spgen:

Creating spatially lagged variables in Stata

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Outline

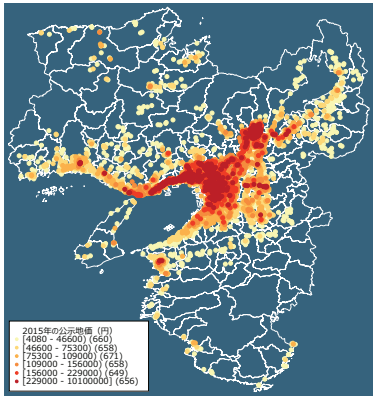
1. What is the spatial data?
2. How is the spgen command useful?
3. Application of the spgen command
4. Final remarks

Scan QR code to download this PDF file:

URL: https://keisukekondokk.github.io/software/doc/spgen_slide_stata_conference_2023.pdf

1. What is the spatial data?

- Spatial data is...(*)
  1. [data structures] Information about the locations and shapes of geographic features and the relationships between them, usually stored as coordinates and topology.
  2. [data models] Any data that can be mapped.
- Demand for spatial data analysis is continuously growing among Stata users (Sp commands from Stata 15, June 2017).

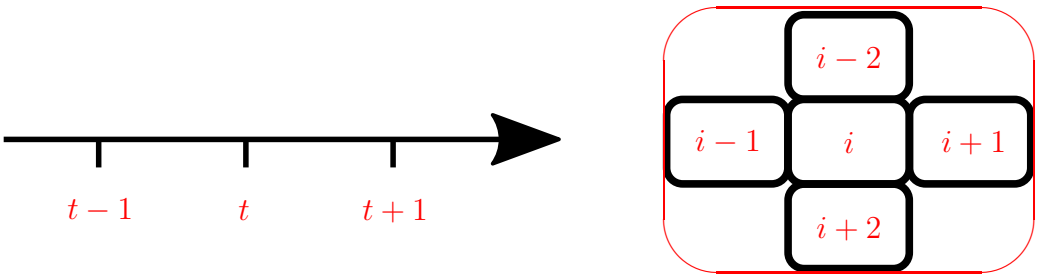


Note: Author's creation based on 2015 land price data in the Osaka metropolitan area (MLIT, Japan)

* ESRI, spatial data, GIS Dictionary, `https://support.esri.com/en-us/gis-dictionary/spatial-data` (accessed July 13, 2023)

1. What is the spatial data?

- What is the **spatial lag**?
- It captures **neighboring observations**.



(a) Time (b) Space

Fig: Lag in Time and Space

Source: Author's creation

2. How is the `spgen` command useful?

☞ Examples of research questions:

Spatial Econometrics

- How do the neighboring regions affect one another?

Infectious Disease Epidemiology

- Do densely populated regions have a higher risk of COVID-19 infection?

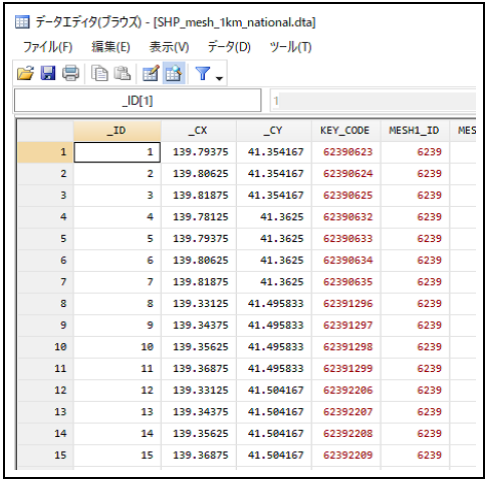
Economic and Marketing Analysis

- Does local market size affect stores' sales?
- How many potential customers are there around stores?
- How many rival stores are there around stores?

2. How is the spgen command useful?

How to use the spgen command

- Consider the dataset with location information (e.g., shape file).
- The spshape2dta command converts the shape files to the dta files.
- The variables _CX and _CY in this data correspond to the longitude and latitudes, respectively.


