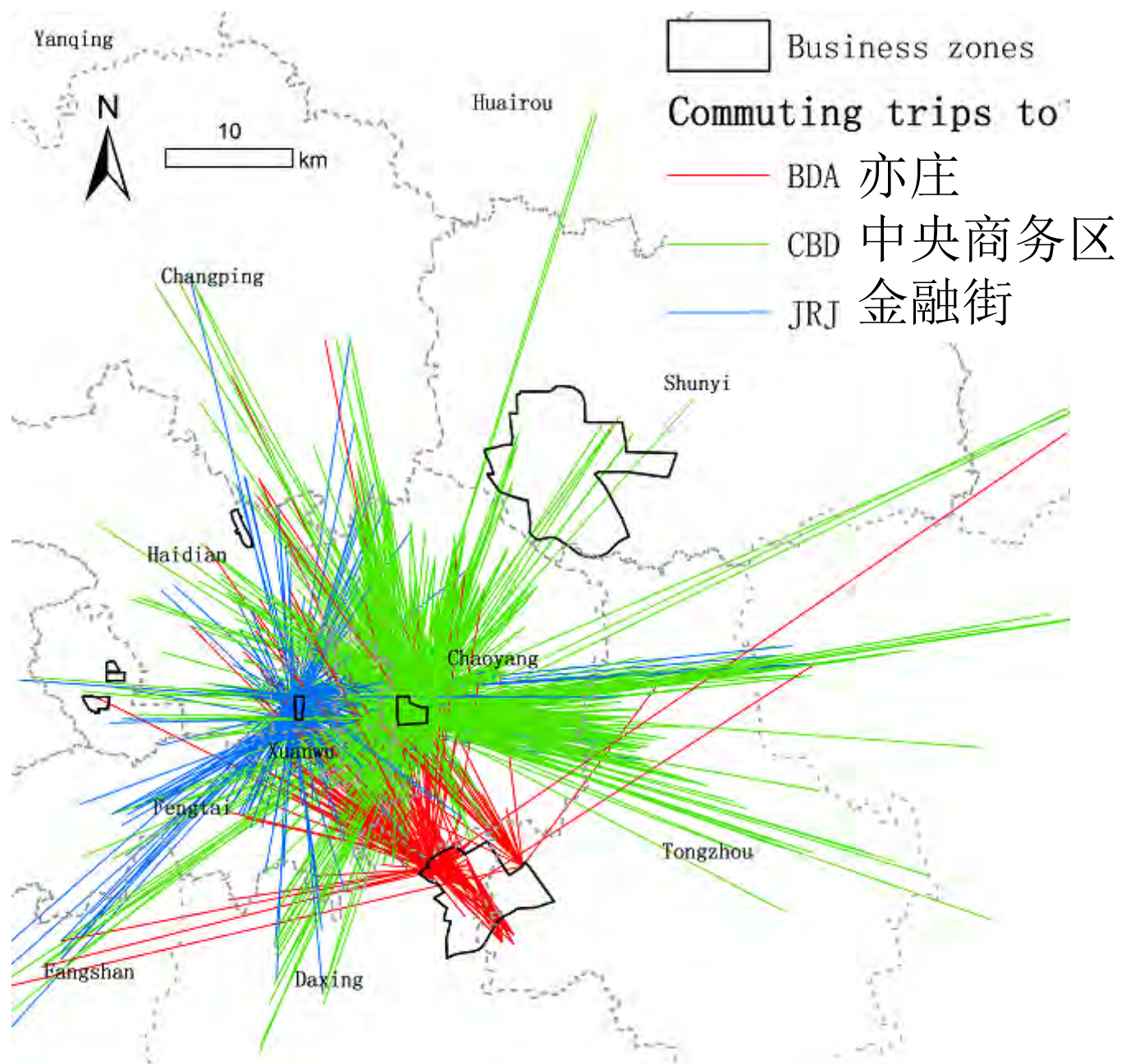
日运送乘客近2000人次

摘自：《2013北京公交社会责任报告》



**Commutes from main residence communities**





**Commutes to main business zones (1)**

# Our contribution: A promising solution for analyzing urban dynamics

- Mining LBS data using conventional conventional surveys and urban GIS layers with sound validation results
- **A decision tree** for determining the final one-week result using periodic information and spatial distribution of one-day result
- Retrieve Beijing commuting pattern with **more accurate spatial info and more samples** in contrast to existing researches using surveys
  - Although limited to bus riders

