Applications of microsimulation in human geography

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- What is microsimulation?
- Advantages and disadvantages
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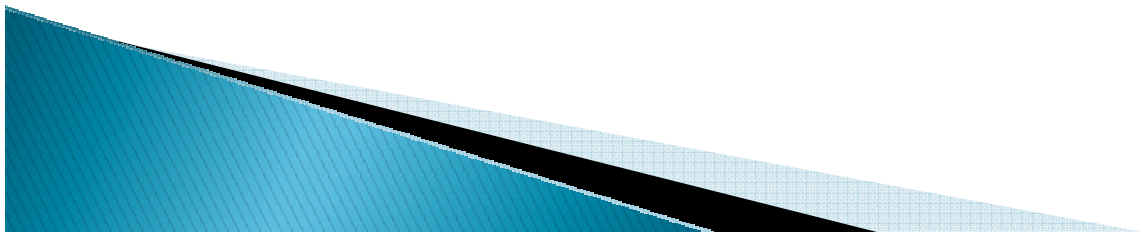
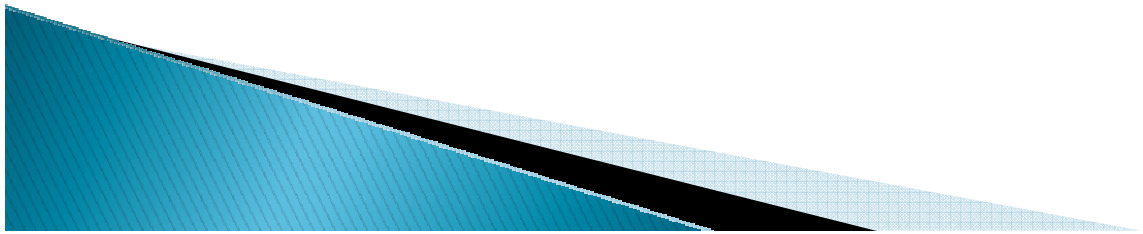
- Examples: service analysis and planning (health and retail)
- Theoretical development



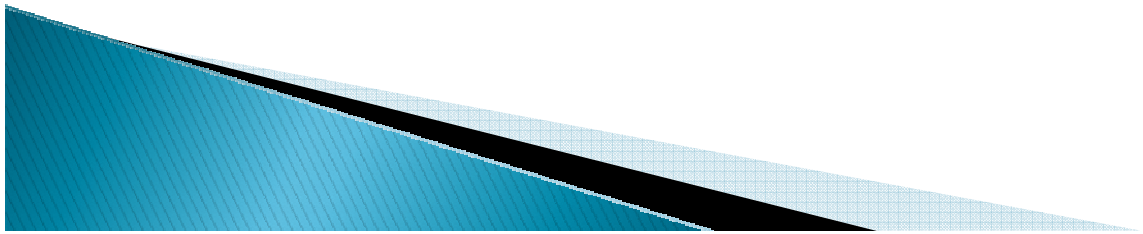
What is microsimulation?

- A technique aiming at building large scale spatial data sets
- Estimate ‘missing data’
- Forecast and update
- Link to other models



Spatial microsimulation methodologies

- Probabilistic synthetic reconstruction techniques (IPF-based approaches): geography strong, interdependencies weak
- Combinatorial optimisation methods (hill-climbing, simulated annealing, genetic algorithms): interdependencies strong; geography weaker! - Clone surveys in effect

