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Spatial Analysis of Western Medical Services in Republican Beijing: A Historical GIS Approach

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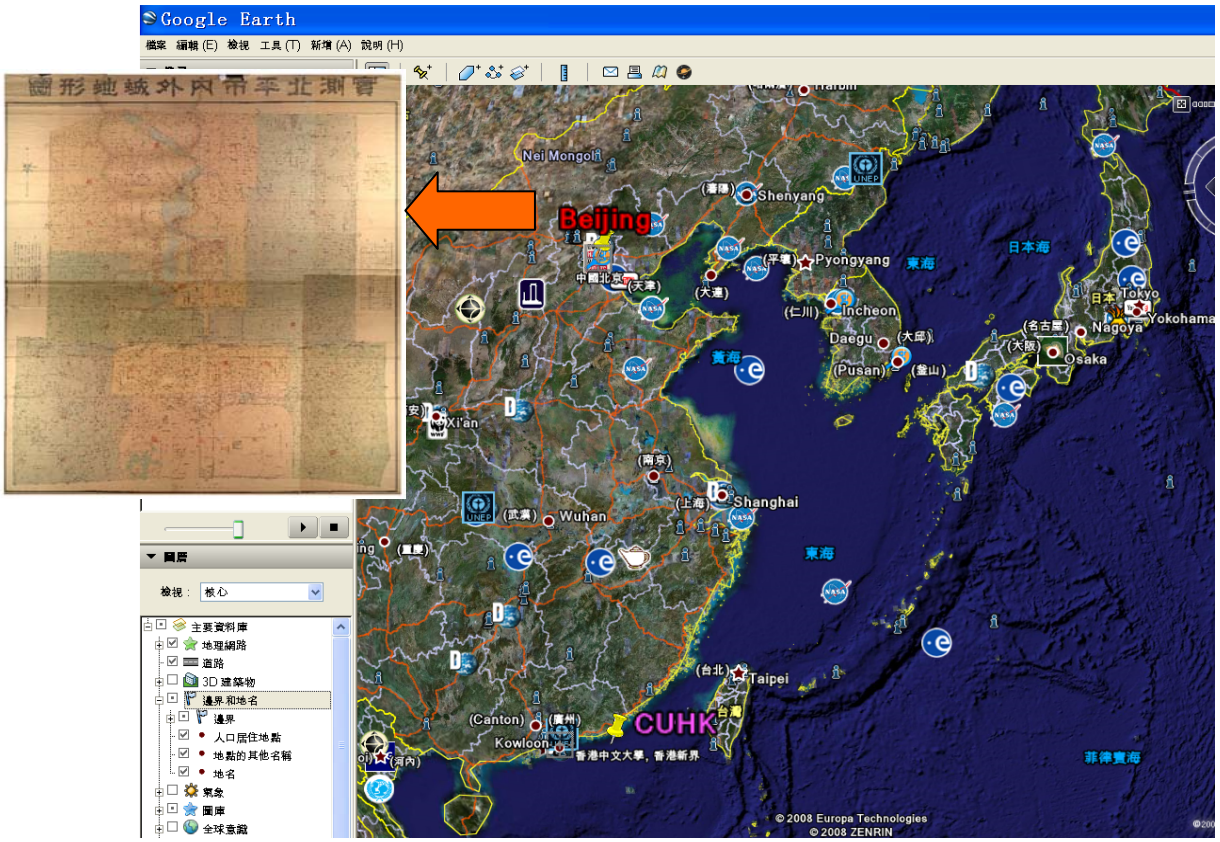
Outline

- **Introduction**
- Major analysis issues and analysis techniques
- Materials and methods
- Results and discussion
- Conclusion

Background



- 医疗史牵涉着西方科技的输入问题，又与在地社会关系密切，为重新审视近代中国社会的发展问题提供了很好的切入点 (梁其姿 2007)。

Background

- GIS and Spatial analysis make sense for historical studies (Bol, P. and Ge,J. 2005; Knowles A.K. 2006; Ian N. Gregory 2007).
  - *GIS is able to integrate data from many sources.*
  - *Quantitative analysis can be conducted by using spatial statistics.*
  - *Visualization tools of GIS may inspire new assumptions.*

Research goal

- Investigate the spatial dynamics of Western medical services in Beijing by using spatial statistics based on GIS.
- Research Enquiries
  - *Spatial patterns of western medical services*
  - *Correlations between Western medicine and factors like TCM, population, religion and market patterns*

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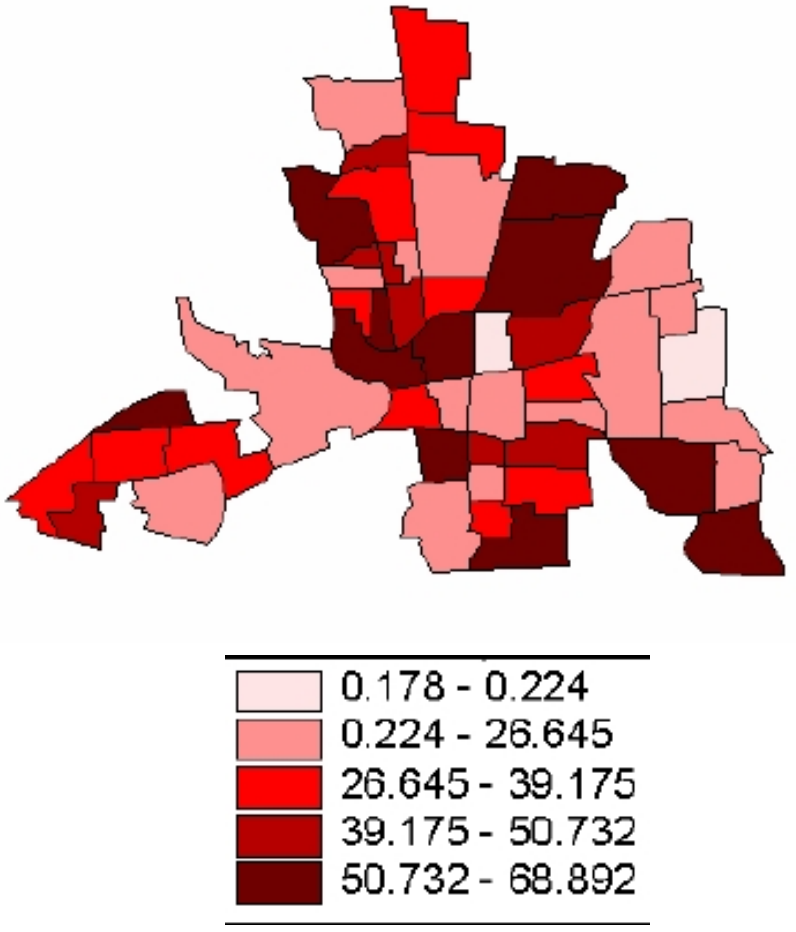
Spatial Autocorrelation