Springer book chapter, AAAG

# 城市贫困

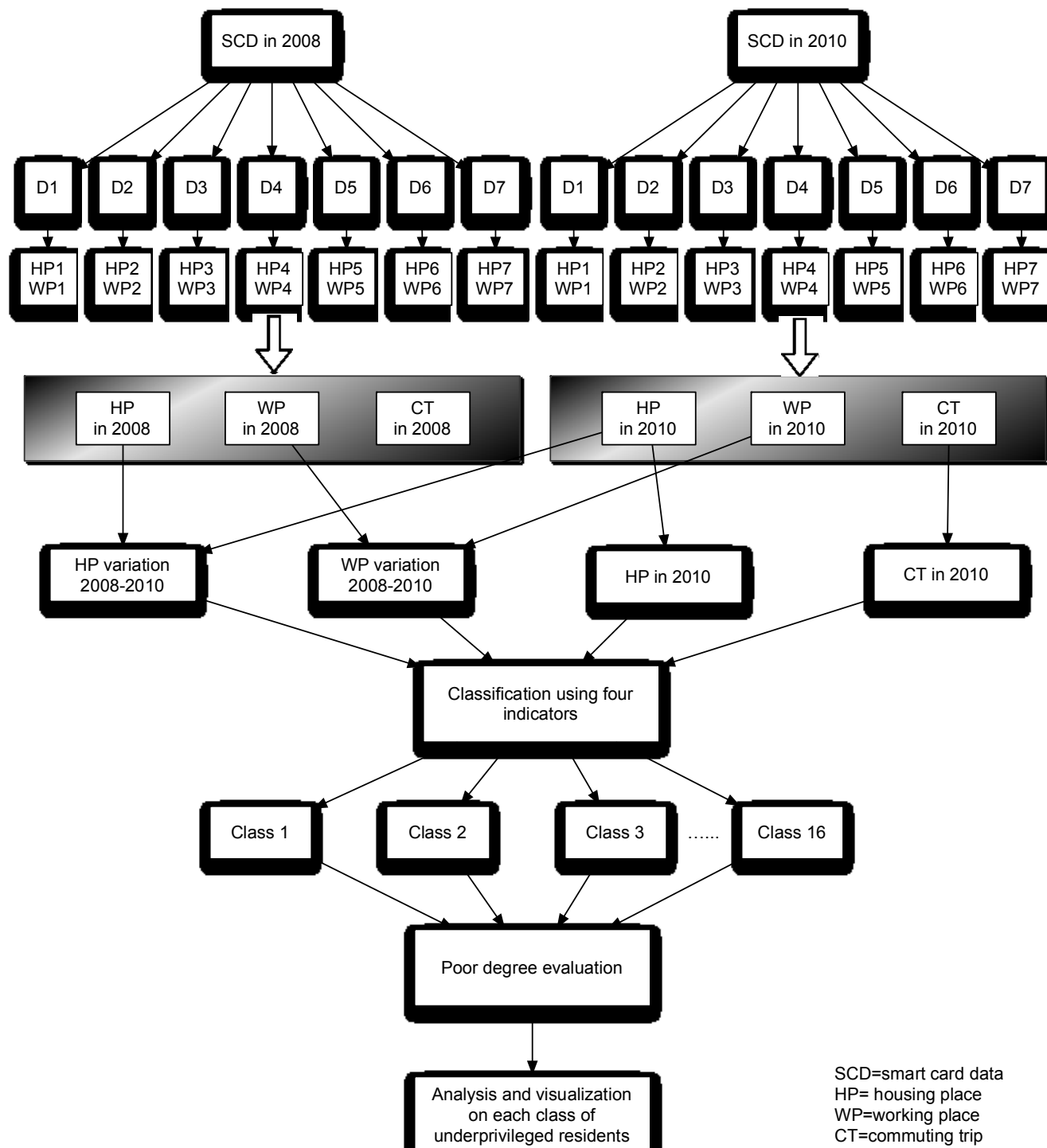
# 中国人针对社会经济问题的敏感性 以及已有城市贫困问题的研究方法



## 频繁公交出行者多为经济上的准（底层）



- 2010交通出行调查
  - For income of 618 households, 417 are in the level 1, 166 are in the level 2, 191 are in the level 3, and 8 are in level 4.
- 柴彦威小组调查
  - Among 125 identified frequent riders, 80.8% residents are with the month income less than 6000 CNY, and most of them (50% of all) only in the 2001-4000 CNY level.
- 当地居民访谈



SCD=smart card data  
 HP= housing place  
 WP=working place  
 CT=commuting trip

# 识别结果



- 11.2万研究对象中，77.4%持卡人居住地点变化，仅13.3%未换工作（其他可能包括找到工作、失业、工作地变化）。**动荡的群体！**

Table 6 Housing place dynamics of FRs during 2008-2010<sup>o</sup>

Housing place <sup>o</sup>		# cardholders <sup>o</sup>	Ratio (%) <sup>o</sup>	
Not changed <sup>o</sup>		25,492 <sup>o</sup>	22.6 <sup>o</sup>	
		87,082 <sup>o</sup>	77.4 <sup>o</sup>	
Changed <sup>o</sup>	Inward (km) <sup>o</sup>	42,013 <sup>o</sup>	37.3 <sup>o</sup>	
		2-5 <sup>o</sup>	9,211 <sup>o</sup>	8.2 <sup>o</sup>
		5-10 <sup>o</sup>	9,651 <sup>o</sup>	8.6 <sup>o</sup>
		10-20 <sup>o</sup>	13,150 <sup>o</sup>	11.7 <sup>o</sup>
		>=20 <sup>o</sup>	10,001 <sup>o</sup>	8.9 <sup>o</sup>
	Outward (km) <sup>o</sup>	45,069 <sup>o</sup>	40.1 <sup>o</sup>	
		2-5 <sup>o</sup>	7,990 <sup>o</sup>	7.1 <sup>o</sup>
		5-10 <sup>o</sup>	10,139 <sup>o</sup>	9.0 <sup>o</sup>
		10-20 <sup>o</sup>	16,400 <sup>o</sup>	14.6 <sup>o</sup>
		>=20 <sup>o</sup>		
Sum <sup>o</sup>				

Table 7 Workplace dynamics of FRs during 2008-2010<sup>o</sup>

Workplace <sup>o</sup>		# cardholders <sup>o</sup>	Ratio (%) <sup>o</sup>		
		14916 <sup>o</sup>	13.3 <sup>o</sup>		
Not changed <sup>o</sup>		2203 <sup>o</sup>	2.0 <sup>o</sup>		
		12713 <sup>o</sup>	11.3 <sup>o</sup>		
Working <sup>o</sup>	Changed <sup>o</sup>	Inward (km) <sup>o</sup>	6142 <sup>o</sup>	5.5 <sup>o</sup>	
			2-5 <sup>o</sup>	1444 <sup>o</sup>	1.3 <sup>o</sup>
			5-10 <sup>o</sup>	1893 <sup>o</sup>	1.7 <sup>o</sup>
			10-20 <sup>o</sup>	2071 <sup>o</sup>	1.8 <sup>o</sup>
			>=20 <sup>o</sup>	734 <sup>o</sup>	0.7 <sup>o</sup>
		Outward (km) <sup>o</sup>	6571 <sup>o</sup>	5.8 <sup>o</sup>	
			2-5 <sup>o</sup>	1371 <sup>o</sup>	1.2 <sup>o</sup>
			5-10 <sup>o</sup>	2018 <sup>o</sup>	1.8 <sup>o</sup>
			10-20 <sup>o</sup>	2156 <sup>o</sup>	1.9 <sup>o</sup>
			>=20 <sup>o</sup>	1026 <sup>o</sup>	0.9 <sup>o</sup>
	Losing job <sup>o</sup>		15909 <sup>o</sup>	14.1 <sup>o</sup>	
	Finding a job <sup>o</sup>		26919 <sup>o</sup>	23.9 <sup>o</sup>	
	Jobless <sup>o</sup>		54830 <sup>o</sup>	48.7 <sup>o</sup>	
Sum <sup>o</sup>		112,574 <sup>o</sup>	100.00 <sup>o</sup>		

<http://arxiv.org/abs/1409.5839>

Table 8 Commuting distance variation of FRs (with commuting trips both in 2008 and 2010)

Commuting distance in 2010 – that in 2008 (km)	# cardholders
$\geq 20$	436
10-20	1,885
5-10	2,266
2-5	2,419
0-2	2,647
-2-0	1,984
-5-(-2)	1,416
-10-(-5)	1,069
-20-(-10)	622
$\leq -20$	172
<b>Sum</b>	<b>14,916</b>