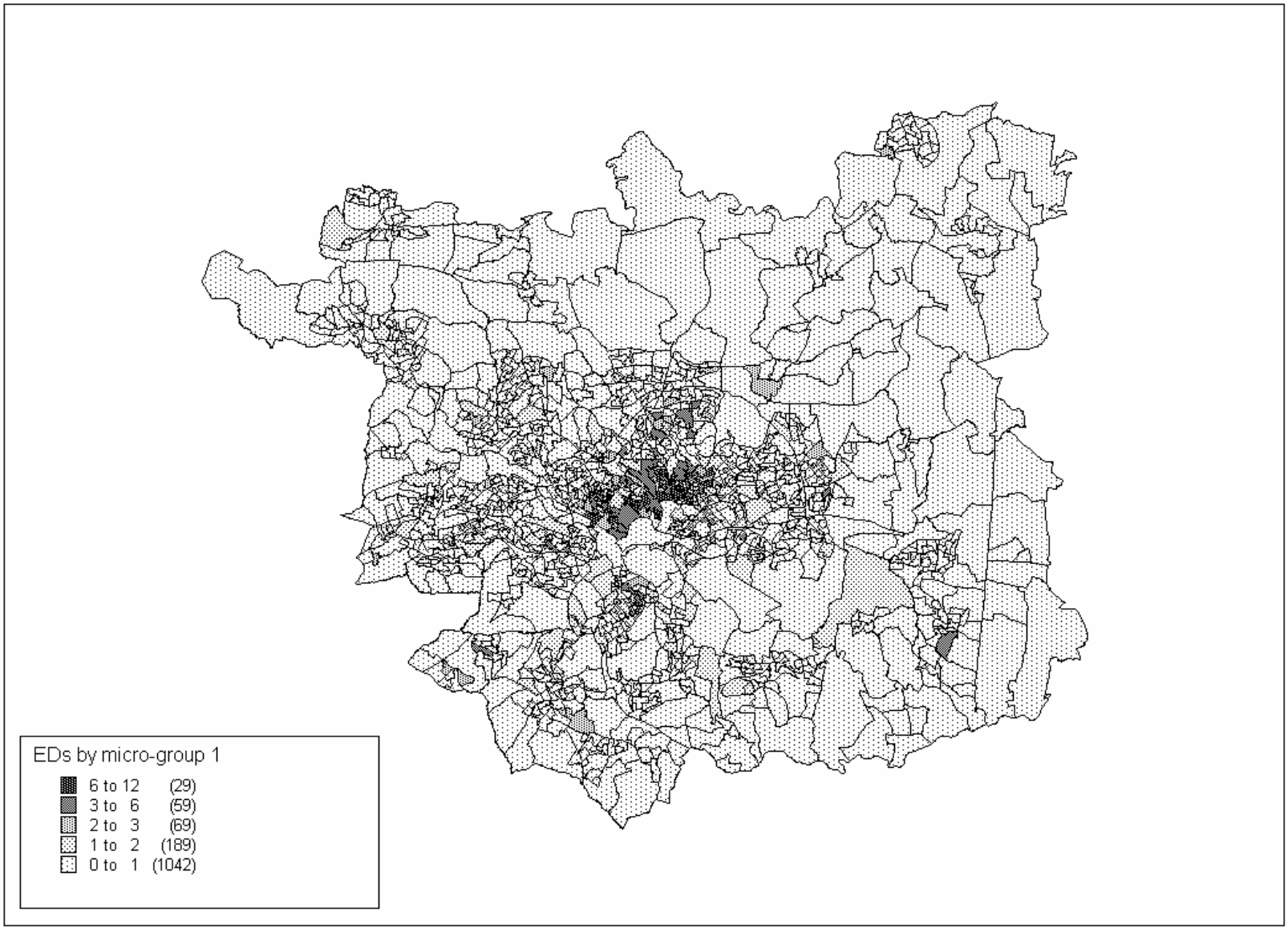


Ie. SimLeeds: outputs

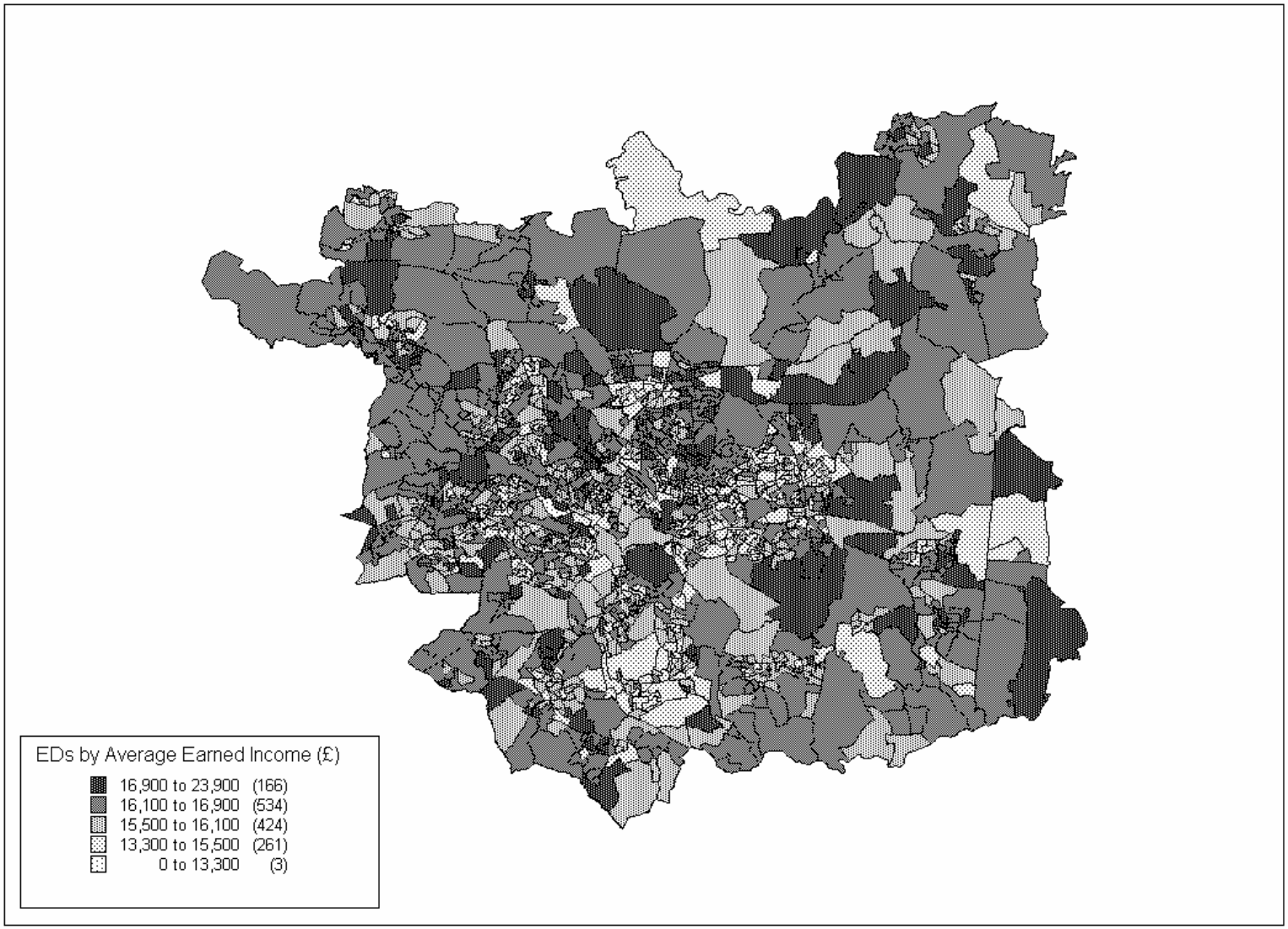
Micro-unit attributes
Location (place of residence) at the ED level.
Location (workplace) at the ward level
Age
Sex
Marital Status
Tenure
Employment Status
Industry (SIC)
Socio-economic group

Earned Income
Income from transfer payments
Wealth
Taxation

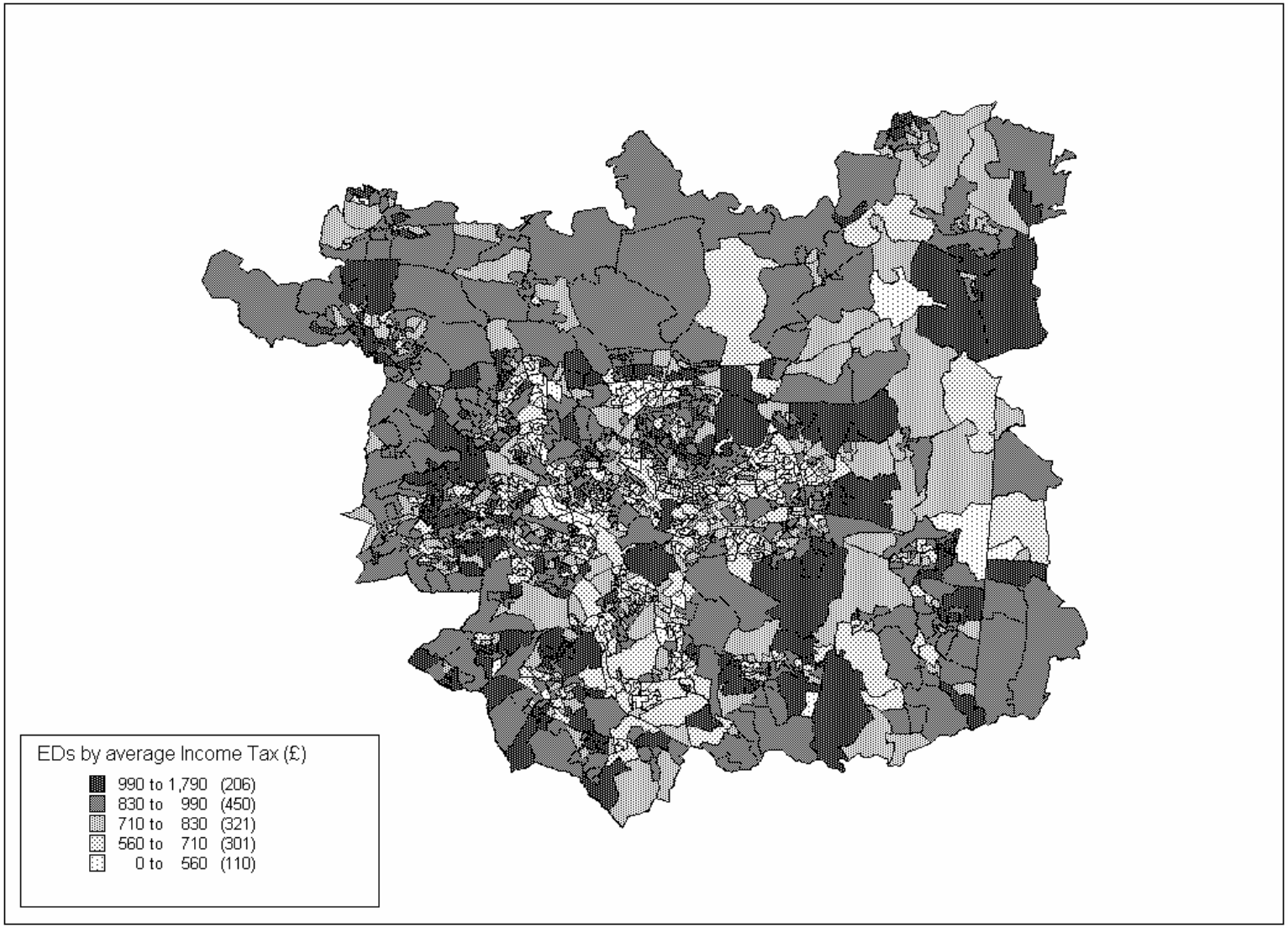
Local Firms
Local Shops
Schools
Health Centres
Leisure



Estimated spatial distribution of black males, aged between 16-29 and living in rented accommodation



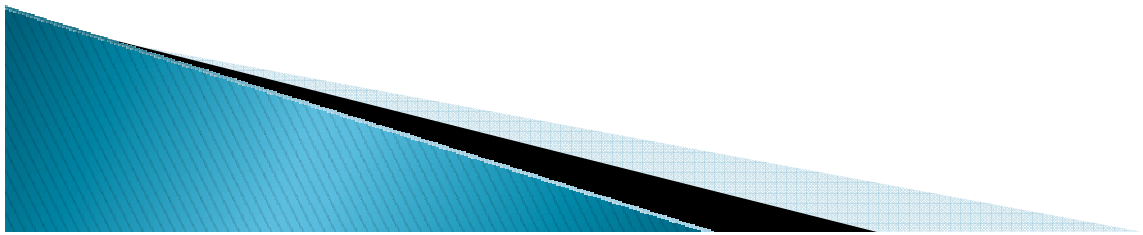
Estimated spatial distribution of average earned income in Leeds.