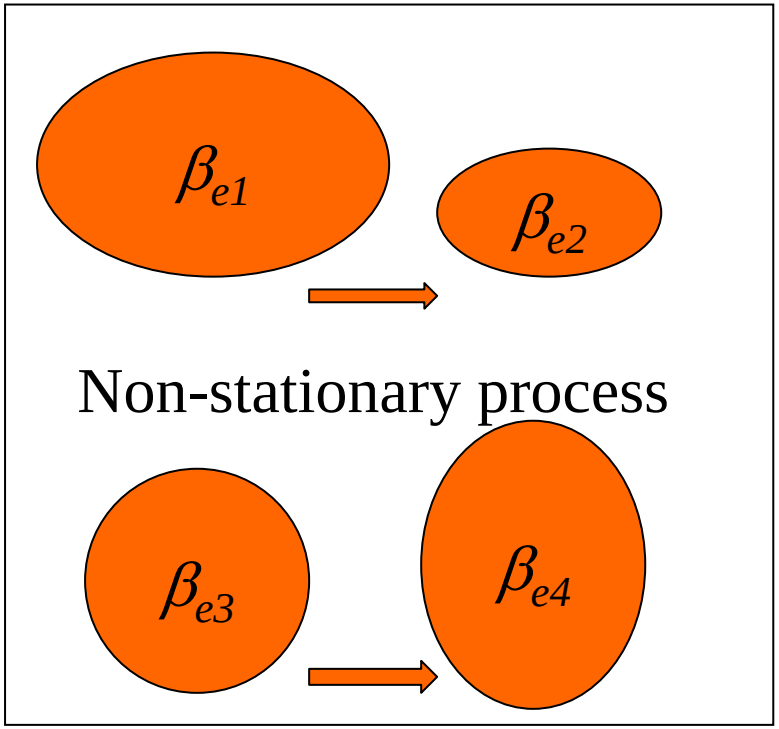
- Everything is related to everything else, but near things are more related than distant ones.
  - *Moran I*
  - *G statistics*



Columbus homicide data (source: Luc Anselin)

Spatial heterogeneity

- It refers to the complexity and variability of a system property in space
  - *Switching regression*
  - *Multilevel models*
  - *Geographically weighted regression (GWR)*



Source: Danlin Yu, 2006

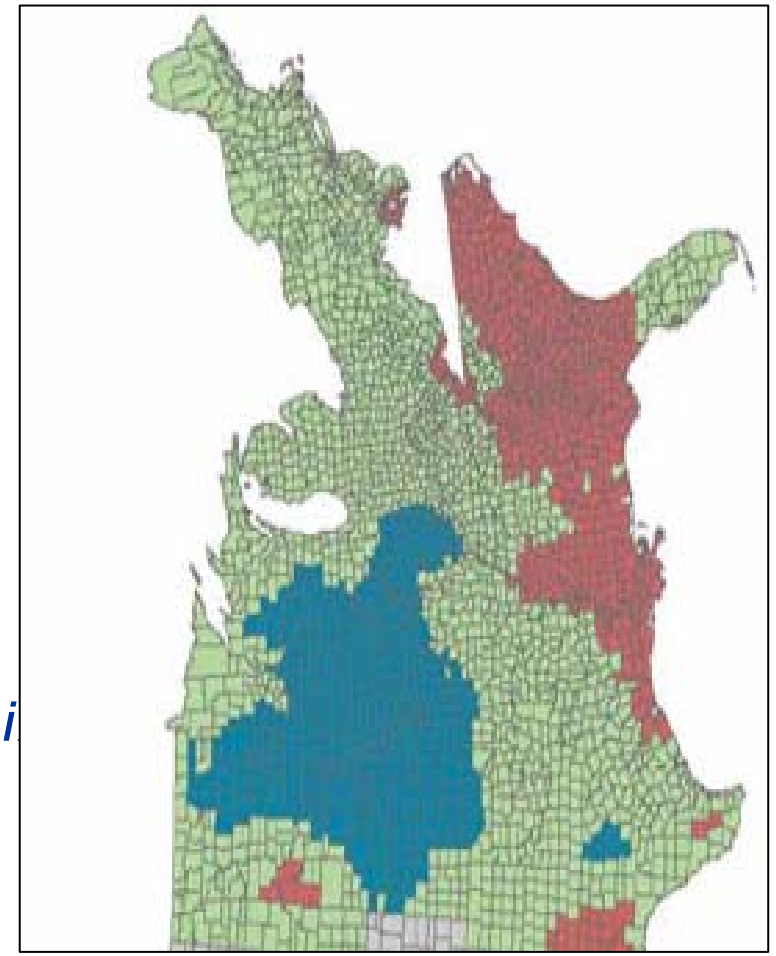
Key issues and analysis technologies

- Spatial patterns of Western medical services
  - *Hot spot analysis (Getis Getis-Ord Gi*)*
- Its correlations with TCM, population, temple and industry-commerce patterns
  - *Geographically Weighted Regression (GWR)*

Hotspot analysis (Getis Getis-Ord Gi*)

$$G_i(d) = \frac{\sum_{j=1}^{n} w_{ij}(d)x_j}{\sum_{i=1}^{n} x_j}$$

- X_j: value of the observation at j
- w_{ij} (d): ij element of a binary W matri
- n: number of observations.



Source: Lauren M. Scott, and Mark V. Janikas,2007

ε_i

GWR

- Analysing spatially varying relationships among different variables

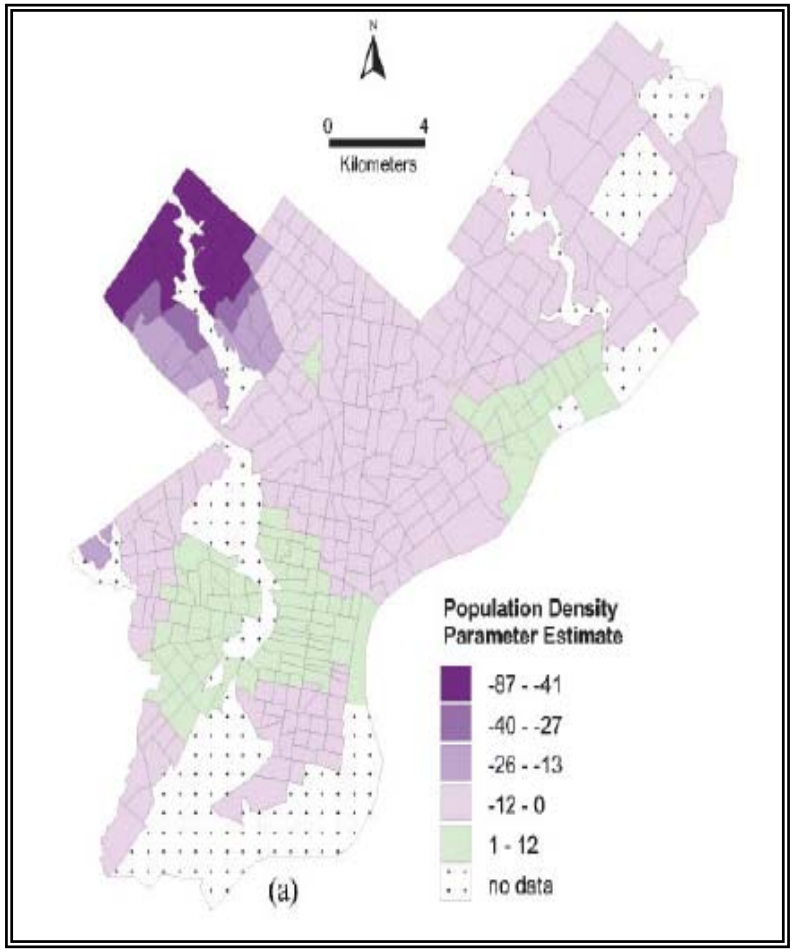
$$y_i = \beta_0(u_i, v_i) + \sum_k \beta_k(u_i, v_i) x_{ik} + \varepsilon_i$$