- 后续研究：城市开发对居住区位改变的影响、结合典型调研建立移动性与贫困的关系

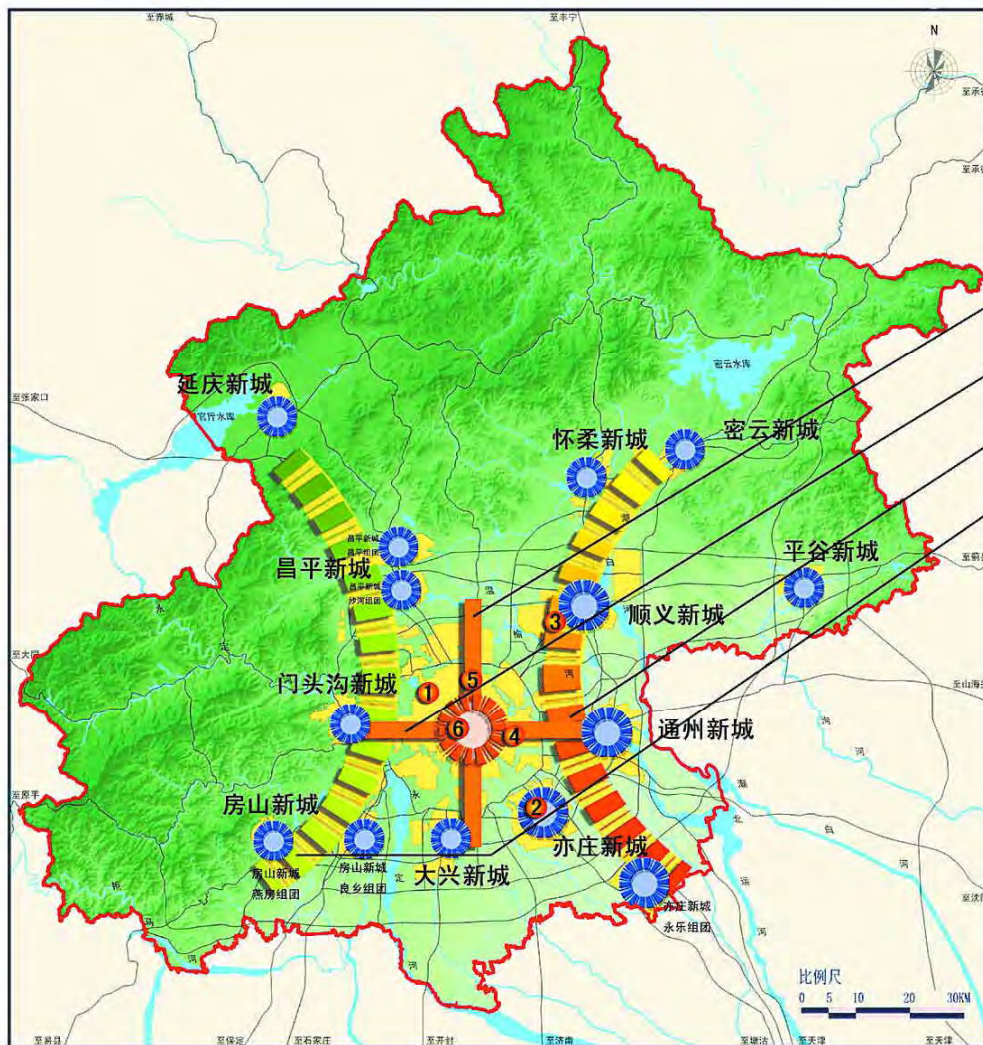


Cities, 近期登出

# 评价城市总体规划实施

# 北京城市总体规划

北京城市总体规划 (二〇〇四年—二〇二〇年)



## 北京城市空间结构规划图 两轴—两带—多中心

- 传统中轴线的南北轴
- 沿长安街的东西轴
- 东部发展带
- 西部发展带

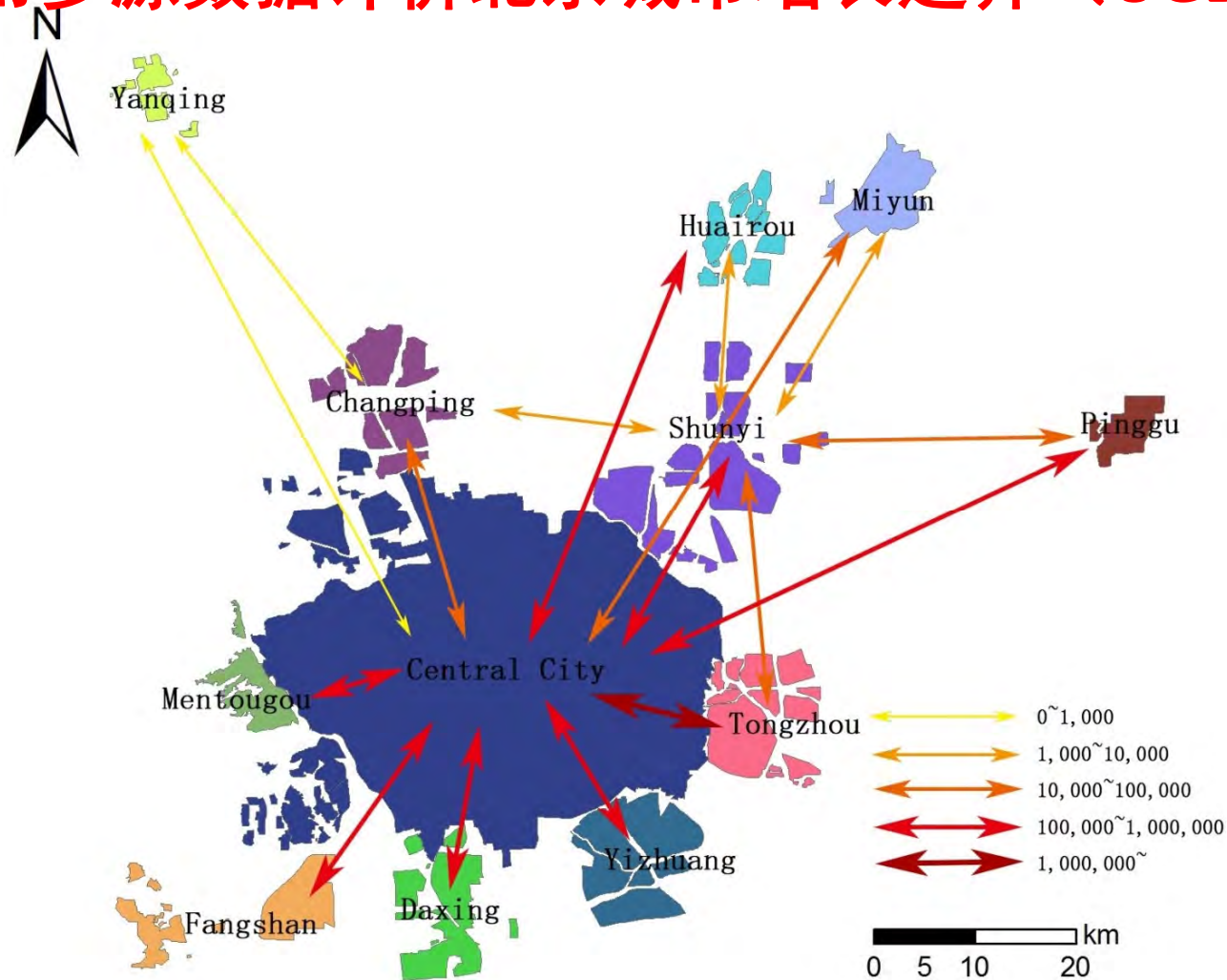
北京市“十一五”规划确定的**六大高端产业功能区**：

1. 中关村科技园区
2. 北京经济技术开发区
3. 临空经济区
4. 商务中心区 (CBD)
5. 奥林匹克中心区
6. 金融街



- 两轴两带多中心
- 1800万人、1650平方公里城镇建设用

# 利用多源数据评价北京城市增长边界（UGBs）



- 虽然有不可忽视的非正式开发，**95%以上的人类活动和移动位于规划城市增长边界内**（出租车轨迹、公交刷卡记录、位置微博/照片等）
- 各个功能组团的活动强度和之间的联系也可以用于评价规划目标（**两轴两带多中心还是单中心？顺义副中心还是通州副中心？**）