Estimated spatial distribution of average income tax in Leeds.

Advantages of microsimulation

- Use richness of survey data spatially
- Data linkage
- Spatial flexibility
- Ability to update and forecast



Pensioner couple

Richard Wilson and Annette Crosbie in One Foot in the Grave

Victor and Margaret Meldrew would not believe the chancellor's latest concession to drivers of green cars. Having already splashed out on an eco-friendly city car to earn the reduced rate of VED, Victor now finds that his old Vauxhall Nova would have qualified after all.

With the 10p starting rate of income tax being extended to savings from April 1999, the couple will be able to reclaim some tax and will be heartened by the £150 a year increase in pensioners' winter fuel payments and the VAT cut on energy-saving materials.

They will benefit from the uprating of the pensioners' tax allowance to £5,790 and, looking ahead,will enjoy a £3 per week increase in state pension. Finally, their children can look forward to a bigger inheritance following the increase in IHT threshold to £234,000.

Gross income £ (per person)	Pre Budget net	Post Budget net	Win /(lose)
4,000	8,000	8,000	0
8,000	15,671	15,681	10
12,000	22,014	22,120	106
15,000	26,634	26,800	166
20,000	33,675	33,863	188
25,000	41,125	41,413	288
30,000	48,781	49,094	313

SimBritain classifications: social policy analysis

- Very poor (below 50% median income)
- Poor (50–25% median)
- Below-average (25–0%)
- Above average (0–25%)
- Affluent (>25%)
- Model includes earned income and benefits of all kinds

Results of no-change scenario

- Increase no of households, esp. single
- Decline in unemployment, inc. in unskilled jobs
- Decline in ill-health; but increase in elderly with disability
- Increase in adults with no qualifics/low skills (social polarisation)
- Increase in loneliness
- So increase in ‘very poor’

Policy changes: recent changes

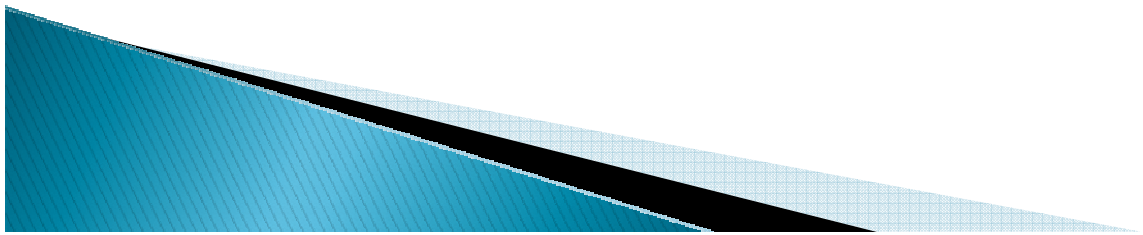
- Working family tax credit (WFTC)
- Minimum wage
- Minimum income guarantee
- Winter fuel payments/free TV license for elderly

Impacts of policy changes

- Very poor – income up 17.9% 1991, 21.7% by 2021
- Poor – income up 7.14% 1991, 6.9% by 2021
- Greatest impact on families with children
- (246 families enjoy 50% increase in income)
- 3720 households change from v.poor–poor

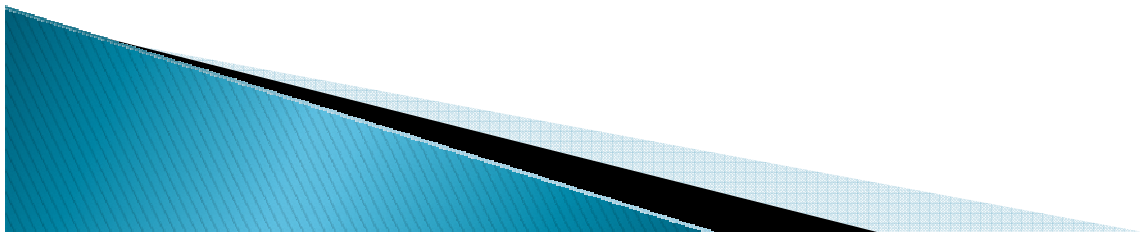
Area-based policy

- Impacts of major investments/divestments
- Common in regional science: input-output models
- Use Sim-Leeds to model the impacts of major factory closure
- Also CAP changes in Ireland