x_{ik} : *Independent variable*

y_i : *Dependant variable*

(ui,vi) : Capture the coordinate location of i

ε_i: *Intercept term*



Source: Jeremy Mennis,2006

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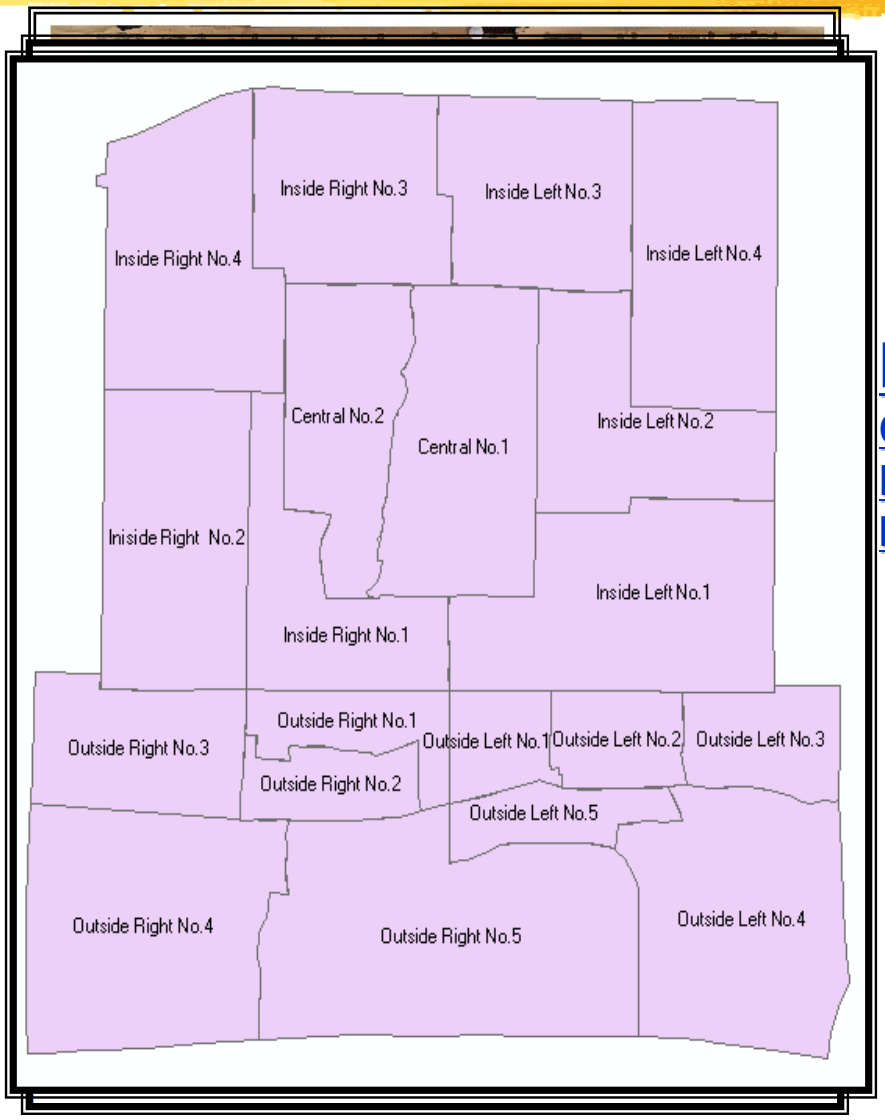
Study Area



Base map : Beijing map of 1937 at a scale of 1 : 5000

20 police districts from Beijing map of 1916

Organization (point) : 931

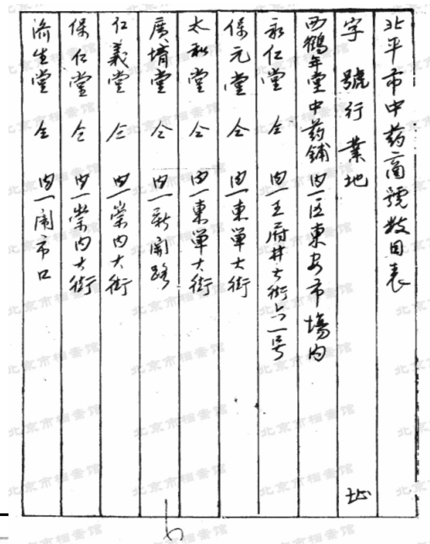
Hutong (Lines) : 3205

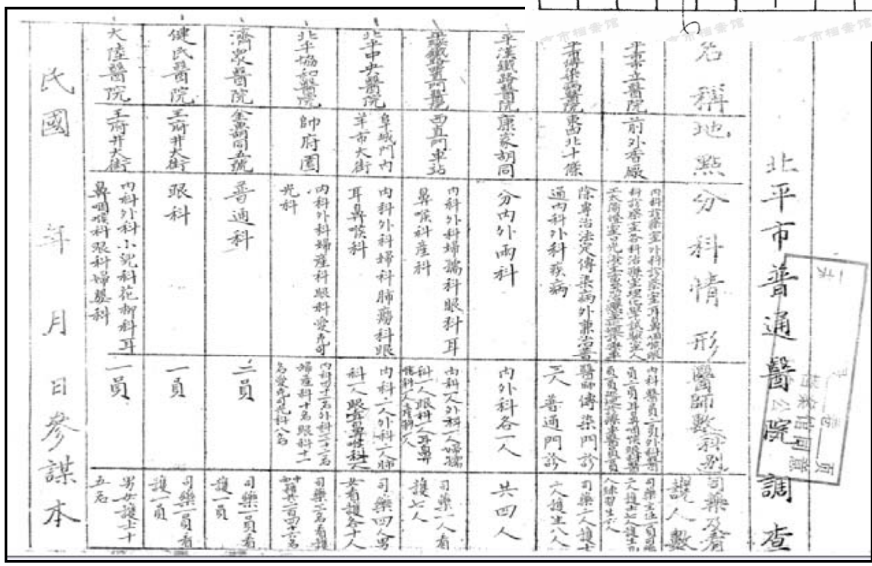
Block (polygon) : 5603

Sources

分區六月八月戶口比較表二十六年

月別	戶口	內一區	內二區	內三區	內四區	內五區	內六區	外一區	外二區	外三區	外四區	外五區	東郊區	西郊區	南郊區	北郊區	共計
六月	戶	21765	20259	24045	21609	15992	11734	12716	15770	19556	19657	21228	26338	26627	22275	18096	297667
	男	76039	71979	78841	63761	47307	32145	65082	59585	78075	54817	62477	71146	73232	62490	49684	946660
	女	42403	47196	54626	45364	34935	25093	17461	26999	33300	36450	29857	55583	56095	50032	37268	592662
八月	戶	21912	20486	24445	21892	16399	11485	12865	16006	19613	19846	21534	26153	26322	22116	17825	298899
	男	76046	72405	80130	65176	48325	31500	64250	59155	75145	55253	63195	70628	72505	62137	48887	944737
	女	43373	48132	56727	46998	37083	25130	19085	28987	34638	37466	30953	55283	55646	49738	36752	605991
比較實增	戶	147	227	400	283	407		149	236	57	189	306					2401
	男	7	426	1289	1415	1018					436	718					5309
	女	970	936	2101	1634	2148	37	1624	1988	1338	1016	1096					14888
比較實減	戶						249						185	305	150	271	1169
	男						645	832	430	2930			518	727	353	797	7232
	女												300	449	294	516	1559