Urban Studies准备中

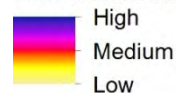
# 大学生汲取社会资本

## 数据情况

- We use the weekday smartcard data from April 6, 2010 to April 9, 2010 (totally 158,262 transit trips, including bus-only, bus plus subway and subway-only trips) to identify and profile the most popular destinations of the student riders from the “985 universities” and associated transit trip flows in Beijing.
- There are eight of 39 “985” universities located in Beijing. We define “popular destinations” as bus and subway stations where a student transit rider stays longer than one hour before he starts a second transit trip.

# The top destinations of the students

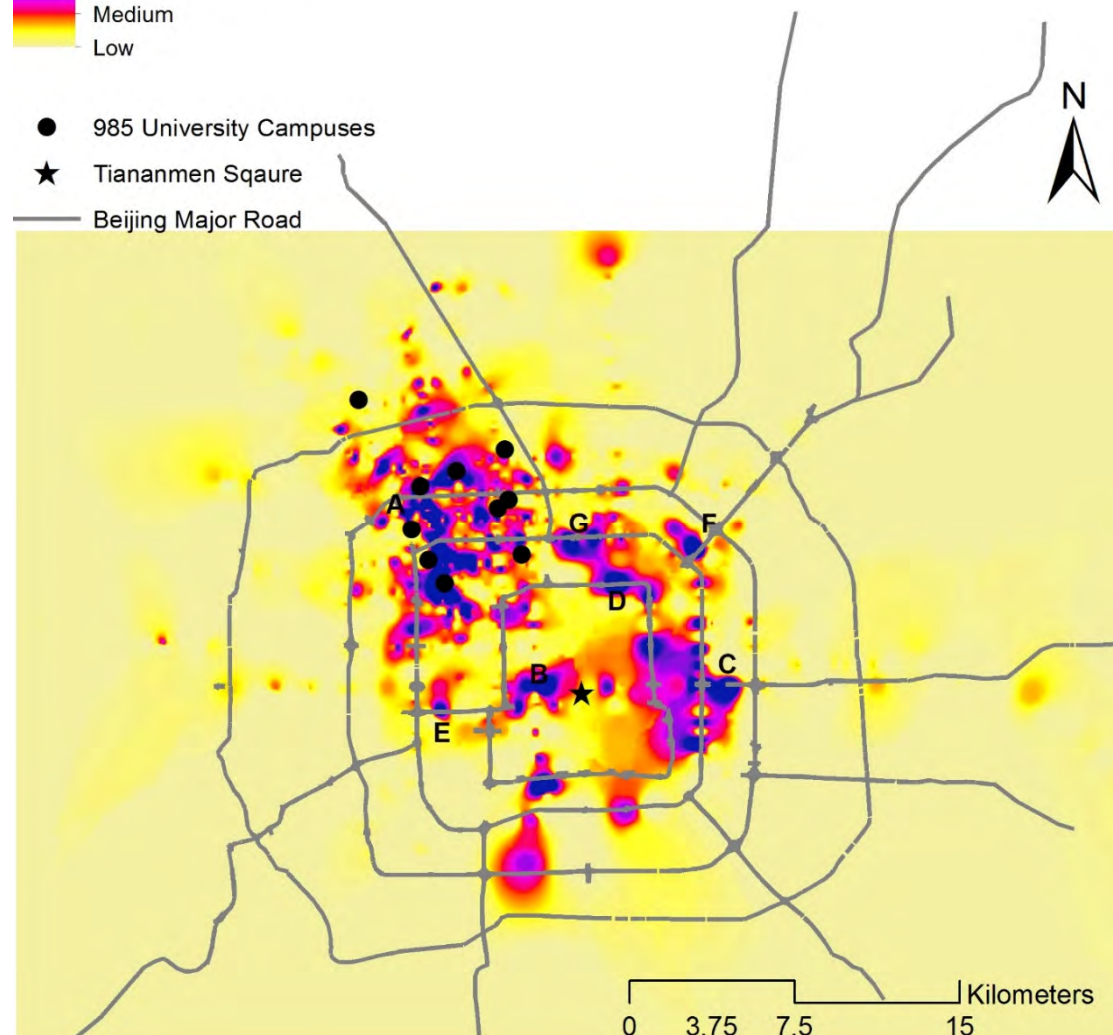
## Destination Hotspots



● 985 University Campuses

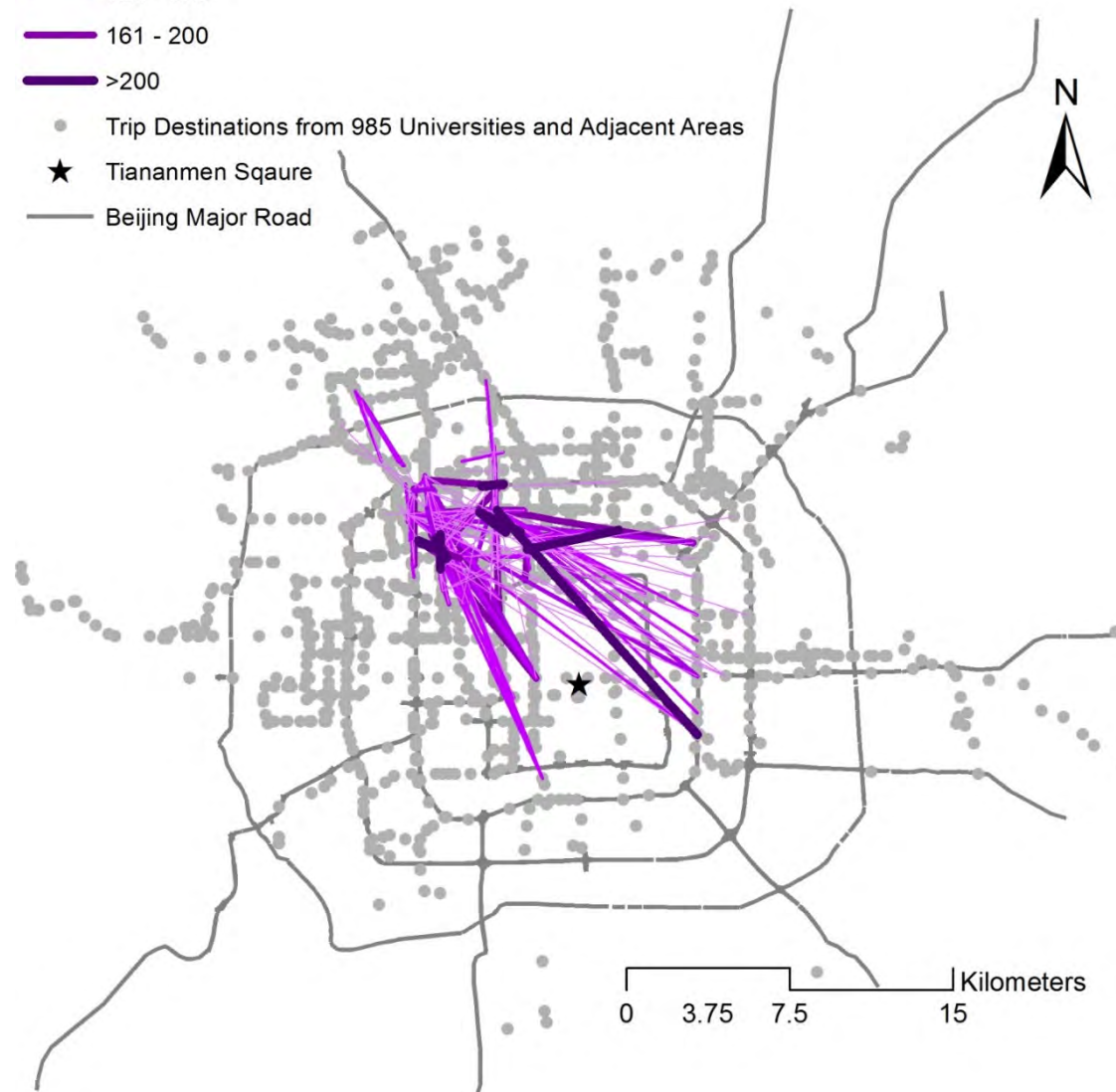
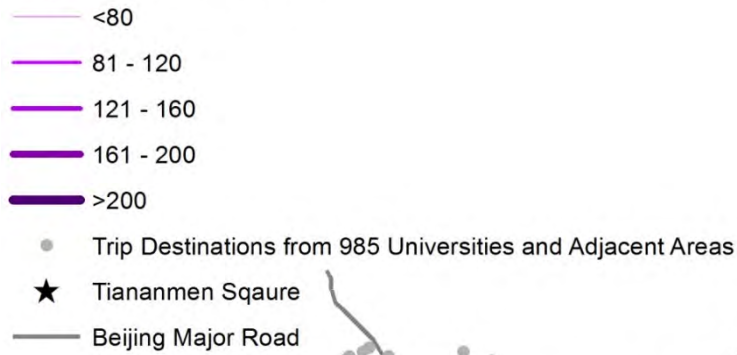
★ Tiananmen Square

— Beijing Major Road



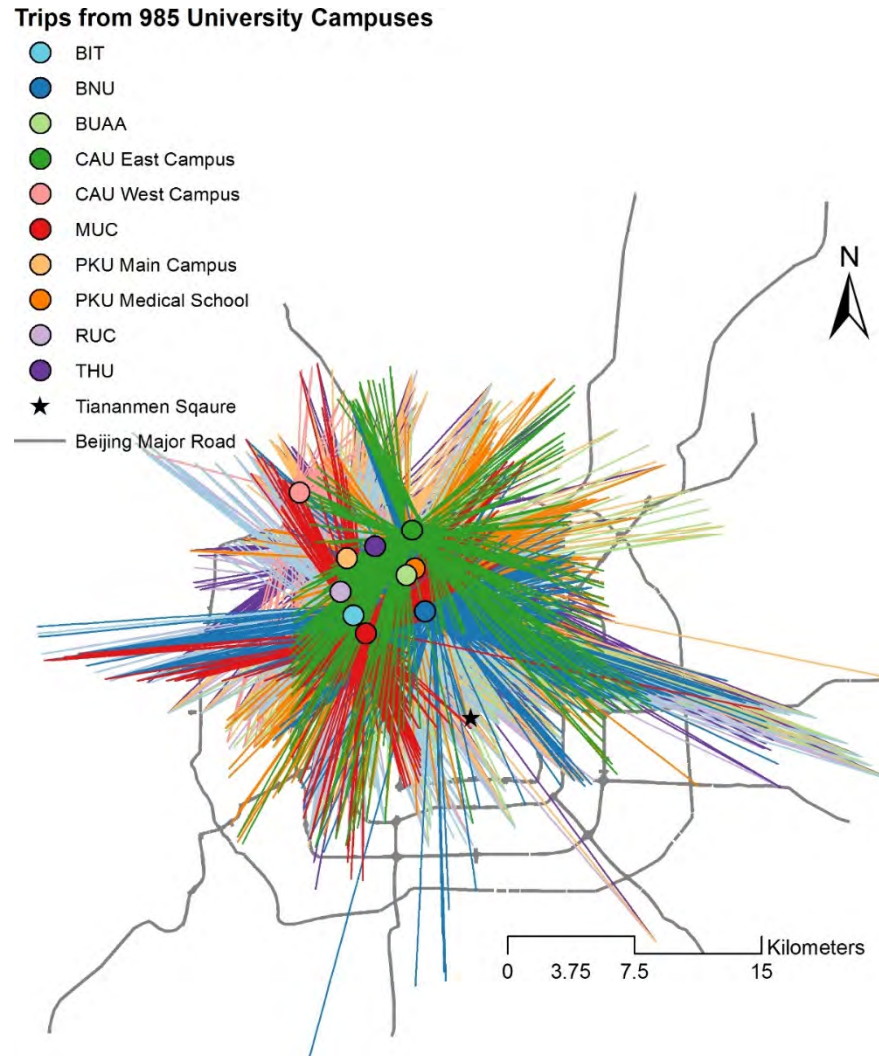
- 距离大学比较近的区域，例如中关村（A）片区包含了最多的“最受欢迎的地方”的热点。而西单（B）和国贸（C）这两个金融片区则站在了“最受欢迎的地方”的第二梯队里，雍和宫（D）、六里桥（E）、三元桥（F）和亚运村（G）同样被包含在“最受欢迎的地方”里。共同特征是这些地方都有密度较高的建筑，商场和餐饮店。