データエディタ(ブラウズ) - [SHP_mesh_1km_national.dta]

ファイル(F) 編集(E) 表示(V) データ(D) ツール(T)

_ID[1] 1

	_ID	_CX	_CY	KEY_CODE	MESH1_ID	MES
1	1	139.79375	41.354167	62390623	6239	
2	2	139.80625	41.354167	62390624	6239	
3	3	139.81875	41.354167	62390625	6239	
4	4	139.78125	41.3625	62390632	6239	
5	5	139.79375	41.3625	62390633	6239	
6	6	139.80625	41.3625	62390634	6239	
7	7	139.81875	41.3625	62390635	6239	
8	8	139.33125	41.495833	62391296	6239	
9	9	139.34375	41.495833	62391297	6239	
10	10	139.35625	41.495833	62391298	6239	
11	11	139.36875	41.495833	62391299	6239	
12	12	139.33125	41.504167	62392206	6239	
13	13	139.34375	41.504167	62392207	6239	
14	14	139.35625	41.504167	62392208	6239	
15	15	139.36875	41.504167	62392209	6239	

Source: Author's creation.

2. How is the spgen command useful?

spgen

```
spgen varlist, lat(varname) lon(varname) swm(swmtype) dist(#) dunit(km|mi)
```

- lat(varname): Latitude
- lon(varname): Longitude
- swm(swmtype): SWM type (Four types)
- dist(#): Dist. threshold
- dunit(km|mi): Dist. unit

```
      [optional settings]
```

☞ The spatial lag of varlist is stored in the dataset.

Note: See the manual for details: https://github.com/keisukekondokk/spgen

2. How is the `spgen` command useful?

```
. spgen x, lon(_CX) lat(_CY) swm(pow 1) dist(.) dunit(km)
```

power function: $d_{ij}^{-\delta}$

$$\boldsymbol{W}\boldsymbol{x} = \underbrace{\begin{pmatrix} 0 & w_{12} & \cdots & w_{1R} \\ w_{21} & 0 & \cdots & w_{2R} \\ \vdots & \vdots & \ddots & \vdots \\ w_{R1} & w_{R2} & \cdots & 0 \end{pmatrix}}_{\text{SWM(pow 1) dist(.)}} \underbrace{\begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_R \end{pmatrix}}_{\times} = \underbrace{\begin{pmatrix} \sum_{k=1}^{R} w_{1k}x_k \\ \sum_{k=1}^{R} w_{2k}x_k \\ \vdots \\ \sum_{k=1}^{R} w_{Rk}x_k \end{pmatrix}}_{\text{Output of spgen}}$$

☞ Row-standardized SWM returns the weighted average of neighbors.

Note: Spatial weight matrix $\boldsymbol{W}$ is often row-standardized (row-sum is equal to one) in the spatial econometrics. Market potential can be calculated with the `nostd` option (Harris, 1954).

2. How is the spgen command useful?

```
. spgen x, lon(_CX) lat(_CY) swm(bin) dist(30) dunit(km) nostd
```

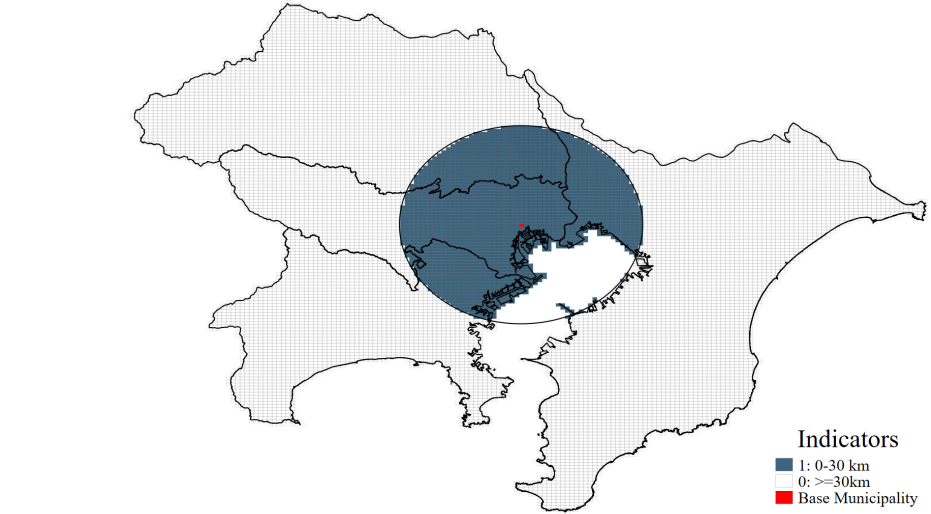
indicator function (threshold distance): $I(d_{ij} < d)$ — Row-standardization Off