$i \in j$

Data processing and analysis

- How to allocate population data by police district into each block ?
  - *Step 1: work out the residential area for each polygon in block layer;*

$$RP_i = AP_i - \sum_k NR_{ik} \times n$$

RP_i: residential area for polygon i

AP_i: area of each polygon i,

NR_{ik}: area of the k th non-residential building for polygon i

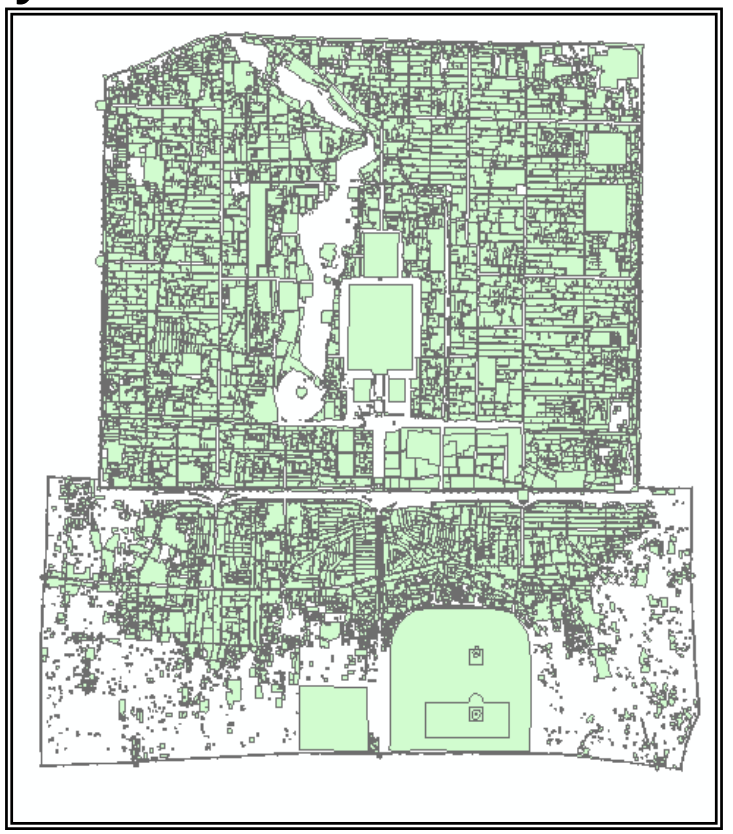
n: number of the k th non-residential building.

  - *Step 2: work out the total area of the residential polygons for each police district j ;*

$$R_j = \sum_{i \in j} RP_i$$

j= 1,2,3,...11 or i=1,2,3,...20

RP_j: residential area of polygon i which is contained by police district j, that is $i \in j$



Polygon layer on base map

$i \in j$

How to allocate population data by police district into each block ?

- *Step 3: work out the density of population*

  for each polygon i

$$DP_i = \frac{P_j}{R_j}$$

  DP_i : density of population for each polygon i

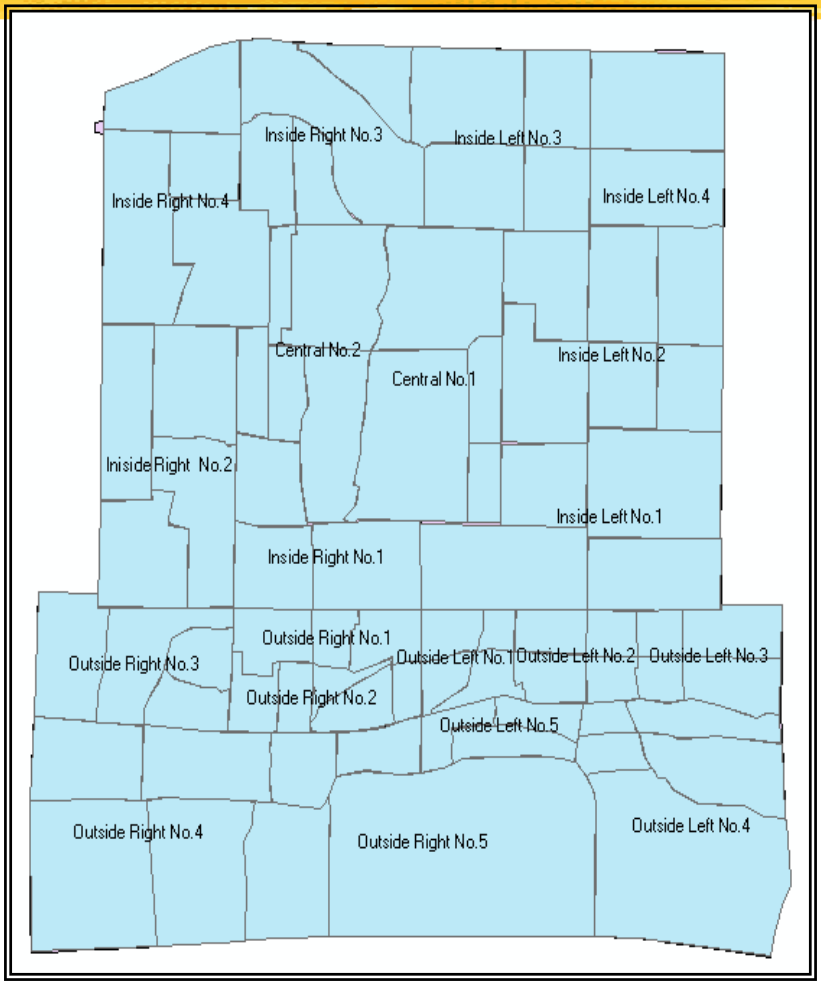
  P_j: population for police district j

- *Step 4: work out the population for each*

  polygon i

$$P_i = DP_i \times RP_i$$

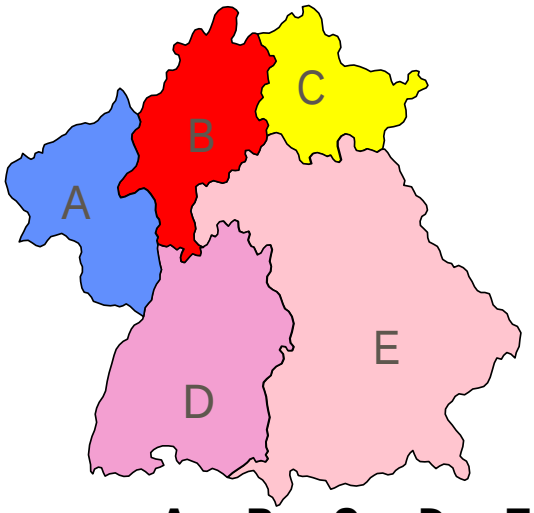
  P_i: population for each polygon i



80 sub-districts based on polygon layer

Hotspot analysis

- Getis-Ord General G
- Distance threshold bands of 0,2000,2500,3000,3500m for spatial weight matrix
  - *Wij=1, if distance < 2000m*
  - *Wij=0, otherwise*



	A	B	C	D	E
A	0	1	0	1	0
B	1	0	1	1	0
C	0	1	0	0	1
D	1	1	0	0	1
E	0	1	1	0	0

Consideration for GWR

- Dependant variable: *number of western hospitals*
- Independent variable: *numbers of TCM drug stores, temples, industrial-commercial organizations, population*

- Global regression (OLS)
  - *measure the average relationships*
  - *explore the important factors*