### Top 200 OD Flows



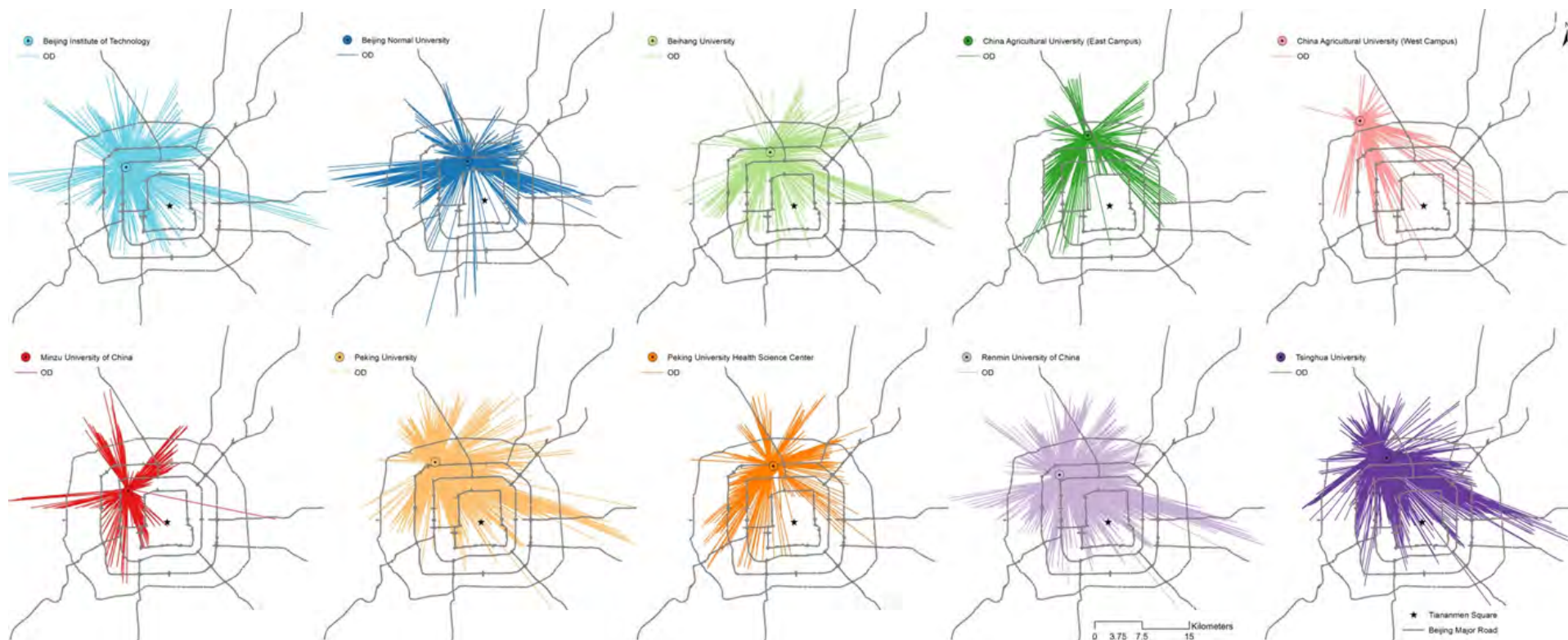
- 显示了大学校园和“最受欢迎的地方”的联系强度。大多数比较强的联系都在三环以内，同时也是北京高收入人群、高知名度团体和高收入公司的所在地。但令人惊讶的是各个大学之间的联系却不怎么强。

# All the transit trips between the campuses and destinations



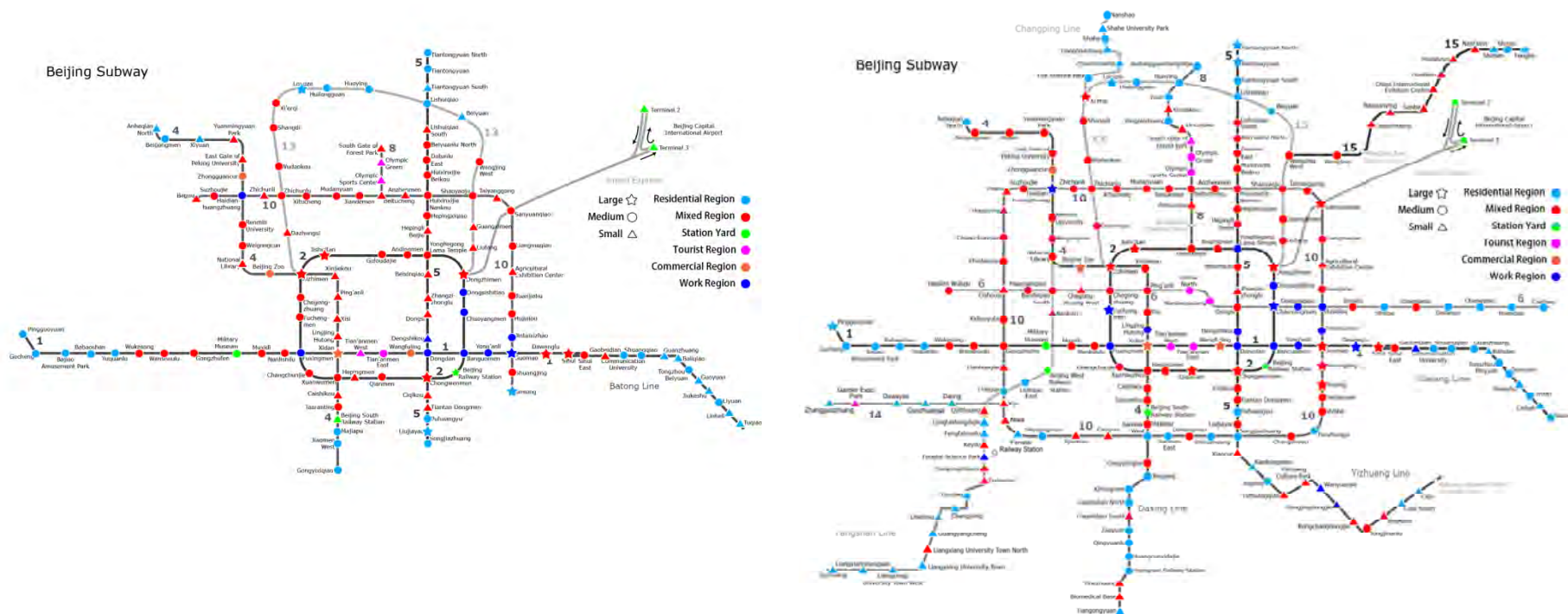
- 表示了各985大学的学生课余时间都去哪。很明显的是大学生去到的地方很多，但是他很少去南三环。985高校和北京经济比较弱的地区联系不强。





# 城市功能识别及其时空演化

# 利用轨道交通刷卡数据研究北京城市功能的演进 (2010年5月 vs 2013年7月)



- 利用刷卡数据识别每个站点的城市功能和客流量
- 通过对比2010和2013年的识别结果（城市功能和客流量），可以评价轨道交通基础设施建设，对城市功能的塑造
- 交通导向开发 **TOD OR NOT?**