$$\boldsymbol{W}\boldsymbol{x} = \underbrace{\begin{pmatrix} 0 & I(d_{ij}<30) & \cdots & I(d_{ij}<30) \\ I(d_{ij}<30) & 0 & \cdots & I(d_{ij}<30) \\ \vdots & \vdots & \ddots & \vdots \\ I(d_{ij}<30) & I(d_{ij}<30) & \cdots & 0 \end{pmatrix}}_{\text{SWM(bin) dist(30) nostd}} \underbrace{\begin{pmatrix} x_1 \\ x_2 \\ \vdots \\ x_R \end{pmatrix}}_{\times} = \underbrace{\begin{pmatrix} \sum_{k=1}^{R} I(d_{1k}<30)x_k \\ \sum_{k=1}^{R} I(d_{2k}<30)x_k \\ \vdots \\ \sum_{k=1}^{R} I(d_{Rk}<30)x_k \end{pmatrix}}_{\text{Output of spgen}}$$

☞ SWM with indicator function (row is not standardized) becomes local sum operator.

2. How is the `spgen` command useful?

☞ Indicator (1/0) of neighboring municipalities within 30 km



Source: Author's creation using geodist (Picard, 2010) and geocircles (Picard, 2015).

2. How is the `spgen` command useful?

☞ Quick comparison between the spgenerate and spgen commands

`spgenerate`

- Users need to prepare spatial weight matrix beforehand.
- It is infeasible for high dimensional spatial weight matrices. High-spec computer is necessary.

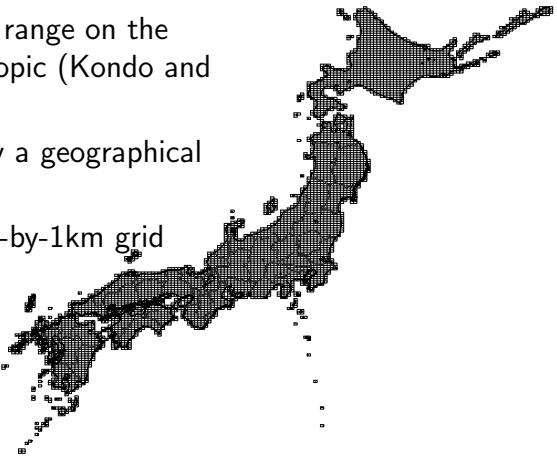
`spgen`

- Users do not need to prepare spatial weight matrices beforehand.
- It is feasible for high dimensional spatial weight matrices. It works on low-spec computers.

3. Application of the `spgen` command

Research Question: Retail Sales and Local Markets Range

- Retail sales are constrained by consumer mobility.
- Analyzing the effect of the local market range on the retail activity is an important research topic (Kondo and Okubo, 2020).
- This simple analysis attempts to identify a geographical range of local markets.
- High-dimensional mesh data at the 1km-by-1km grid level is used (391,451 obs.).

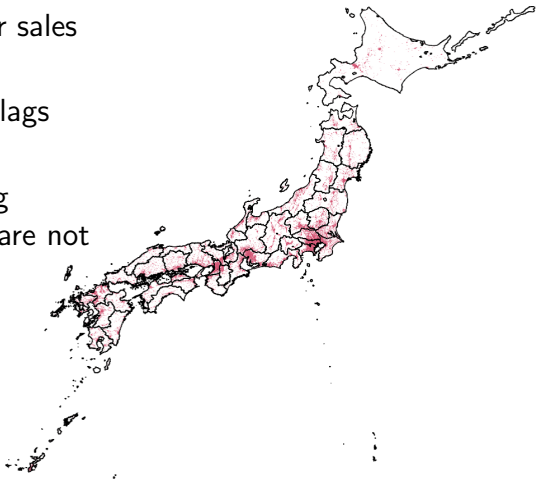


Source: Author's creation based on the shapefiles of mesh data obtained from the e-Stat (Statistical Bureau, MIC).

