Spatial econometrics: mapping, geodemographics and multilevel analysis

Rich Harris,
University of Bristol

CMPO

The Future of Mapping

- Live in an information age
- Web 2.0
  - Information disseminated further, faster
- So called neo-geography
  - The age of the 'enthusastic amateur'

Maps are useful

- But only if you can make sense of them
- And only if what you think you are seeing is not imagined or due to error
- Maps can reveal spatial processes

A robust future for mapping

- Where sciences complements technology
- Where analysis is more than description
  - inference and explanation

Case Study

- Geodemographics
  - Links geography to data to make sense of both
- Prevalence of geodemographic maps
  - on line for decision makers and others
  - Structured method for making sense of information
- Statistical framework for the analyses?

Sample of 10 000, some read The Guardian

Making sense of the map

		p	index
7B1	Afro-Caribbean Communities (1)	0.128	377
2B2	Settled in the City (2)	0.115	339
7B2	Afro-Caribbean Communities (2)	0.096	282
…			
5A1	Senior Communities (1)	0.009	26
1B1	Younger Blue Collar (1)	0.008	24
1C1	Older Blue Collar (1)	0.007	20

Sounds impressive?

	p	index
7B1	0.128	377
2B2	0.115	339

- Statistical evidence?
- Difference between the means
  - What is n?

Multilevel modelling (MLwiN)

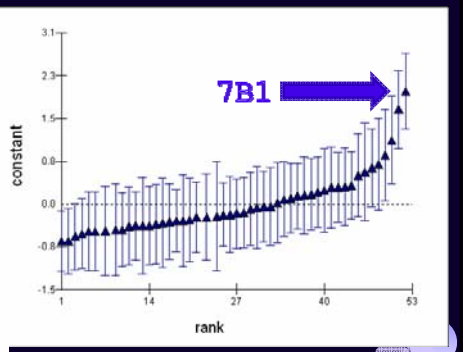
$NEWS11_{ij} \sim \text{Binomial}(denom_{ij}, \pi_{ij})$

$\text{logit}(\pi_{ij}) = \beta_{0j}\text{constant}$

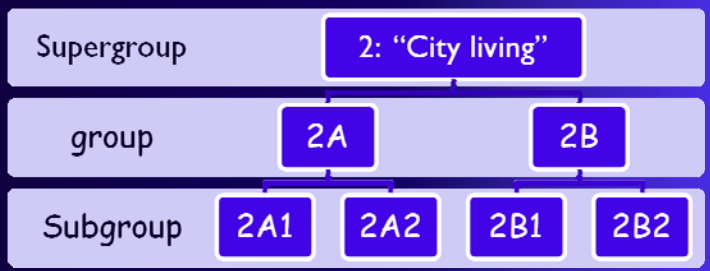
$\beta_{0j} = -3.312(0.107) + u_{0j}$

$\begin{bmatrix} u_{0j} \end{bmatrix} \sim N(0, \Omega_u) \; : \; \Omega_u = \begin{bmatrix} 0.428(0.116) \end{bmatrix}$

$\text{var}(NEWS11_{ij}|\pi_{ij}) = \pi_{ij}(1 - \pi_{ij})/denom_{ij}$

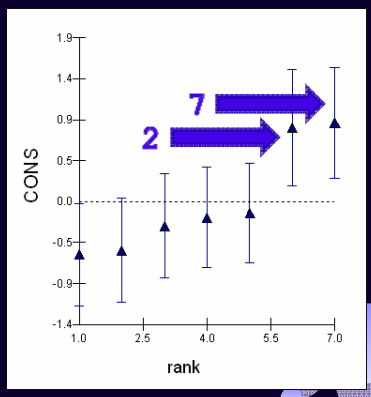


Which scale?



Model the hierarchy

$$NEWS11_{ijkl} \sim \text{Binomial}(denom_{ijkl}, \pi_{ijkl})$$
$$\text{logit}(\pi_{ijkl}) = \beta_{0jkl}\text{CONS}$$
$$\beta_{0jkl} = -3.162(0.260) + f_{0l} + v_{0kl} + u_{0jkl}$$
$$[f_{0l}] \sim N(0, \Omega_f) : \Omega_f = [0.435(0.254)]$$
$$[v_{0kl}] \sim N(0, \Omega_v) : \Omega_v = [0.026(0.044)]$$
$$[u_{0jkl}] \sim N(0, \Omega_u) : \Omega_u = [0.051(0.047)]$$
$$\text{var}(NEWS11_{ijkl}|\pi_{ijkl}) = \pi_{ijkl}(1 - \pi_{ijkl})/denom_{ijkl}$$