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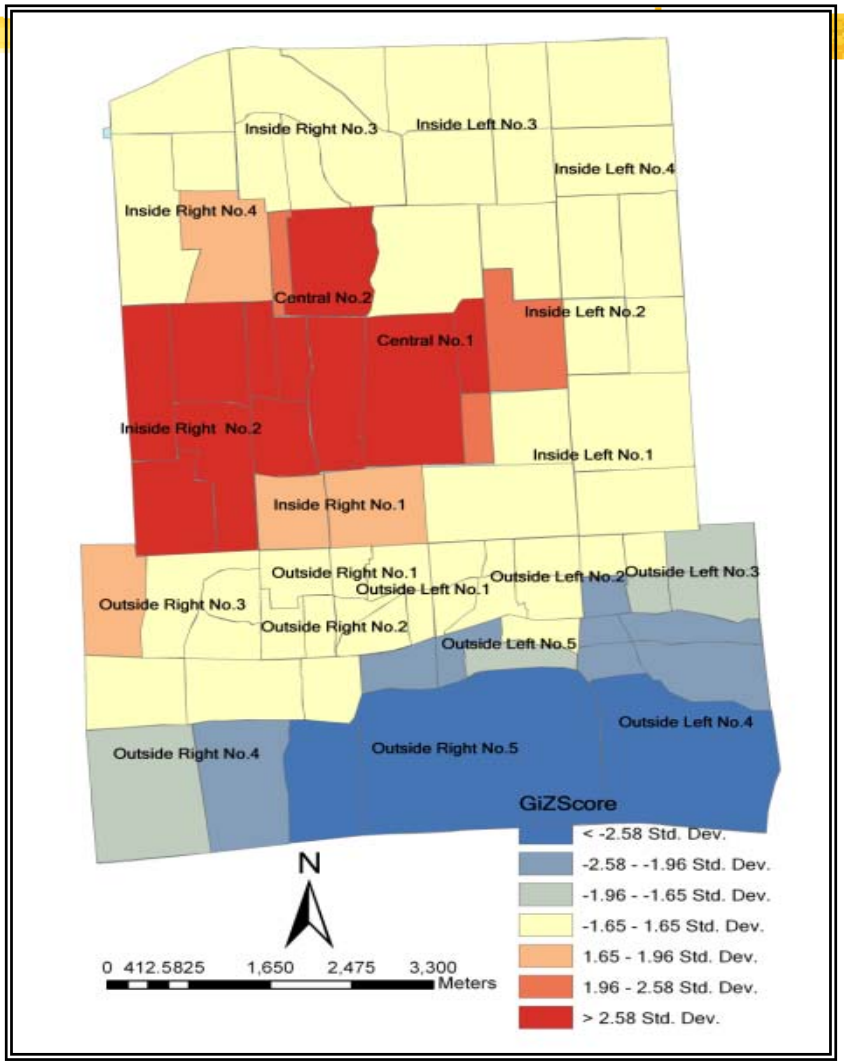
Cluster and Hotspot analysis



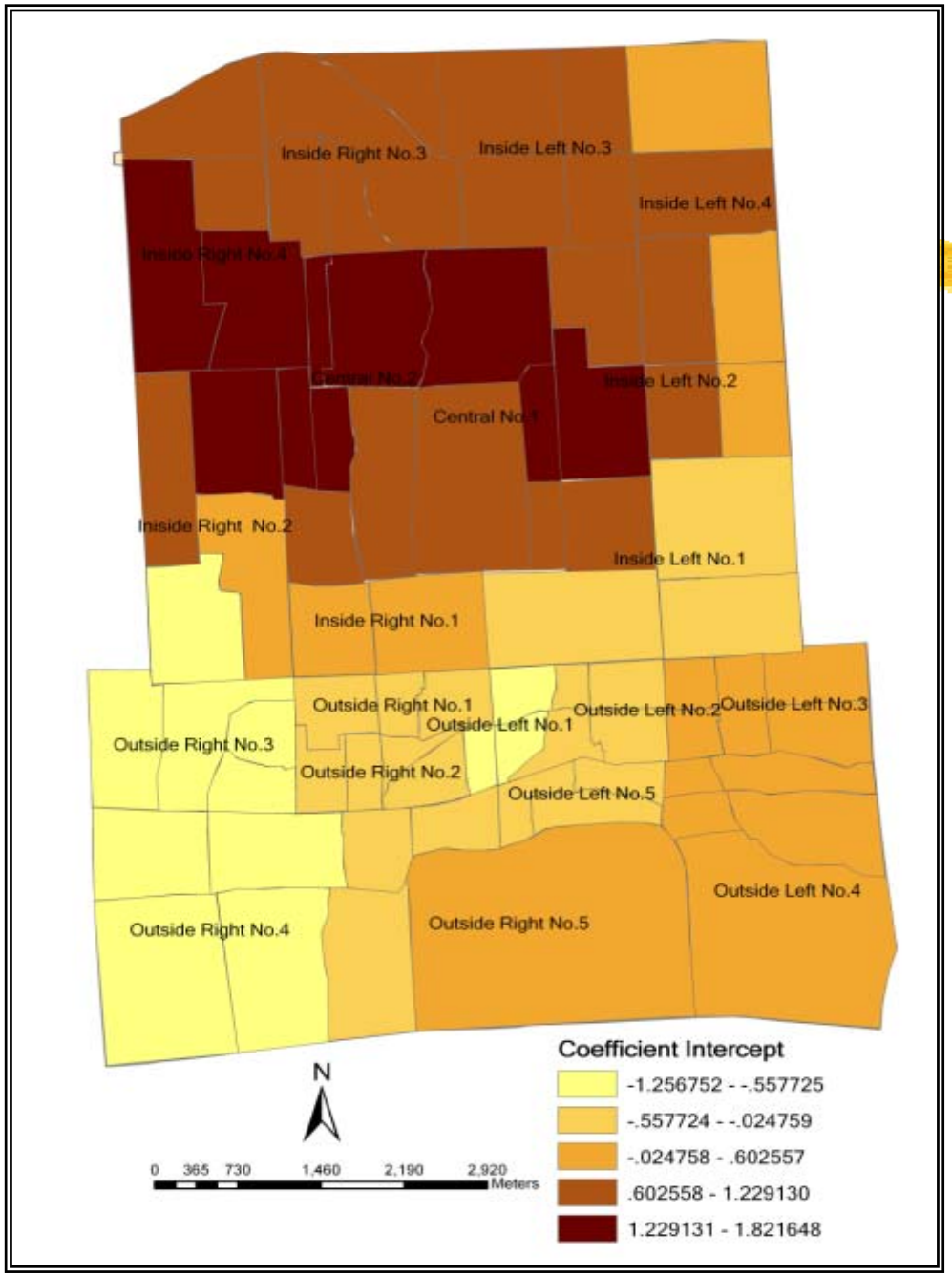
[Hot-spot analysis for western hospitals]

GWR analysis

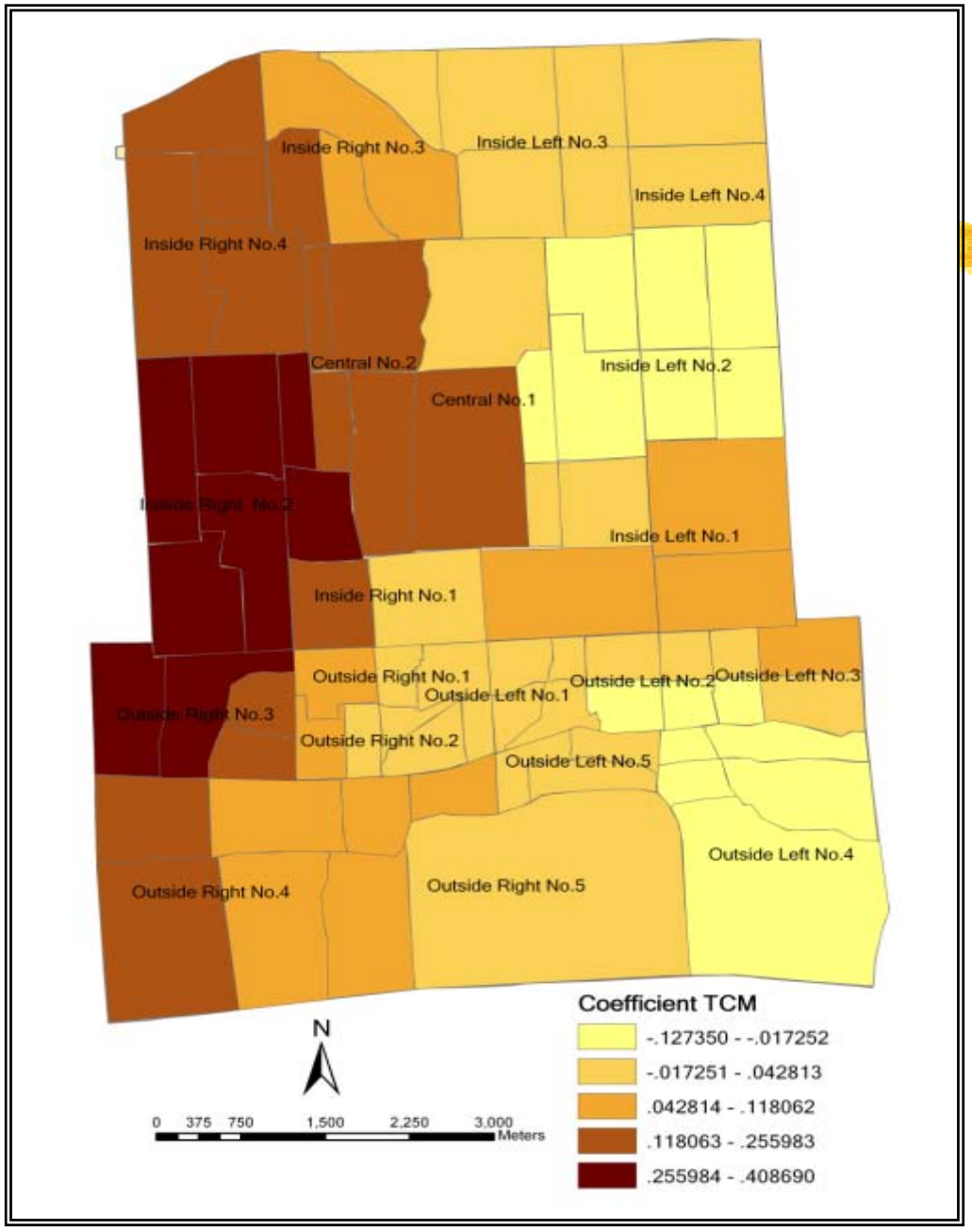
- Global regression (OLS)