3. Application of the spgen command

Mesh Data: Sales per floor area

- The 38,334 of 391,451 grids are valid for sales per floor area.
- The `rowif()` option returns the spatial lags only for the selected observations.
- We can save calculation time by skipping observations with missing values, which are not used in the regression.

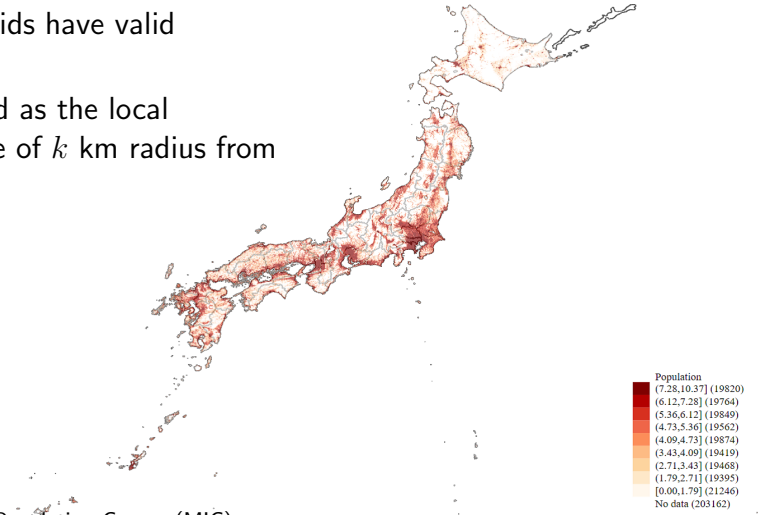


Source: Author's creation based on the 2014 Census of Commerce (METI). The red mesh grid indicates that the sales per floor area take valid values. The 35,936 mesh grids have anonymized data due to the small number of establishments in the corresponding mesh grids.

3. Application of the `spgen` command

Mesh Data: Population

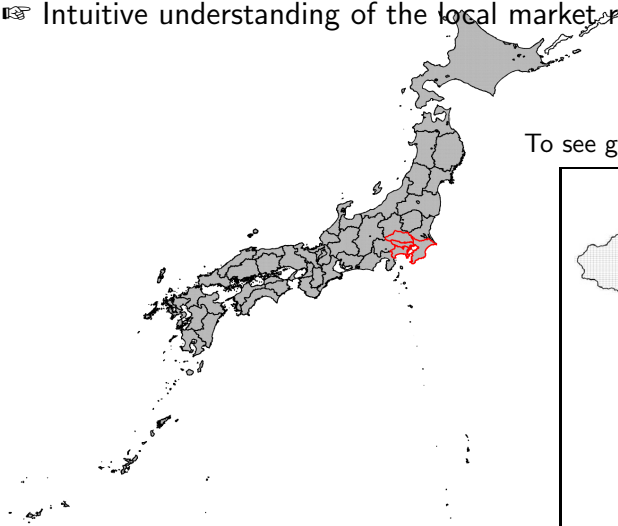
- The 178,397 of 391,451 grids have valid numbers.
- Local market size is defined as the local population within the circle of k km radius from each mesh grid.



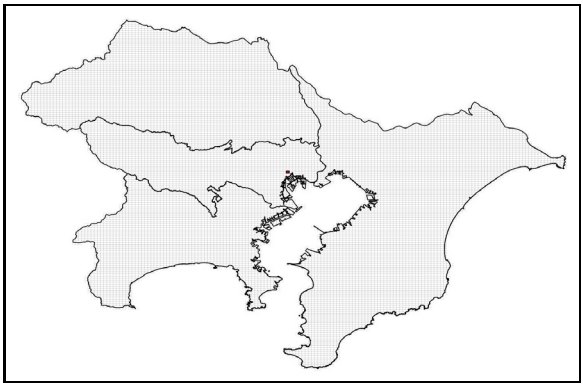
Source: Author's creation based on the 2015 Population Census (MIC).
The red mesh grid indicates the logarithm of population.

3. Application of the `spgen` command

☞ Intuitive understanding of the local market range



To see grid lines, we zoom in Tokyo metropolitan area.