Explanation

Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	-4.2473	0.2004	-21.191	< 2e-16	***
MARRYD1	-0.9565	0.1498	-6.385	1.71e-10	***
OWNRNT1	0.5350	0.1834	2.917	0.003531	**
ROCC07	0.3853	0.1652	2.332	0.019688	*
ROCC10	1.4835	0.2196	6.754	1.43e-11	***
NEWSDEL9	0.6541	0.1296	5.048	4.45e-07	***
MARRYD3	-0.8562	0.2317	-3.696	0.000219	***
MARRYD4	-0.9455	0.2975	-3.179	0.001479	**
MARRYD5	-0.5772	0.1939	-2.978	0.002905	**
OWNRNT2	0.8692	0.2076	4.187	2.83e-05	***
INCOME04	0.7397	0.1897	3.900	9.61e-05	***
INCOME05	0.5854	0.2147	2.727	0.006390	**
INCOME06	1.2498	0.1949	6.413	1.42e-10	***
INCOME07	0.7426	0.2722	2.728	0.006364	**
INCOME08	1.0737	0.2903	3.698	0.000217	***
INCOME09	1.7320	0.2584	6.703	2.05e-11	***
INCOME10	1.7392	0.3362	5.173	2.30e-07	***
INCOME11	1.5826	0.2409	6.568	5.09e-11	***

Standardised residuals

Geography of the residuals

		Mean
7	Multicultural	-0.051
2	City Living	-0.094
…		
1	Blue Collar Communities	-0.160
6	Typical Traits	-0.162

- But…
- Effects of spatial patterning on the standard errors?

$$NEWS11_{ijkl} \sim \text{Binomial}(denom_{ijkl}, \pi_{ijkl})$$

$$\text{logit}(\pi_{ijkl}) = \beta_{0jkl}CONS + -0.841(0.149)MARRYD1_{ijkl} + 0.484(0.182)OWNRNT1_{ijkl} + 0.359(0.163)ROCC07_{ijkl} + 1.355(0.227)ROCC10_{ijkl} + 0.611(0.125)NEWSDEL9_{ijkl} + -0.782(0.226)MARRYD3_{ijkl} + -0.844(0.283)MARRYD4_{ijkl} + -0.512(0.193)MARRYD5_{ijkl} + 0.691(0.211)OWNRNT2_{ijkl} + 0.735(0.183)INCOME04_{ijkl} + 0.571(0.207)INCOME05_{ijkl} + 1.216(0.189)INCOME06_{ijkl} + 0.703(0.267)INCOME07_{ijkl} + 1.029(0.282)INCOME08_{ijkl} + 1.639(0.256)INCOME09_{ijkl} + 1.702(0.328)INCOME10_{ijkl} + 1.484(0.240)INCOME11_{ijkl}$$

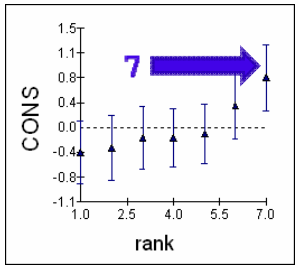
$$\beta_{0jkl} = -4.126(0.262) + f_{0l} + v_{0kl} + u_{0jkl}$$

$$\left[f_{0l}\right] \sim N(0, \Omega_f) : \Omega_f = \left[0.197(0.127)\right]$$

$$\left[v_{0kl}\right] \sim N(0, \Omega_v) : \Omega_v = \left[0.026(0.045)\right]$$

$$\left[u_{0jkl}\right] \sim N(0, \Omega_u) : \Omega_u = \left[0.035(0.049)\right]$$

$$\text{var}(NEWS11_{ijkl}|\pi_{ijkl}) = \pi_{ijkl}(1 - \pi_{ijkl})/denom_{ijkl}$$

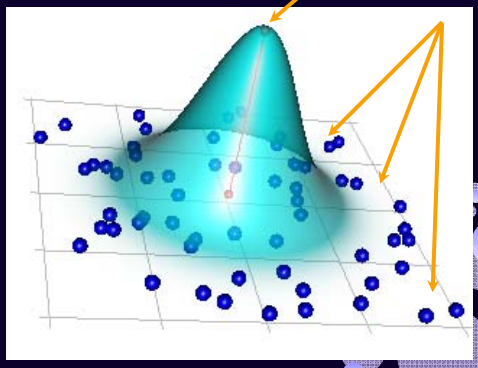


More geography!