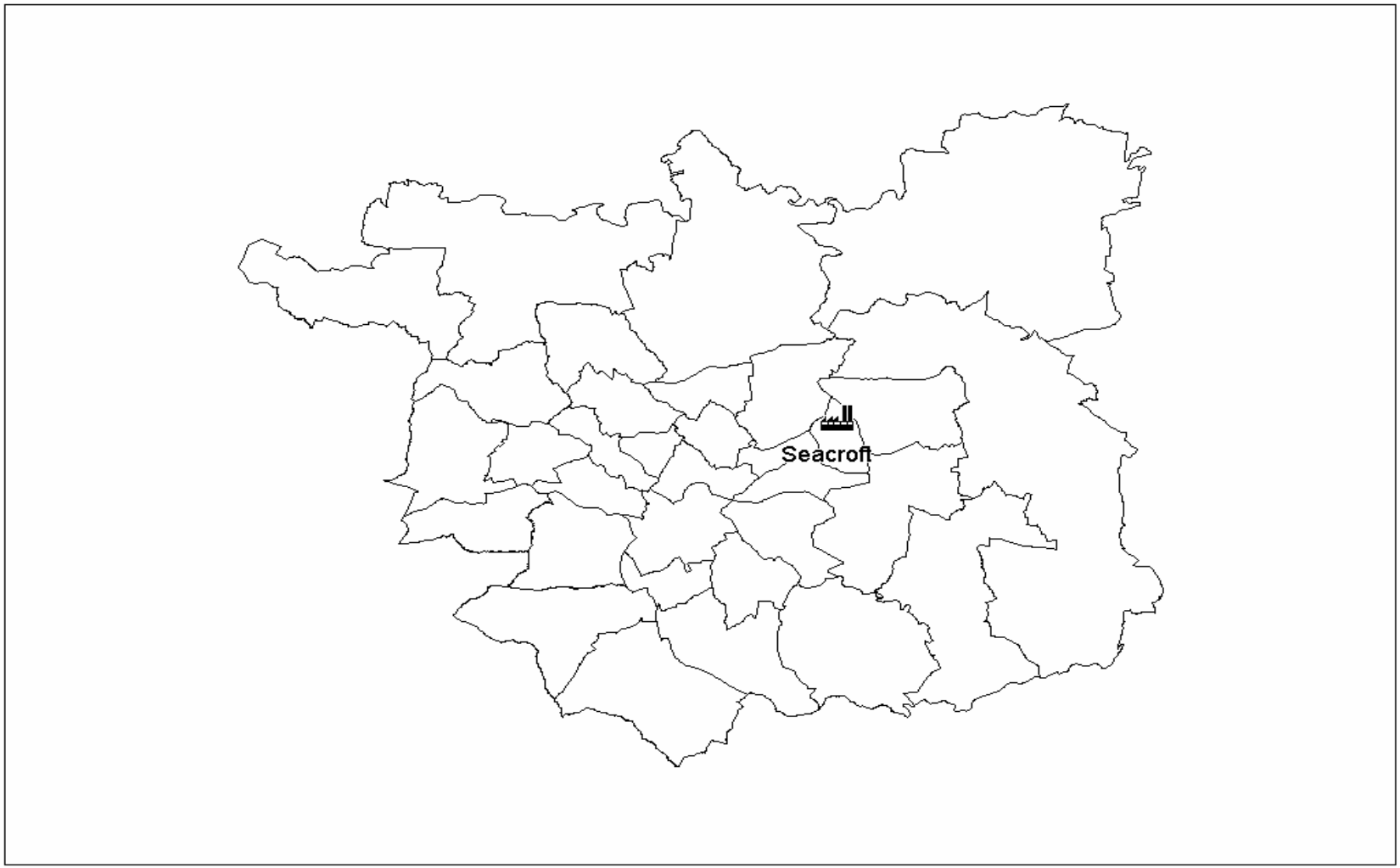


Input – Output models

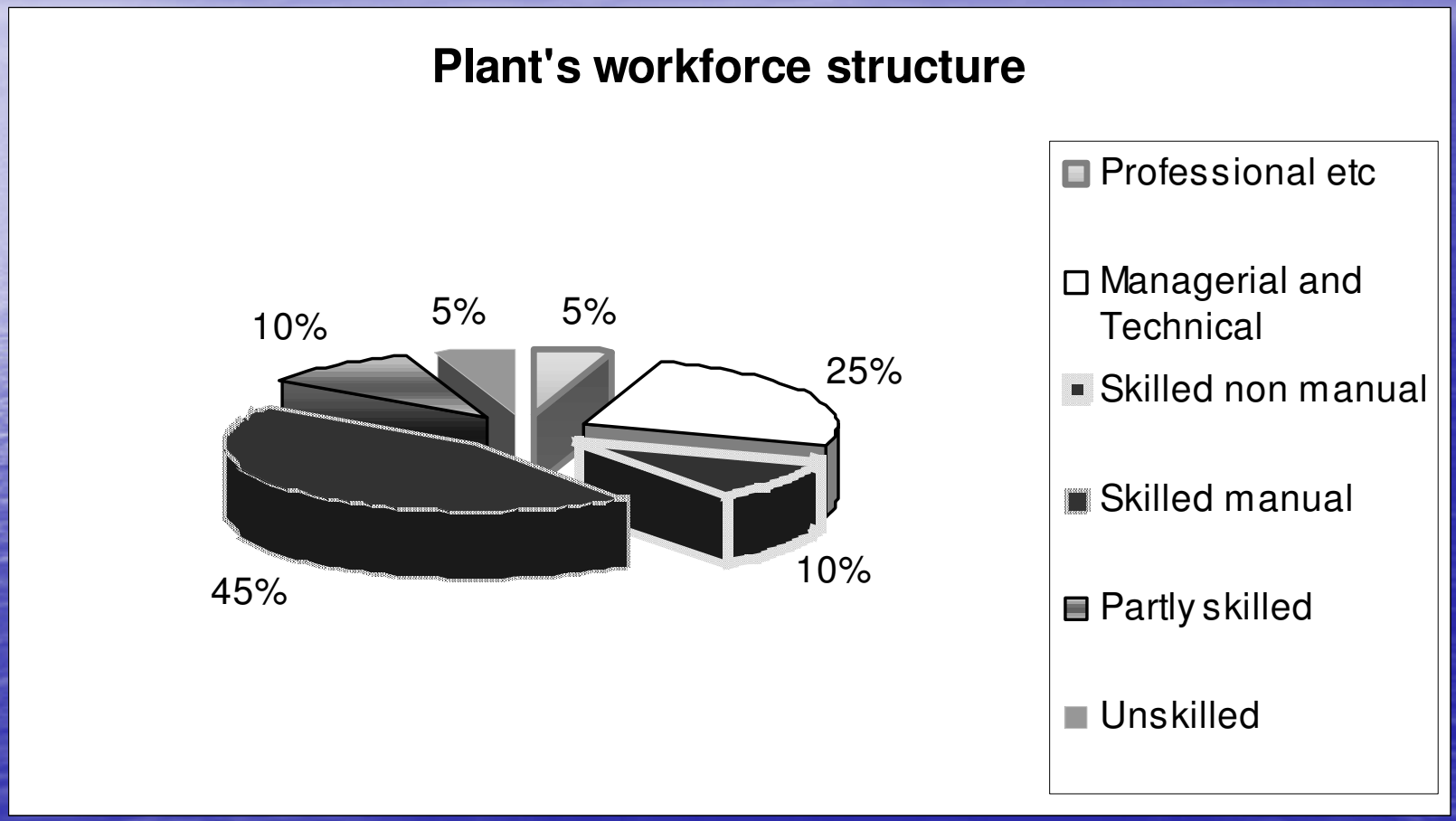
- Long successful history
- Spatial scale – Regional/ at best city wide (e.g. Batey and Madden, 2000)
- Multiplier effects rarely disaggregated locally
- New research agenda



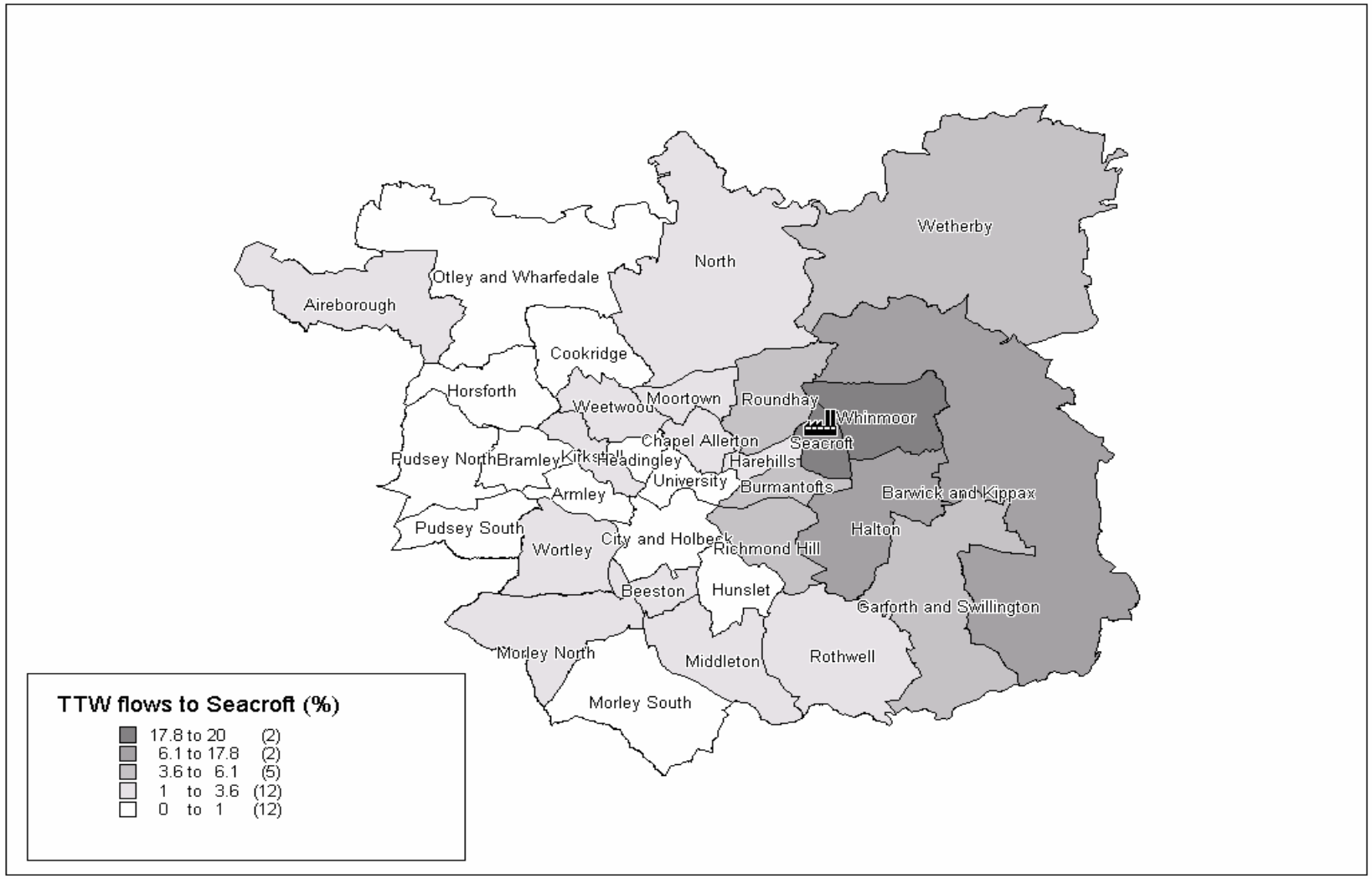
Using *SimLeeds* for impact assessment
- modelling a plant closure in Leeds