# Both size and function change

Station Name	Scale	2010	2011	2012	2013.3	2013.7
阜成门	● ★ ★ ★ ★	Mixed Region	Mixed Region	Mixed Region	Work Region	Work Region
刘家窑	★ ★ ★ ● ●	Residential Region	Residential Region	Residential Region	Residential Region	Mixed Region
北苑	▲ ▲ ● ● ●	Residential Region	Mixed Region	Residential Region	Residential Region	Residential Region
西苑	▲ ● ● ● ●	Residential Region	Residential Region	Residential Region	Residential Region	Mixed Region
灵镜胡同	▲ ● ● ● ●	Mixed Region	Work Region	Work Region	Work Region	Work Region
后沙峪	∅ ● ▲ ▲ ▲		Mixed Region	Mixed Region	Work Region	Work Region
六里桥东	∅ ∅ ▲ ● ●			Mixed Region	Residential Region	Residential Region
六里桥	∅ ∅ ▲ ▲ ●			Station Yard	Residential Region	Residential Region
北海北	∅ ∅ ∅ ▲ ●				Mixed Region	Tourist Region
南锣鼓巷	∅ ∅ ∅ ▲ ●				Mixed Region	Tourist Region

Large ☆  
 Medium ○  
 Small △

Residential Region ●  
 Mixed Region ●  
 Station Yard ●  
 Tourist Region ●  
 Commercial Region ●  
 Work Region ●

**Explorative Analysis on Extreme Travel Behavior in Beijing**

**EARLY BIRDS, NIGHT OWLS, AND TIRELESS ITINERANTS**

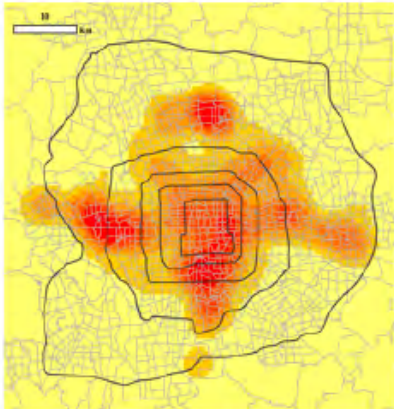
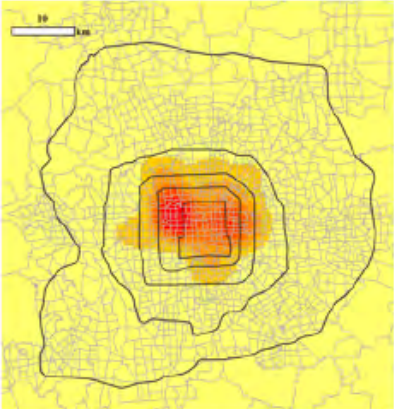

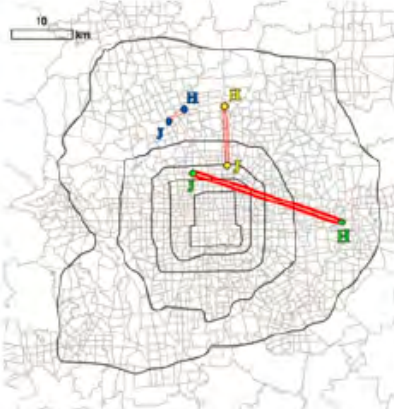
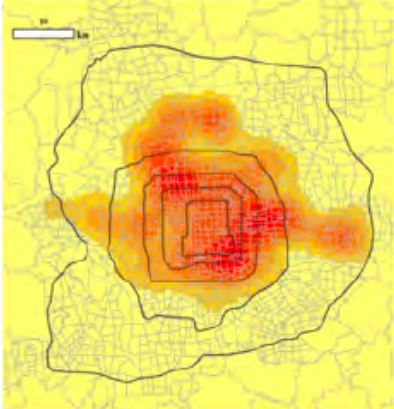
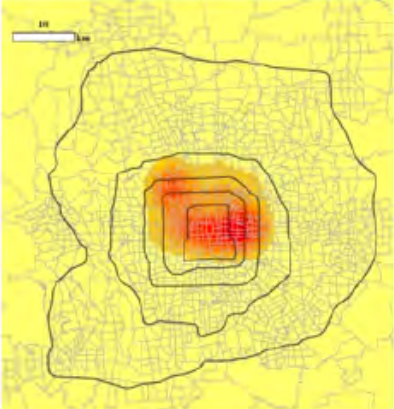
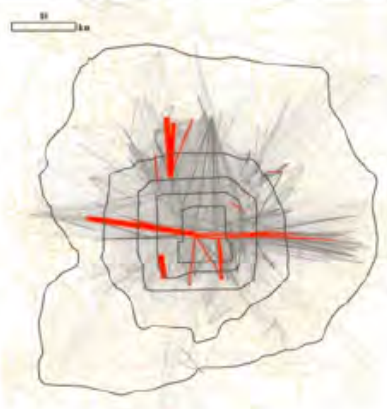


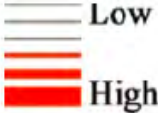
# 利用一周公共交通刷卡数据研究北京极端出行

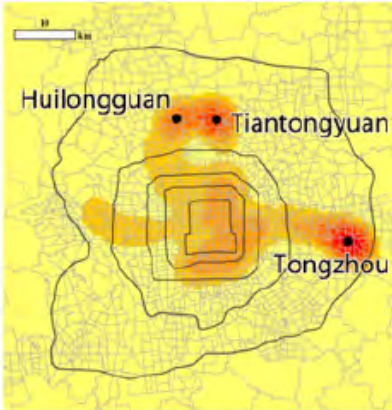
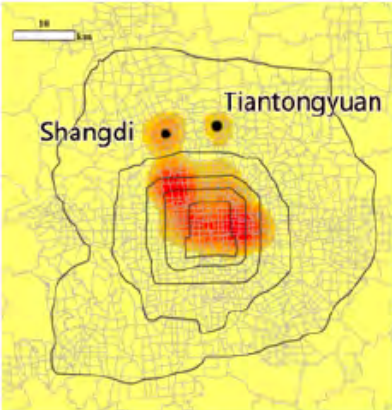

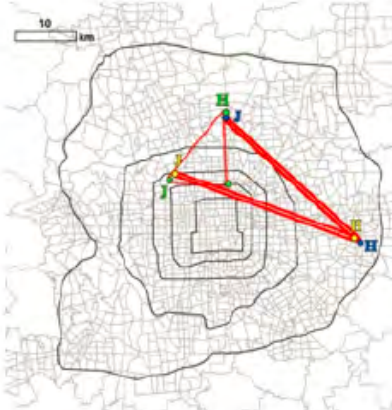
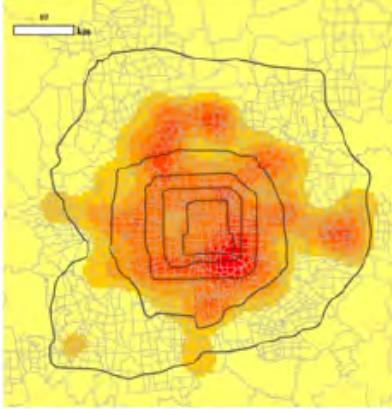