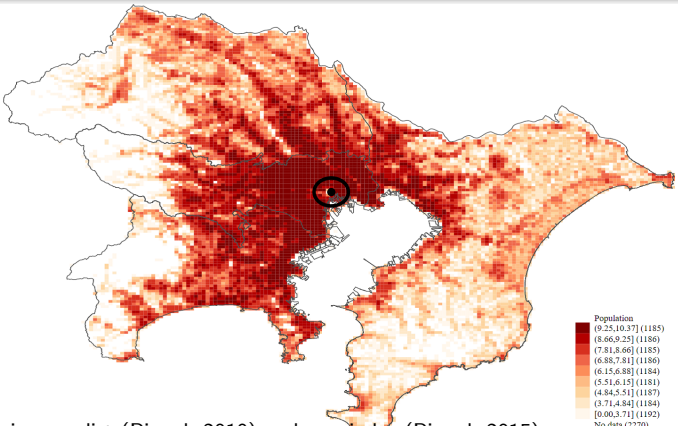


Source: Author's creation based on the shapefiles of mesh data obtained from the e-Stat (Statistical Bureau, MIC).

3. Application of the spgen command

☞ Local Market Range 0–5 km from each mesh grid

```
. gen rowif_sales_per_area = (sales_per_area > 0 & sales_per_area = .)
. spgen pop_total_all, lon(lon) lat(lat) swm(bin) nostd dist(5) dunit(km) rowif(rowif_sales_per_area)
largesize replace
```



Source: Author's creation using geodist (Picard, 2010) and geocircles (Picard, 2015).

3. Application of the spgen command

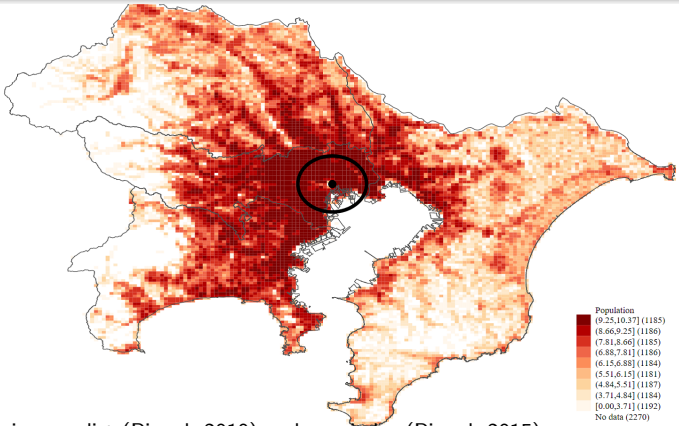
```
. spgen pop_total_all, ///
>   lon(lon) lat(lat) swm(bin) nostd dist(5) dunit(km) rowif(rowif_sales_per_area) largesize replace
. ROWIF option returns spatial lags for observations with rowif_sales_per_area = 1
. Size of spatial weight matrix:  38334 * 381559
. Calculating spatial lagged variable...
. -----------------
. |Completed:  10%|
. |Completed:  20%|
. |Completed:  30%|
. |Completed:  40%|
. |Completed:  50%|
. |Completed:  60%|
. |Completed:  70%|
. |Completed:  80%|
. |Completed:  90%|
. |Completed:  100%|
. -----------------
. splag1_pop_total_all_b was generated in the dataset.
```

Notes: 39.28 minutes (OS: Windows 10 Pro 64bit, CPU: Intel Xeon W-2133, Memory: 64GB)

3. Application of the spgen command

☞ Local Market Range 0–10 km from each mesh grid

```
. gen rowif_sales_per_area = (sales_per_area > 0 & sales_per_area = .)
. spgen pop_total_all, lon(lon) lat(lat) swm(bin) nostd dist(10) dunit(km)
rowif(rowif_sales_per_area) largesize replace
```

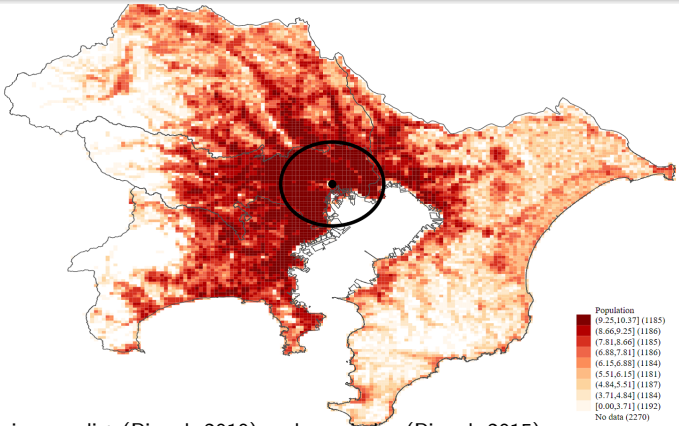


Source: Author's creation using geodist (Picard, 2010) and geocircles (Picard, 2015).