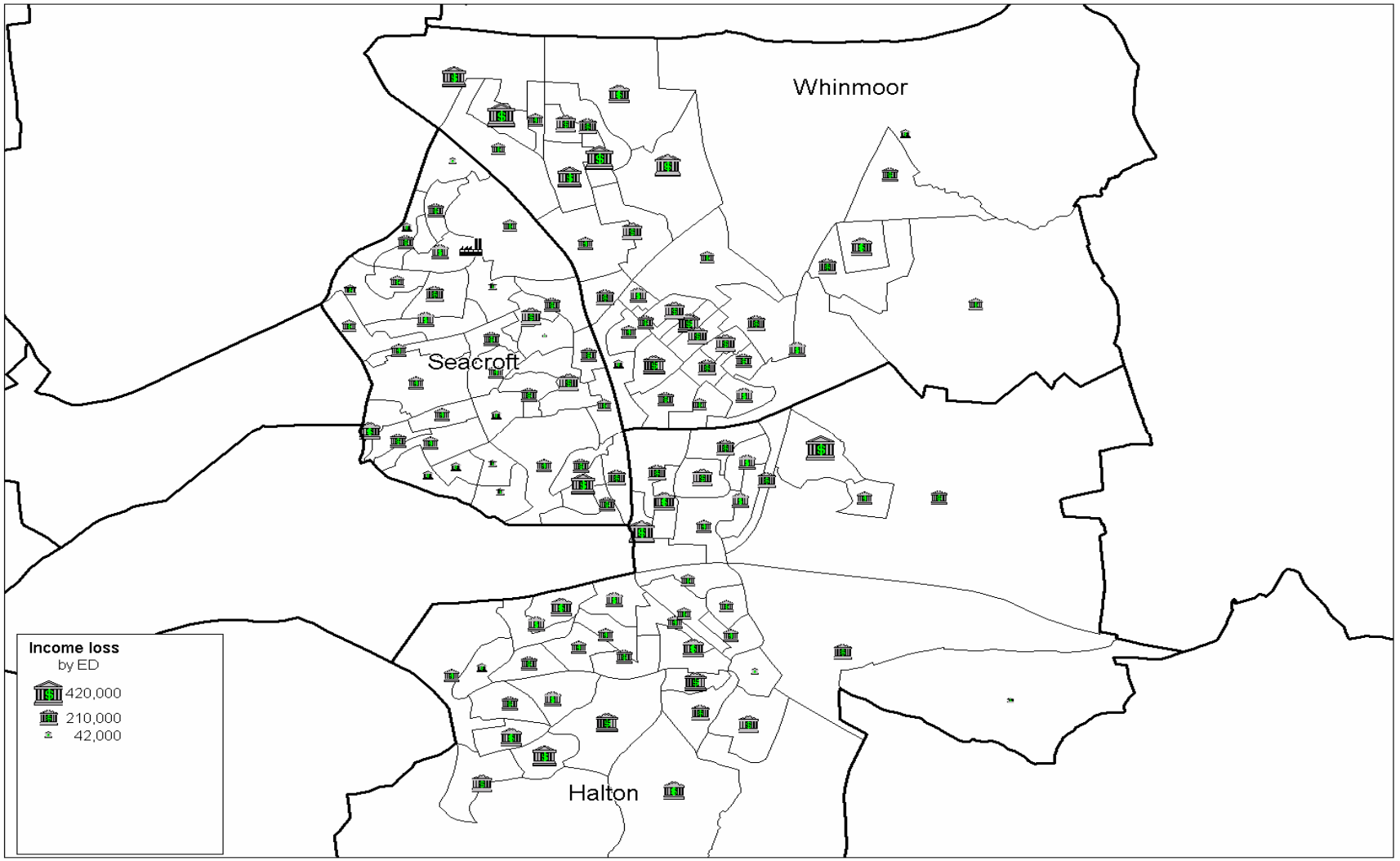
The plant's workforce structure



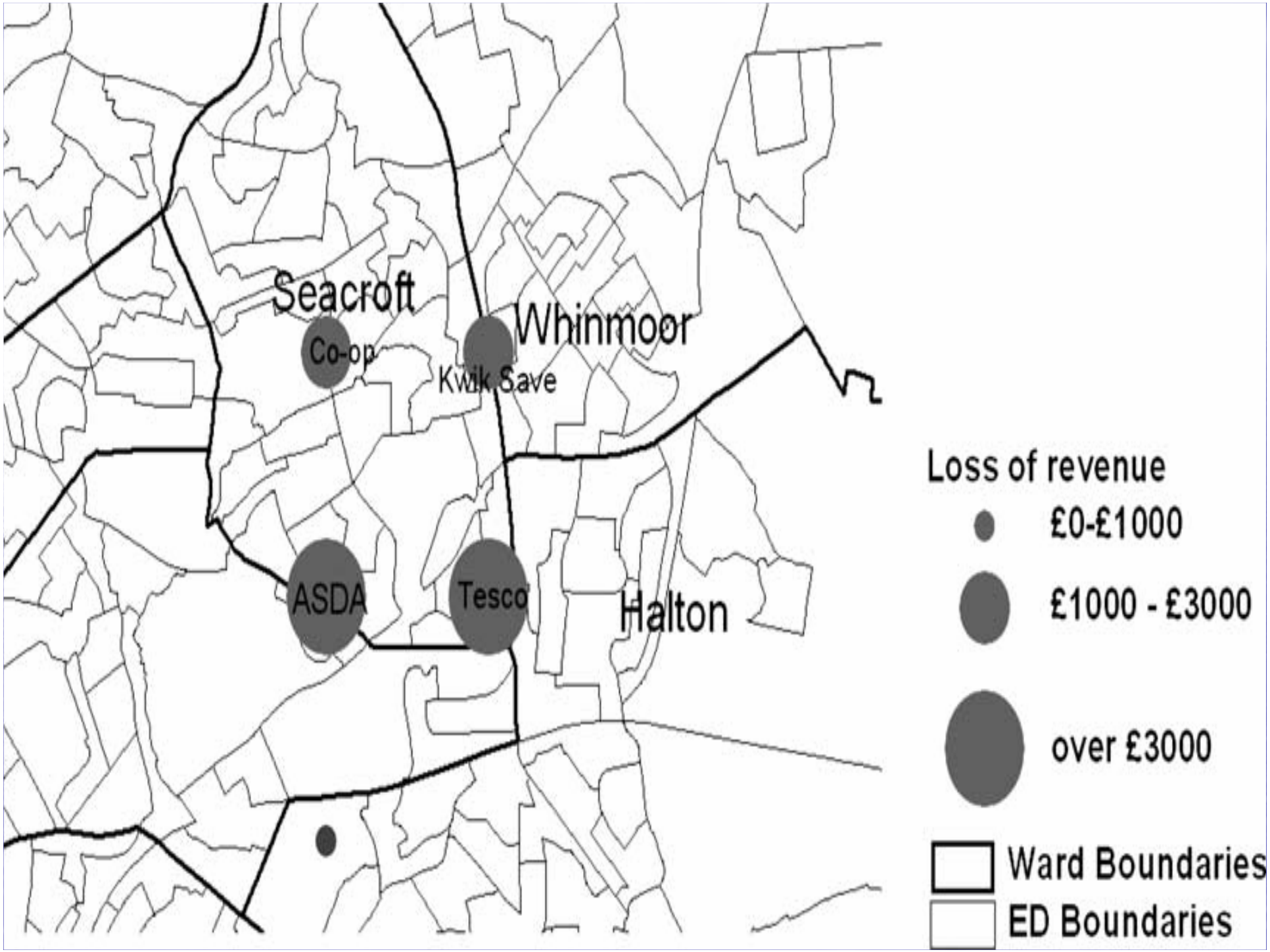
Journey to work to Seacroft



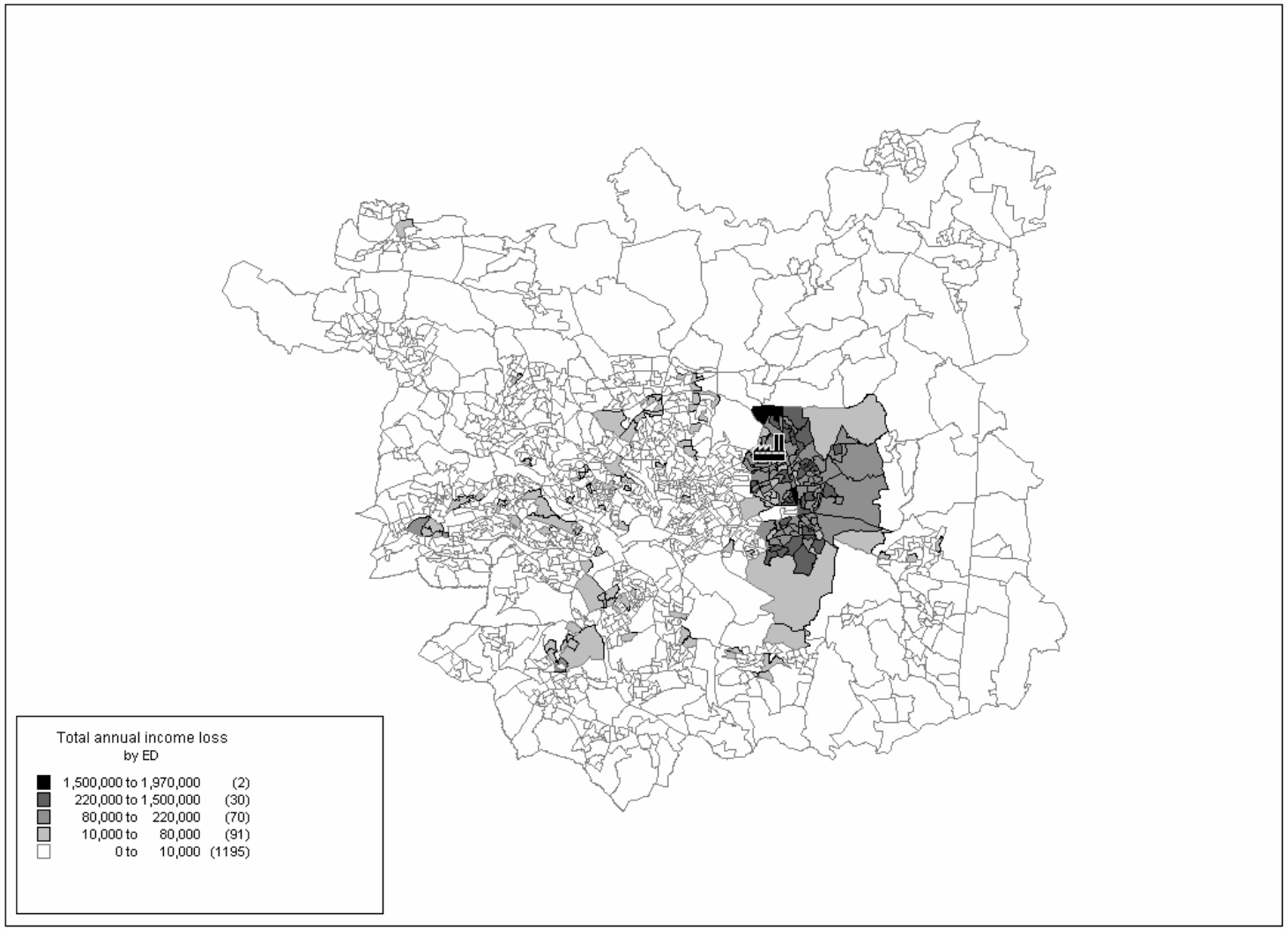
Estimated spatial distribution of total income loss in Seacroft, Halton and Whinmoor



Estimated spatial distribution of change of demand for *Food & non-alcoholic* drinks in Seacroft, Halton and Whinmoor

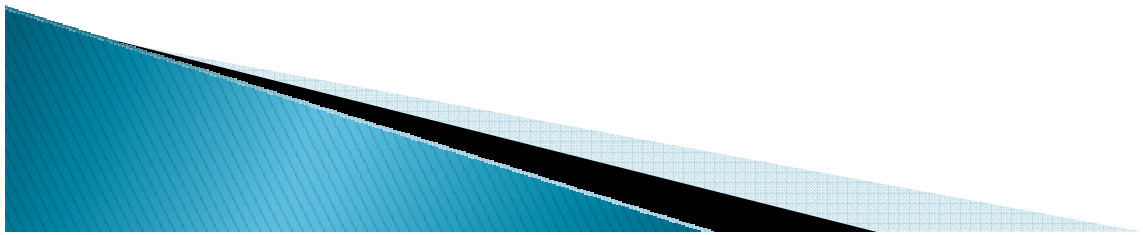

Seacroft
Co-op
Whinmoor
Kwik Save
ASDA
Tesco
Halton
Loss of revenue
£0-£1000
£1000 - £3000
over £3000
Ward Boundaries
ED Boundaries

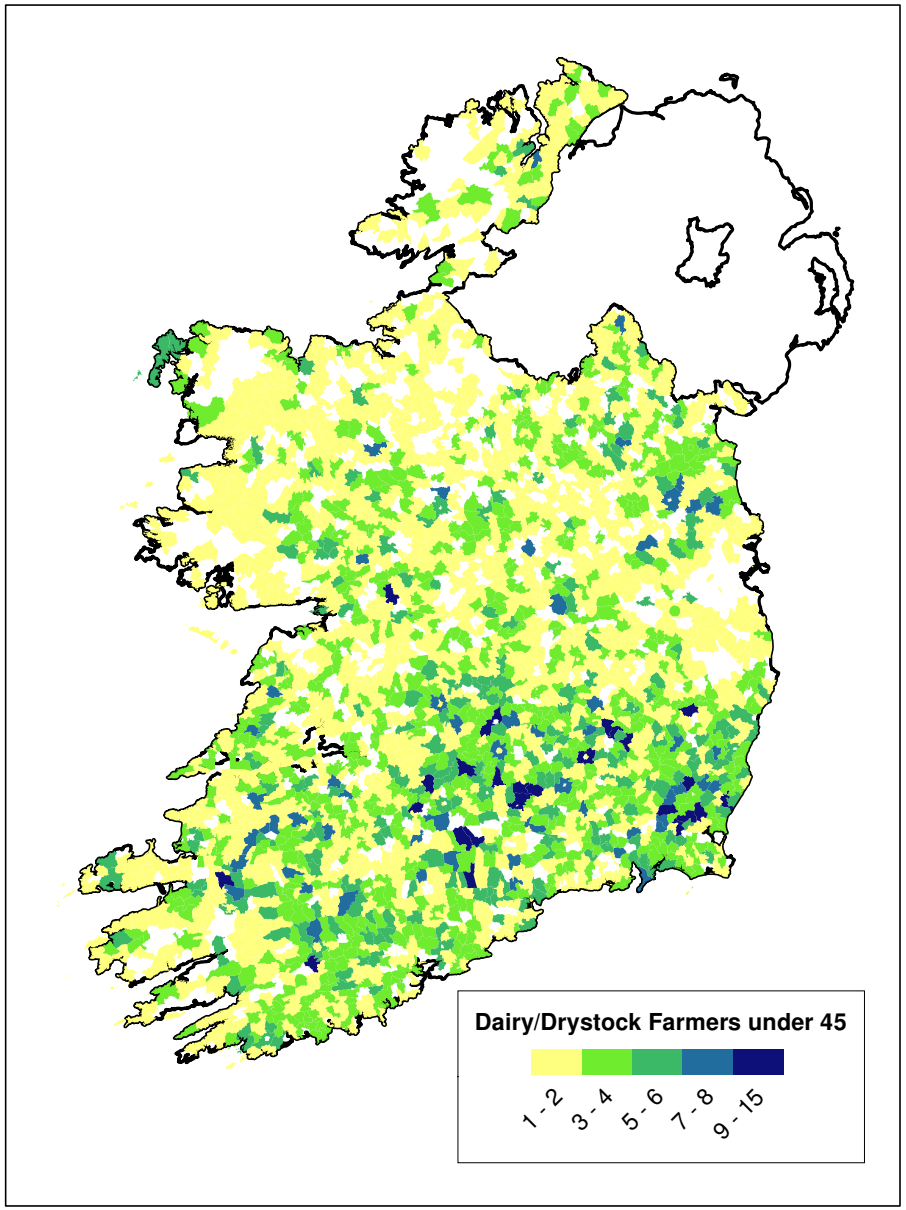
Modelling inter-industry links: total income loss