- Are the effects of the predictor variables (the Xs) the same everywhere on Y?
- Geographically Weighted Regression (GWR)

GWR

- What is it?
  - Extension of regression model
  - Allows model to vary over space
- How it works...
- Resource Intensive
  - grid technologies



Spatial variation in regression parameters

Summary of GWR coefficient estimates:

	Min.	1st Qu.	Median	3rd Qu.	Max.	Global
X.Intercept.	0.01950	0.02024	0.02053	0.02096	0.02193	0.0205
MARRYD1	-0.03511	-0.03484	-0.03424	-0.03323	-0.03306	-0.0340
OWNRNT1	0.01061	0.01108	0.01295	0.01423	0.01453	0.0129
ROCC07	0.02178	0.02284	0.02347	0.02501	0.02617	0.0239
ROCC10	0.09680	0.10040	0.10670	0.11180	0.11450	0.1041
NEWSDEL9	0.01657	0.01713	0.01775	0.01915	0.01947	0.0184
MARRYD3	-0.03222	-0.03071	-0.02898	-0.02849	-0.02778	-0.0310
MARRYD4	-0.02975	-0.02937	-0.02837	-0.02708	-0.02690	-0.0283
MARRYD5	-0.02265	-0.02229	-0.02097	-0.02024	-0.01991	-0.0212
OWNRNT2	0.02763	0.02870	0.03096	0.03371	0.03438	0.0303
INCOME04	0.01823	0.01929	0.02206	0.02309	0.02504	0.0206
INCOME05	0.01191	0.01288	0.01606	0.01771	0.01814	0.0143
INCOME06	0.04068	0.04247	0.04662	0.04870	0.04941	0.0436
INCOME07	0.02004	0.02108	0.02228	0.02447	0.02576	0.0205
INCOME08	0.02923	0.03001	0.03230	0.03440	0.03477	0.0320
INCOME09	0.07595	0.08267	0.08894	0.09259	0.09646	0.0809
INCOME10	0.07901	0.08236	0.08654	0.08967	0.09481	0.0810
INCOME11	0.06419	0.06488	0.06573	0.06606	0.06708	0.0666

Income £15k to <£20k

$$NEWS11_{ijkl} \sim \text{Binomial}(denom_{ijkl}, \pi_{ijkl})$$

$$\begin{aligned}\text{logit}(\pi_{ijkl}) = {} & \beta_{0jkl}CONS + \text{-0.839(0.150)}MARRYD1_{ijkl} + \text{0.489(0.182)}OWNRNT1_{ijkl} + \\ & \text{0.360(0.163)}ROCC07_{ijkl} + \text{1.383(0.227)}ROCC10_{ijkl} + \text{0.613(0.125)}NEWSDEL9_{ijkl} + \\ & \text{-0.776(0.226)}MARRYD3_{ijkl} + \text{-0.838(0.283)}MARRYD4_{ijkl} + \text{-0.509(0.194)}MARRYD5_{ijkl} + \\ & \text{0.694(0.212)}OWNRNT2_{ijkl} + \beta_{10l}INCOME04_{ijkl} + \text{0.569(0.208)}INCOME05_{ijkl} + \\ & \text{1.219(0.190)}INCOME06_{ijkl} + \text{0.704(0.267)}INCOME07_{ijkl} + \text{1.034(0.283)}INCOME08_{ijkl} + \\ & \text{1.645(0.257)}INCOME09_{ijkl} + \text{1.704(0.329)}INCOME10_{ijkl} + \text{1.491(0.240)}INCOME11_{ijkl}\end{aligned}$$

$$\beta_{0jkl} = \text{-4.143(0.255)} + f_{0l} + v_{0kl} + u_{0jkl}$$

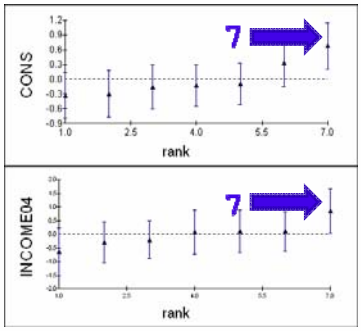
$$\beta_{10l} = \text{0.756(0.291)} + f_{10l}$$

$$\begin{bmatrix} f_{0l} \\ f_{10l} \end{bmatrix} \sim N(0, \Omega_f) \; : \; \Omega_f = \begin{bmatrix} \text{0.169(0.114)} & \\ \text{0.064(0.129)} & \text{0.340(0.289)} \end{bmatrix}$$

$$\begin{bmatrix} v_{0kl} \end{bmatrix} \sim N(0, \Omega_v) \; : \; \Omega_v = \begin{bmatrix} \text{0.028(0.045)} \end{bmatrix}$$

$$\begin{bmatrix} u_{0jkl} \end{bmatrix} \sim N(0, \Omega_u) \; : \; \Omega_u = \begin{bmatrix} \text{0.032(0.048)} \end{bmatrix}$$

$$\text{var}(NEWS11_{ijkl} | \pi_{ijkl}) = \pi_{ijkl}(1 - \pi_{ijkl})/denom_{ijkl}$$



The future of mapping

- Displaying information geographically
- Analysing information geographically, too
- Information for credible decision making
- Potential for geodemographics linked to "spatial econometrics"

Further information

- OAC, geodemographic classification
  - www.areaclassification.org.uk
- Multilevel modelling
  - www.cmm.bristol.ac.uk
- GWR
  - http://ncg.nuim.ie/ncg/GWR/
- Spatial econometrics
  - http://spatialeconometrics.altervista.org