3. Application of the spgen command

☞ Local Market Range 0–15 km from each mesh grid

```
. gen rowif_sales_per_area = (sales_per_area > 0 & sales_per_area = .)
. spgen pop_total_all, lon(lon) lat(lat) swm(bin) nostd dist(15) dunit(km)
rowif(rowif_sales_per_area) largesize replace
```

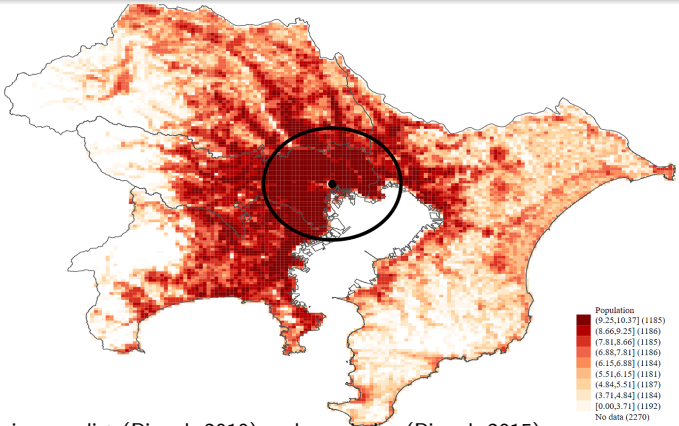


Source: Author's creation using geodist (Picard, 2010) and geocircles (Picard, 2015).

3. Application of the spgen command

☞ Local Market Range 0–20 km from each mesh grid

```
. gen rowif_sales_per_area = (sales_per_area > 0 & sales_per_area = .)
. spgen pop_total_all, lon(lon) lat(lat) swm(bin) nostd dist(20) dunit(km)
rowif(rowif_sales_per_area) largesize replace
```

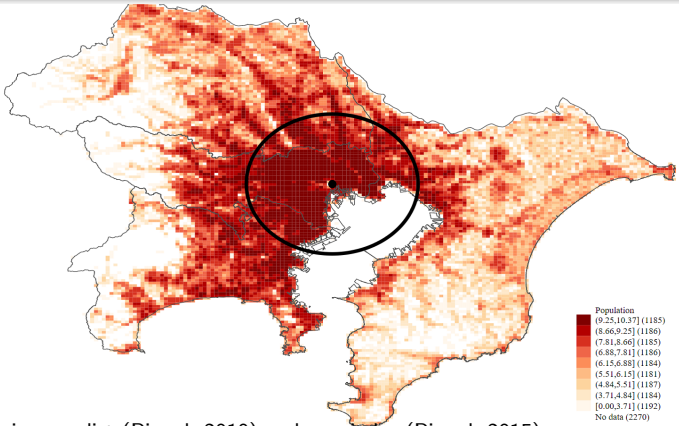


Source: Author's creation using geodist (Picard, 2010) and geocircles (Picard, 2015).

3. Application of the spgen command

☞ Local Market Range 0–25 km from each mesh grid

```
. gen rowif_sales_per_area = (sales_per_area > 0 & sales_per_area = .)
. spgen pop_total_all, lon(lon) lat(lat) swm(bin) nostd dist(25) dunit(km)
rowif(rowif_sales_per_area) largesize replace
```

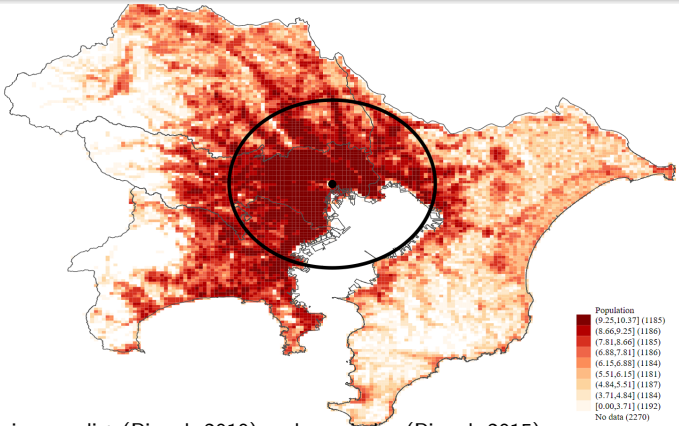


Source: Author's creation using geodist (Picard, 2010) and geocircles (Picard, 2015).