Variable	Coef	StdError	t_Stat	Prob
Intercept	0.384186	0.389663	0.985945	0.327325
Industry-commerce	-0.00061	0.006631	-0.092025	0.926919
Temple	-0.046722	0.042488	-1.099646	0.275001
Population	0.000055	0.000028	1.97731	0.051682
TCM	0.128497	0.064381	1.995877	0.049578

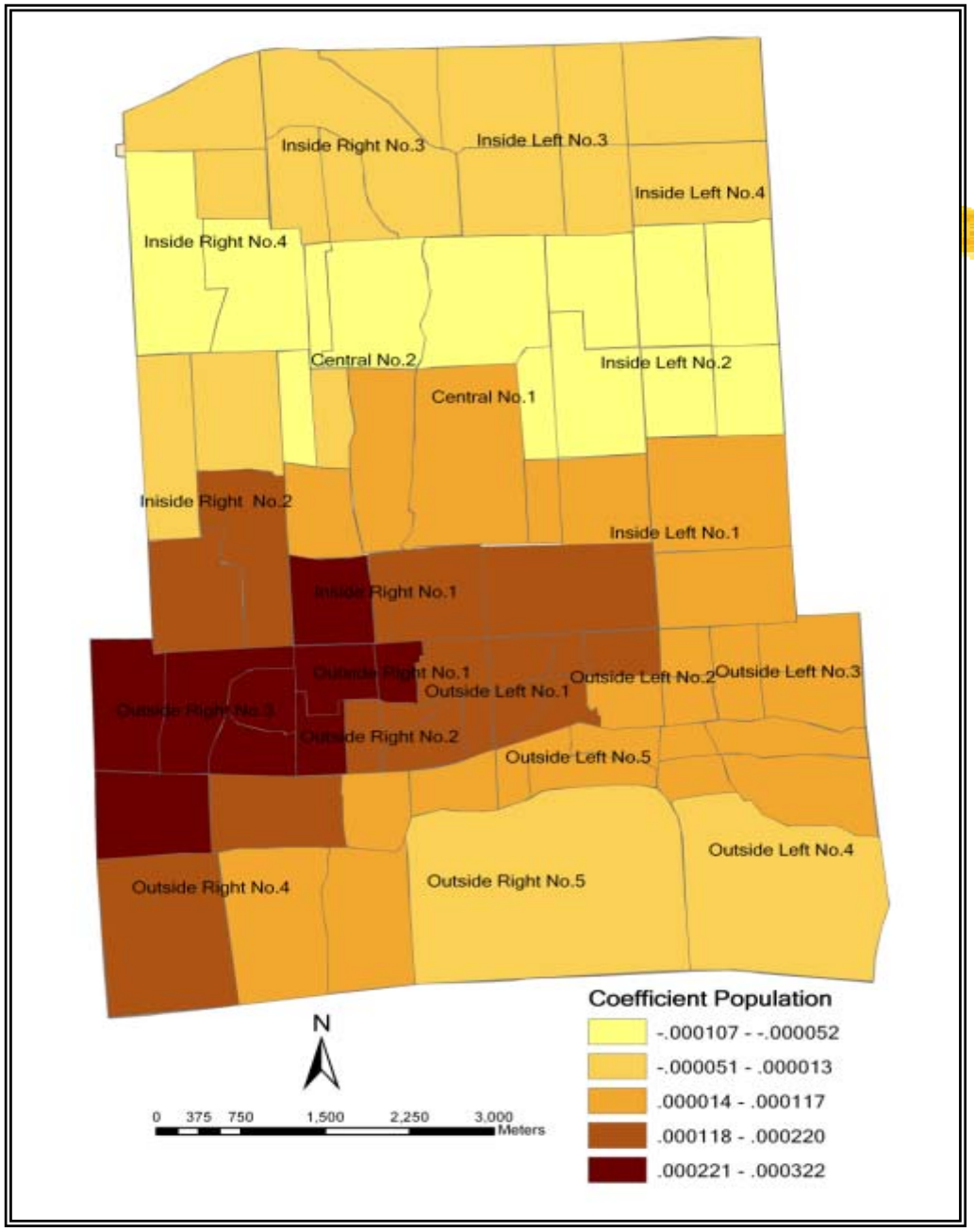
R2 for OLS is 10.66%; R2 for GWR is 67.23%