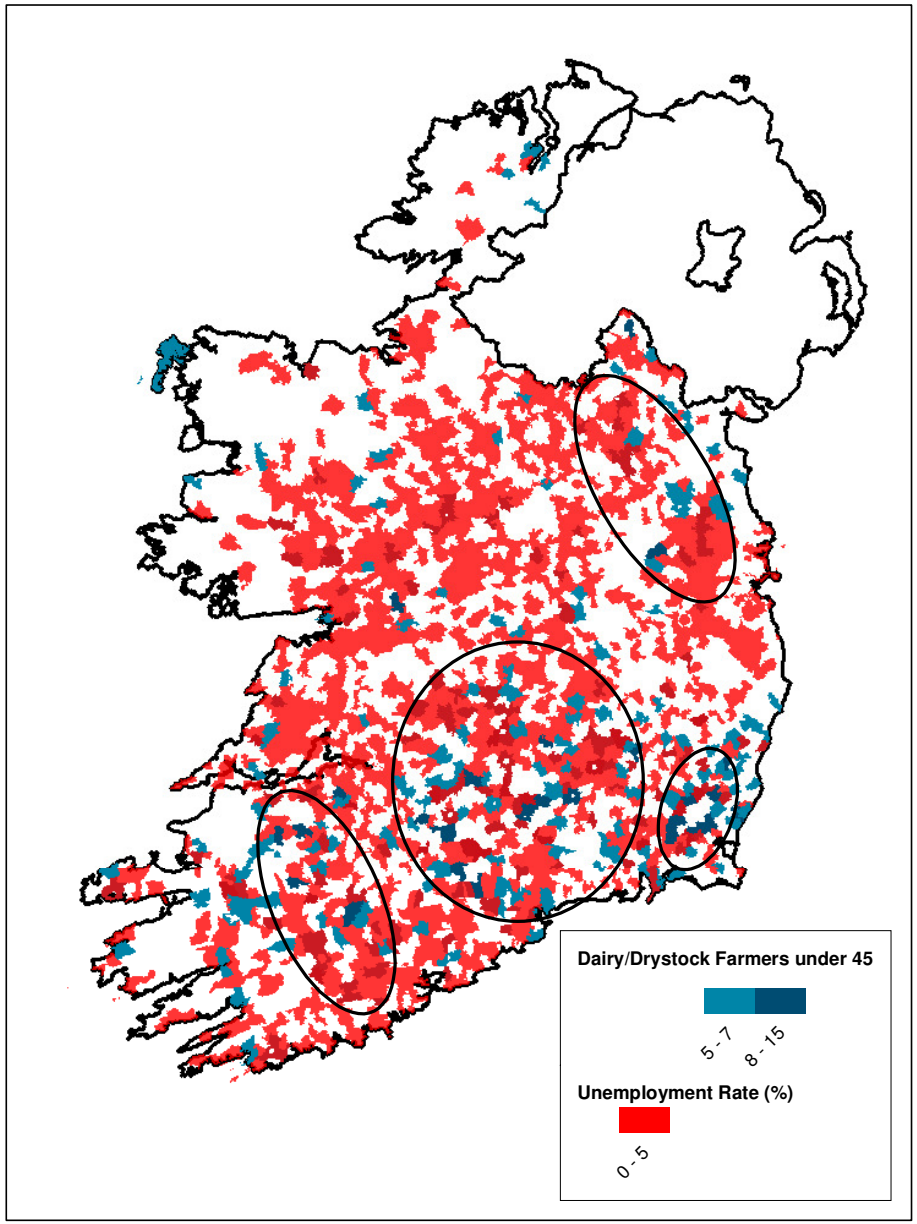
CAP reforms in Ireland: Key questions

1. How will CAP reform affect different communities in Ireland? What is the spatial distribution of ‘winners’ and ‘losers’?
2. What are the relationships between areas identified in Question 1 and NSS areas? Will CAP reform help or impede NSS goals?