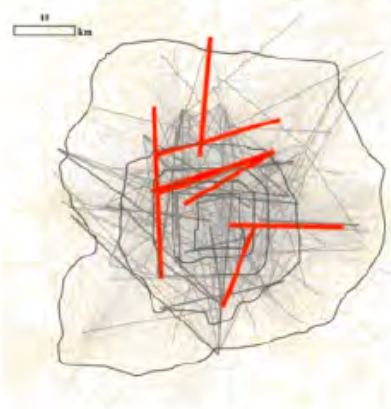
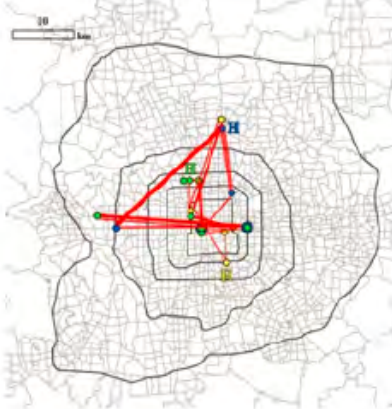




## 利用刷卡和出行调查数据分析北京极端出行行为

- 充分利用大数据在样本大、时空信息完善的特点，勾画特定人群的时空分布及移动性，回答在哪里、如何活动和移动（说格局）？
- 同时利用小数据的社会经济等信息，回答是谁、在做什么、为什么（讲故事）？

Type	Definition
Early Birds (EBs)	First trip < 6AM, more than two days in a week (60% of weekdays)
Night Owls (NOs)	last trip (boarding time) > 10PM, more than two days in a week (60% weekdays)
Tireless Itinerants (TIs)	>= one and a half hours commuting, more than two days in a week
Recurring Itinerants (RIs)	>= 30 trips in weekdays of a week (>= 6 trips per day)

Extreme travelers	Kernel density of housing	Kernel density of jobs	Commuting trips	Typical trips
EBs	 <p>(10.3 k)</p>	 <p>(9.4 k)</p>	 <p>(4.9 k)</p>	
NOs	 <p>(31.6 k)</p>	 <p>(25.0 k)</p>	 <p>(17.5 k)</p>	
Legend	 <p>Low High</p>		 <p>Low High</p>	<ul style="list-style-type: none"> <li><span style="color: yellow;">●</span> Person A</li> <li><span style="color: blue;">●</span> Person B</li> <li><span style="color: green;">●</span> Person C</li> <li>— Ring roads</li> <li><span style="color: red;">—</span> Routes</li> </ul>

Extreme travelers	Kernel density of housing	Kernel density of jobs	Commuting trips	Typical trips
TIs	 <p>Huilongguan, Tiantongyuan, Tongzhou</p> <p>(6.7 k)</p>	 <p>Shangdi, Tiantongyuan</p> <p>(6.7 k)</p>	 <p>Tongzhou</p> <p>(6.7 k)</p>	
RIs	 <p>(25.4 k)</p>	 <p>Yizhuang</p> <p>(7.8 k)</p>	 <p>(2.7 k)</p>	
Legend	 <p>Low High</p>		 <p>Low High</p>	<ul style="list-style-type: none"> <li><span style="color: yellow;">●</span> Person A</li> <li><span style="color: blue;">●</span> Person B</li> <li><span style="color: green;">●</span> Person C</li> <li>— Ring roads</li> <li><span style="color: red;">—</span> Routes</li> </ul>



Type	EBs	NOs	TIs	RIs	AB
Sleep/Rest	0.4%	0.4%	0.0%	0.2%	0.1%
Shopping	1.0%	0.4%	0.0%	6.9%	1.4%
Pick-up or Drop-off Others	1.0%	0.0%	0.0%	11.7%	4.6%
Accompany Others	0.0%	0.0%	0.0%	0.4%	0.2%
Taking Delivery of Goods	0.6%	0.0%	0.0%	1.3%	0.4%
Go Home	1.3%	96.2%	0.0%	0.7%	44.4%
Have Meals	1.3%	0.0%	0.0%	31.2%	2.4%
Work	60.2%	2.1%	100.0%	2.4%	21.9%
Official Travel	0.9%	0.0%	0.0%	10.0%	0.9%
Go to Class/Study	11.8%	0.0%	0.0%	5.5%	3.9%
Personal Affairs	6.8%	0.0%	0.0%	0.5%	2.6%
Homework/Take Care of the Family	0.6%	0.0%	0.0%	10.8%	0.1%
Recreation, Entertainment and Fitness	10.9%	0.4%	0.0%	0.2%	6.4%
Visit Relatives and Friends	1.8%	0.0%	0.0%	3.1%	10.1%
Others	1.2%	0.4%	0.0%	15.1%	0.6%

**Table 4 Selected socioeconomic characteristics of extreme travelers**

ID	Extreme travelers	EBs (676)	NOs (236)	TIs (627)	RIIs (100)	ABs (116,142)
1	% annual household income $\geq$ 100 k CNY	4.9	4.2	6.7	5.0	7.4
2	% renting house	11.0	17.8	20.4	16.0	16.1
3	# average household car ownership	0.22	0.21	0.25	0.22	0.31
4	% higher education (undergraduate and graduate)	14.2	18.2	33.5	25.0	21.1
5	% Beijing <u>Hukou</u>	87.0	82.2	74.8	83.0	82.4
6	% public-sector employees	13.5	7.6	15.8	7.0	10.4
7	% fulltime workers	60.9	84.7	94.4	42.0	45.9
	% fulltime students	12.7	2.1	1.3	1.0	7.3
	% retirees	20.9	5.9	0.8	38.0	29.1

Note that numbers in brackets are the total count of extreme travelers.

- **基于公共交通刷卡数据开展了诸多定量城市研究**
  1. 通勤出行、职住平衡和过度通勤
  2. 城市贫困
  3. 评价城市总体规划实施
  4. 大学生汲取社会资本
  5. 城市功能识别及其时空演进
- **大数据时代，传统数据同样重要！**
- **本报告所介绍的诸多实践，是科学地理解城市的一次尝试**  
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这套课件为龙瀛及其合作者近年来在城市模型领域研究的部分合集，包括传统的城市模型、基于大数据的城市模型、大模型这一城市与区域研究新范式，以及最近的面向规划设计应用的初步探索。

这些PPT在不同的学术会议和论坛上做过发表，时间和精力有限，并没有专门针对此课件进行调整。课件内容难免有不完善之处，欢迎将意见和建议致信到longying1980@gmail.com