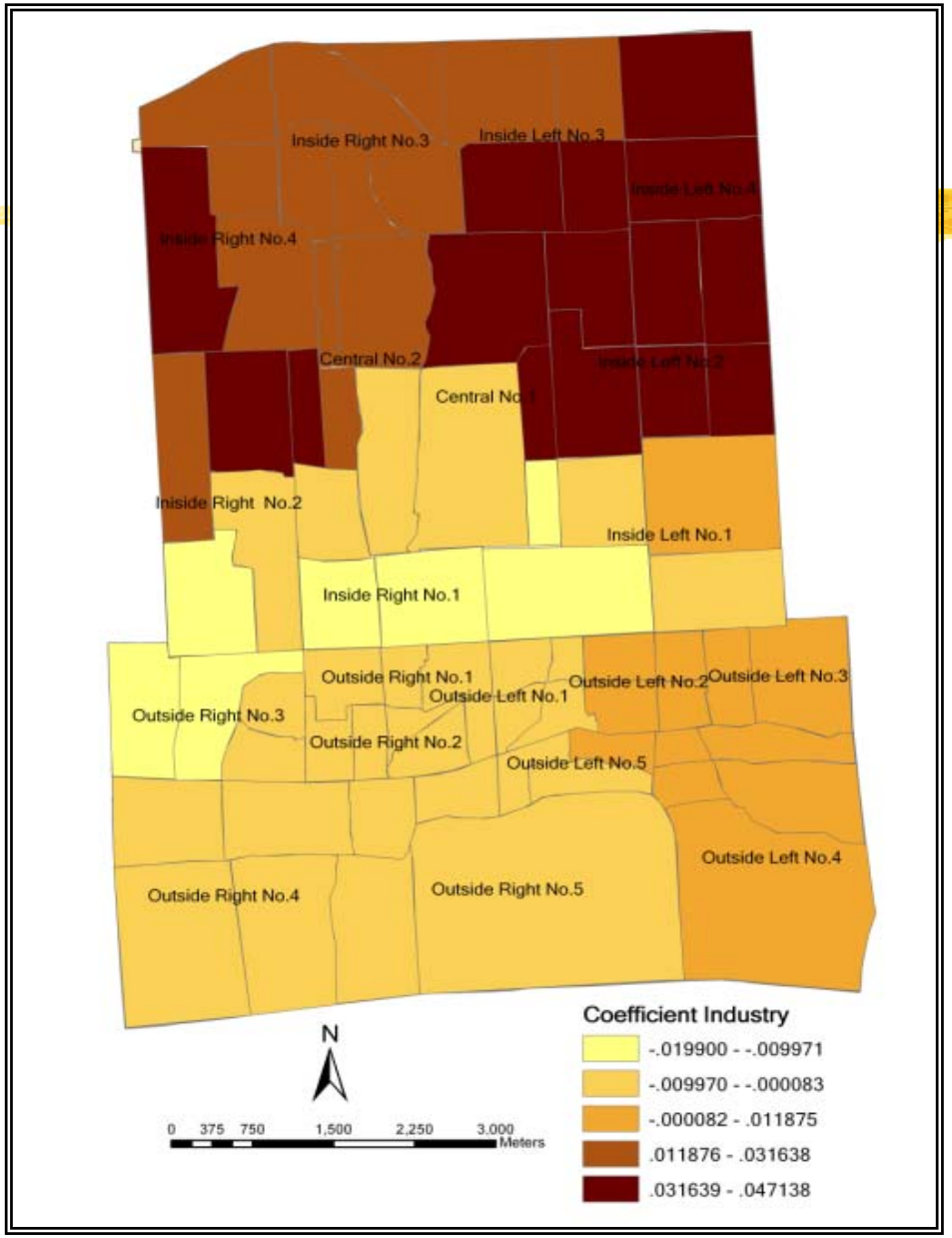
Spatial Distribution of the Intercept Parameter



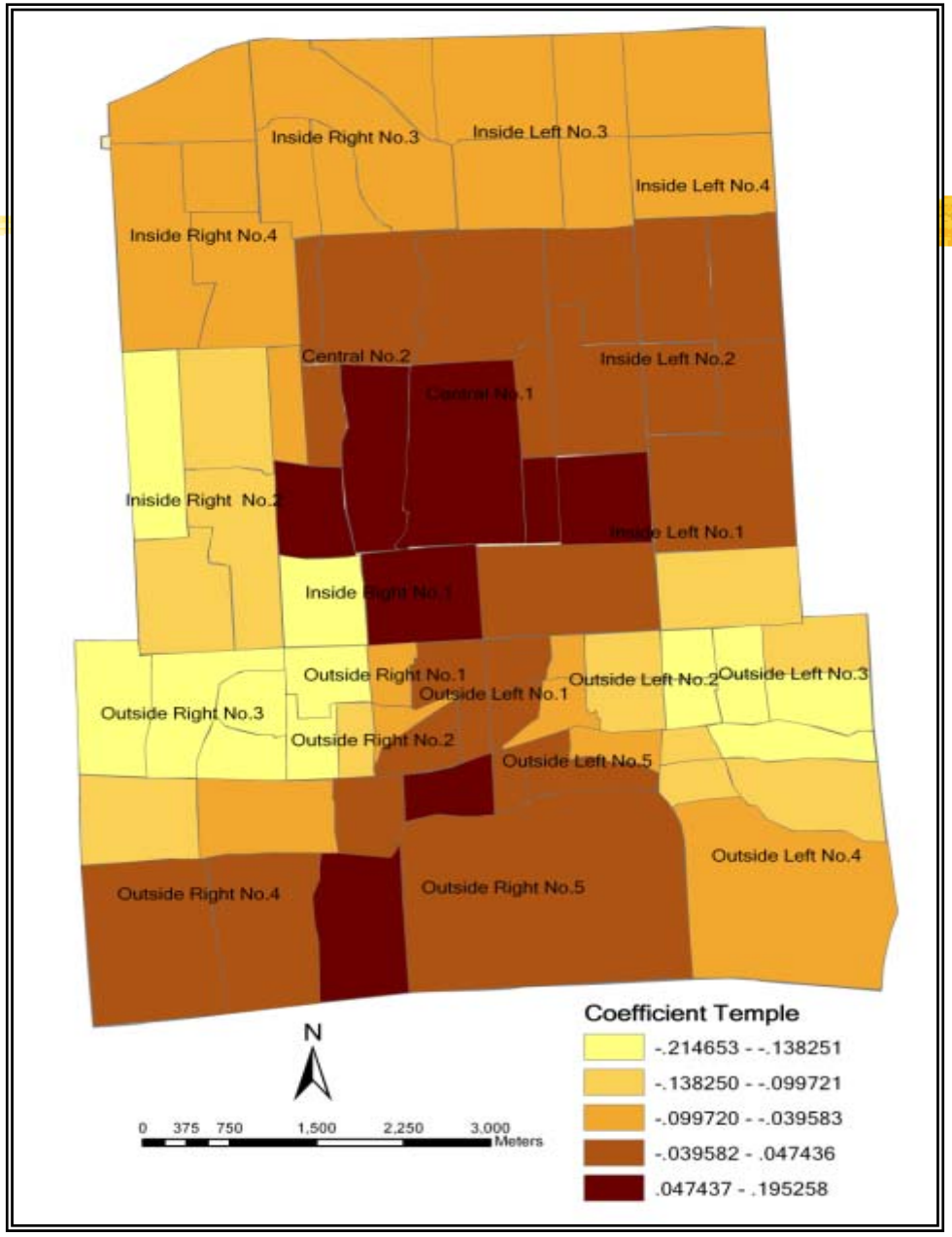
Spatial Distribution of the TCM Parameter