3. Application of the spgen command

☞ Local Market Range 0–30 km from each mesh grid

```
. gen rowif_sales_per_area = (sales_per_area > 0 & sales_per_area = .)
. spgen pop_total_all, lon(lon) lat(lat) swm(bin) nostd dist(30) dunit(km)
rowif(rowif_sales_per_area) largesize replace
```



Source: Author's creation using geodist (Picard, 2010) and geocircles (Picard, 2015).

3. Application of the spgen command

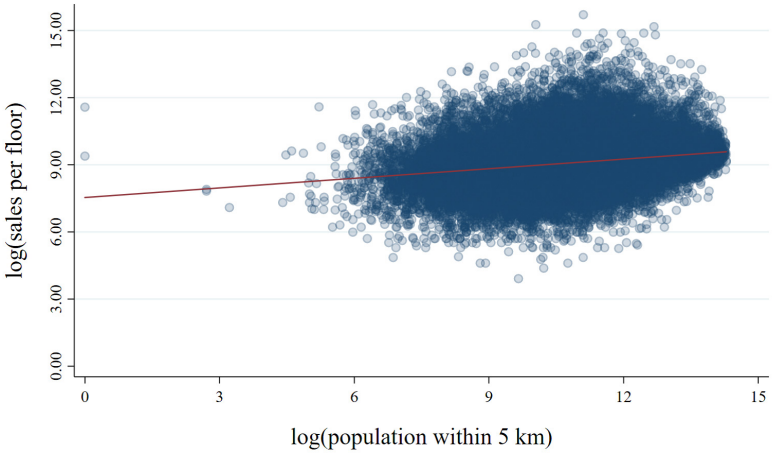


Fig: Scatter plot of sales per floor area and local market size within a 5 km circle

Source: Author's creation based on the 2014 Census of Commerce (METI) and the 2015 Population Census (MIC).

3. Application of the spgen command

$$\log(\text{SalesPerFloor}_i) = \beta_{0\text{-}k\text{km}} \log(\text{LocalPopulation}_{i,0\text{-}k\text{km}}) + \text{Controls}_i + u_i$$

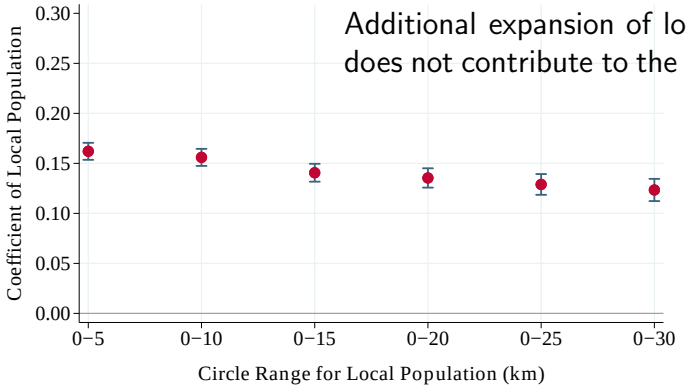


Fig: Coefficient Plot of Local Population

Source: Author's creation. Controls include prefecture dummies.

4. Final Remarks

- Beyond the conventional spatial econometrics, the `spgen` command helps researchers who conduct a spatial analysis using geocoded microdata and high-dimensional mesh data (big data).

`spgenerate`

- Spatial econometrics

`spgen`

- Spatial econometrics
- Geocoded microdata + Geospatial data (big data)

- A future challenge is parallel computing for speeding up the calculation.

Thank you for listening.

Any comments and suggestions would be greatly appreciated.

To install the spgen command, type:

```
ssc install spgen
```

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https://keisukekondokk.github.io/

References

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