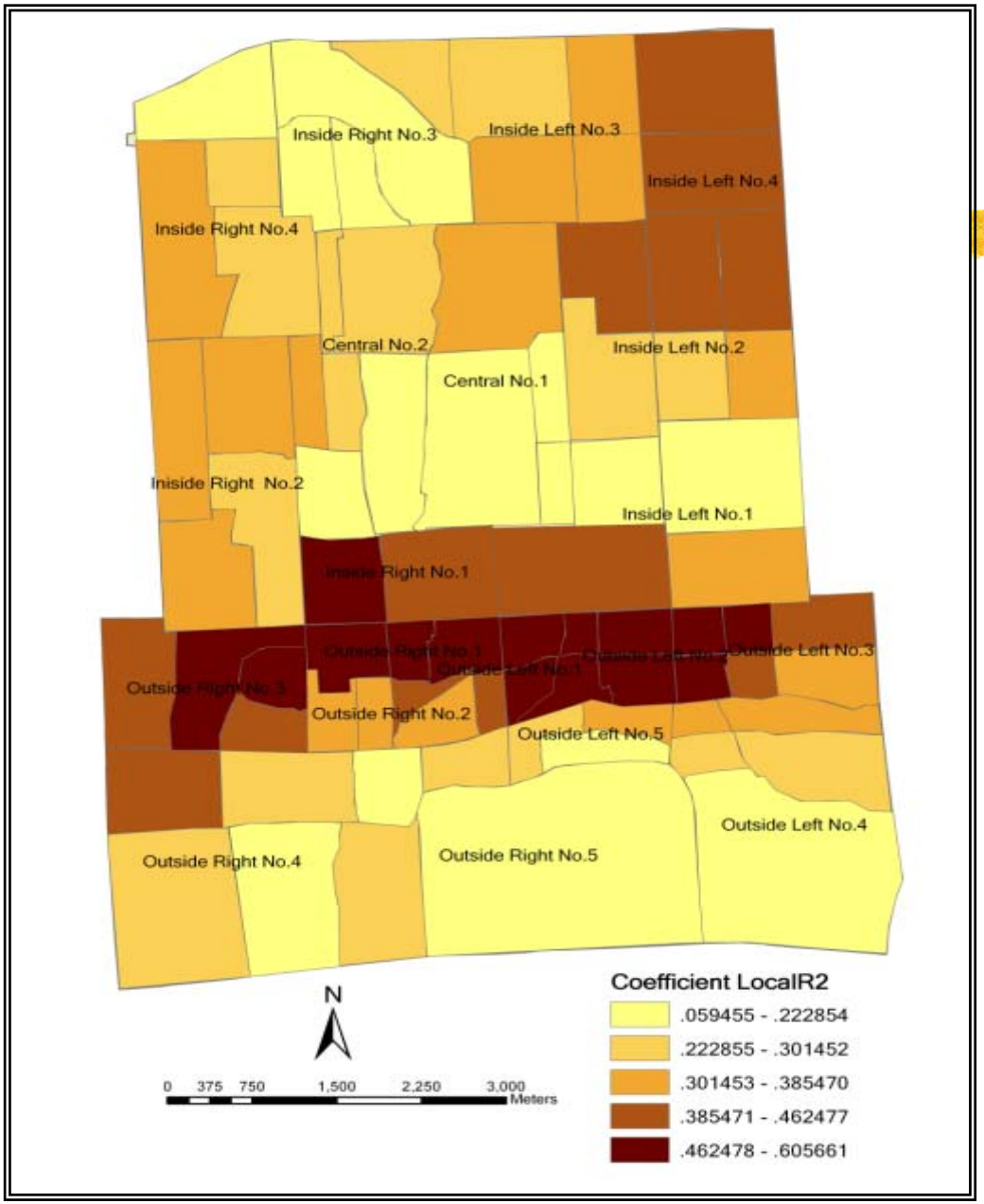
Spatial Distribution of the Population Parameter



Spatial distribution of the industry-commerce parameter

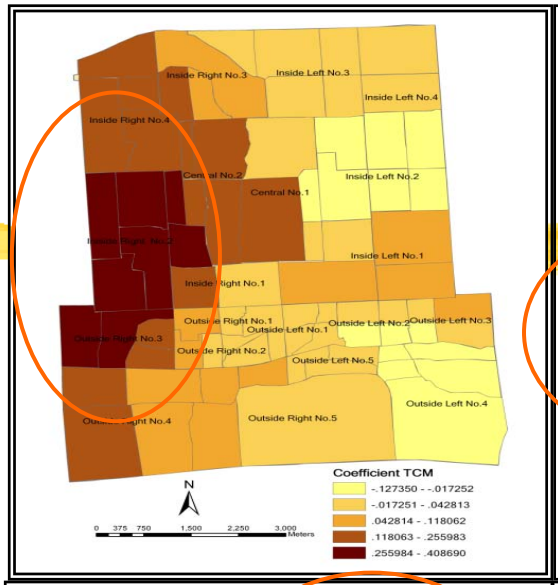


Spatial Distribution of the Temple Parameter

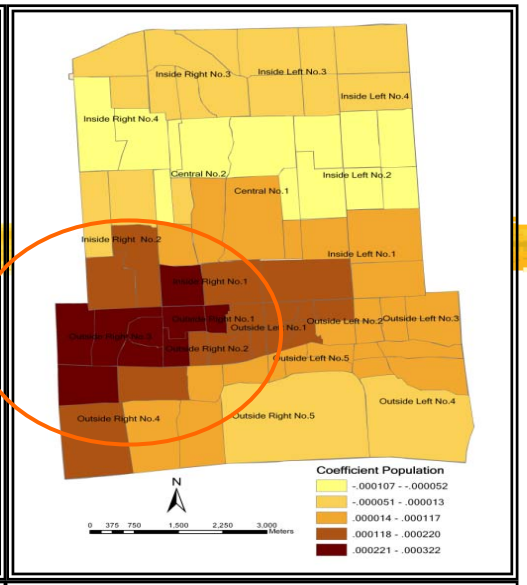


Spatial distribution of the R2 parameter

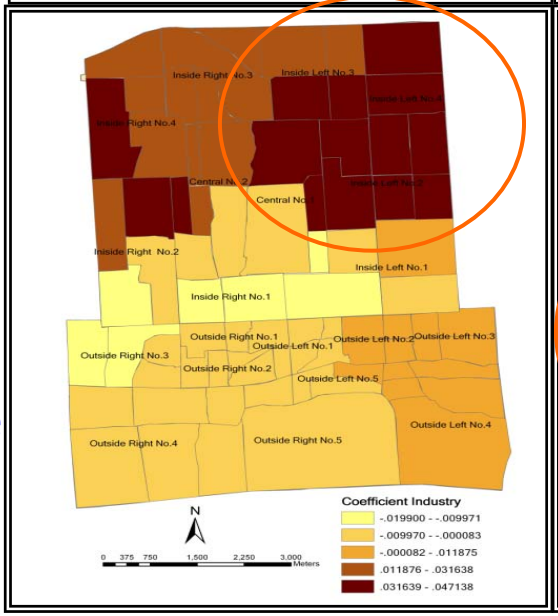
TCM



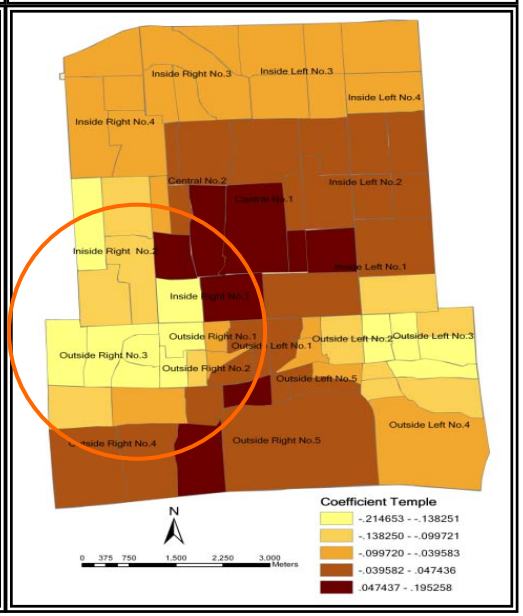
Population



Industry-commerce



Temple



A comparison of the spatial patterns of parameter estimates for TCM, population, industry-commerce and temple

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Conclusion

- In this study, spatial statistics, including hotspot analysis and GWR, were used to analyze the spatial patterns of Western medical services and its relationships with TCM, population, temple and industry-commerce patterns.
  - *There were significant hot-spots spreading from the west to the east in the North City and significant cold spots in the southern part of the South City.*
  - *There were more hospitals concentrated in the North City than in the South City.*

Conclusion

- *The North city had higher basic level of Western medical services than the South City if other variables are considered the same.*
- *TCM drug stores had greater statistical impact on the presence of Western hospitals in the Western areas than in the other areas.*
- *Population variable played a more important role affecting Western medical services in the central areas and poverty might have had a negative effect on its development.*
- *Industry-commerce had a greater effect on the presence of Western hospitals in the North City than in the South City.*
- *Temples had negative statistical impact on the presence of Western hospitals in most areas of Beijing city.*


Thank you!
Questions?
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