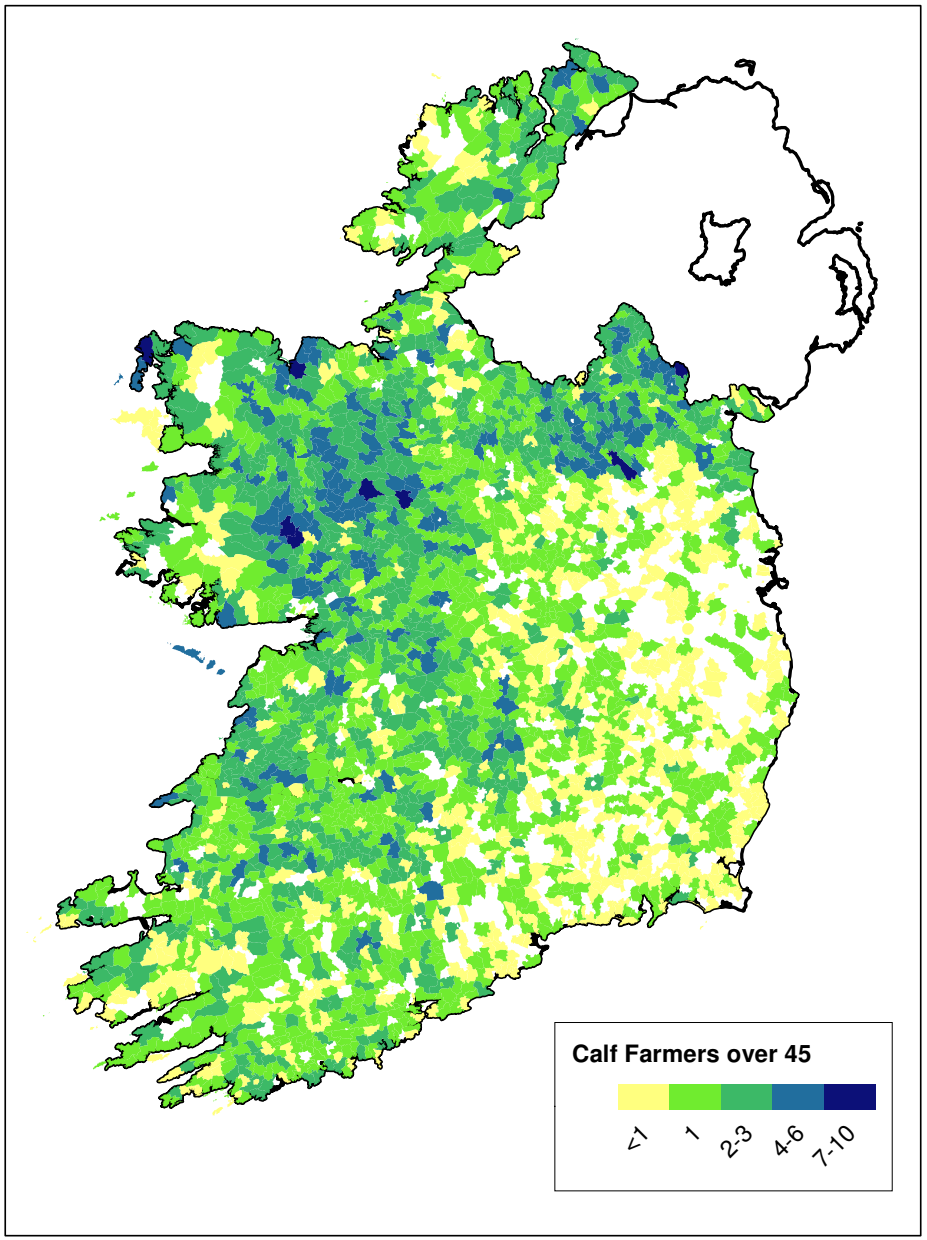




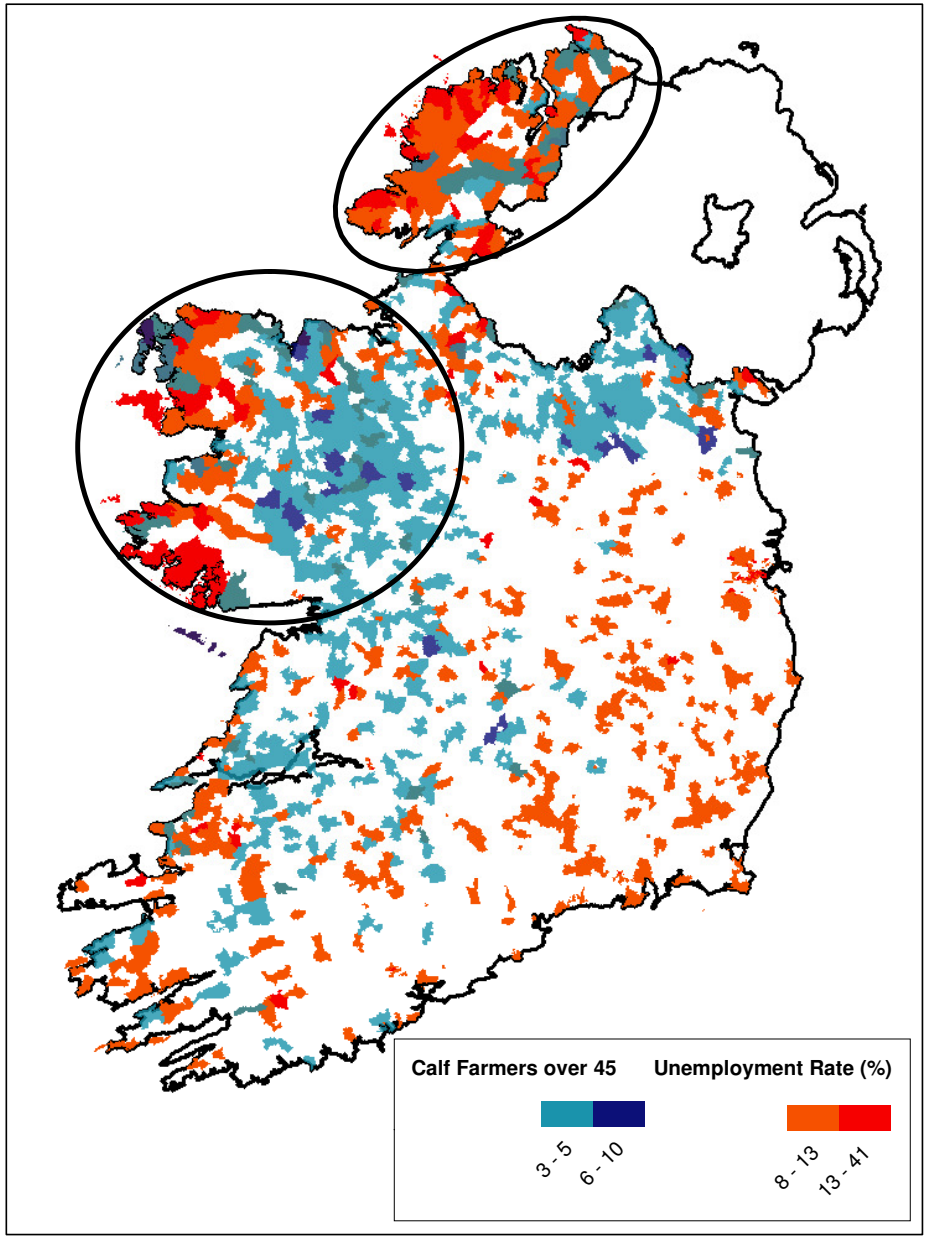
Number of Dairy/Drystock Farmers under 45.



Dairy/Drystock Farmers under 45 and Low Unemployment.



Number of Calf Farmers over 45.



Calf Farmers over 45 and High Unemployment:

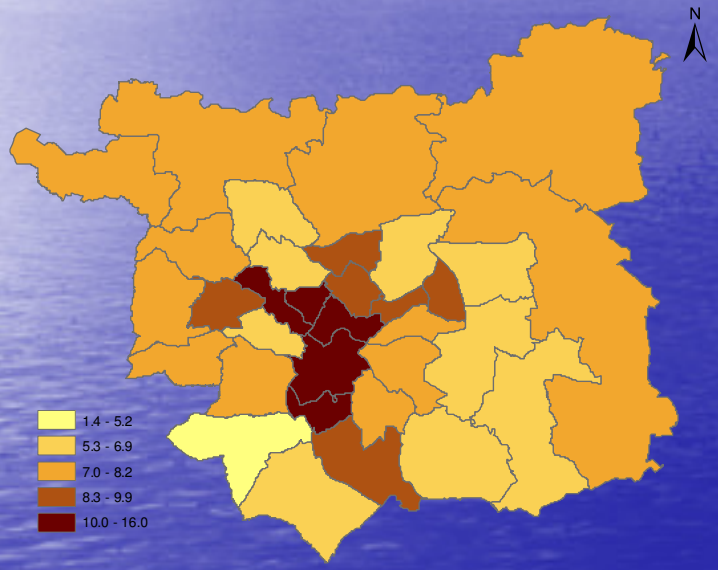
Other examples

- Health
  - obesity
  - type 2 diabetes
  - smoking
  - mental health/depression

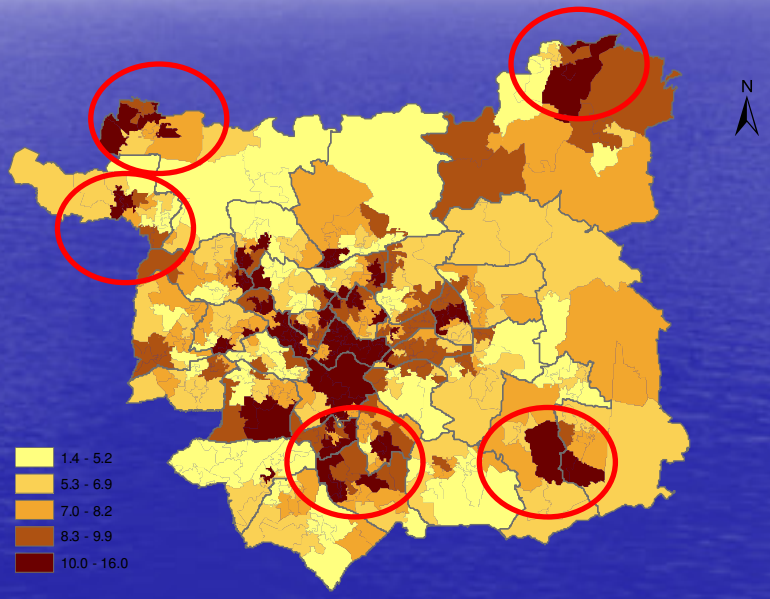
(fast food outlets; hospitalization rates)

- Retail

Childhood obesity in Leeds

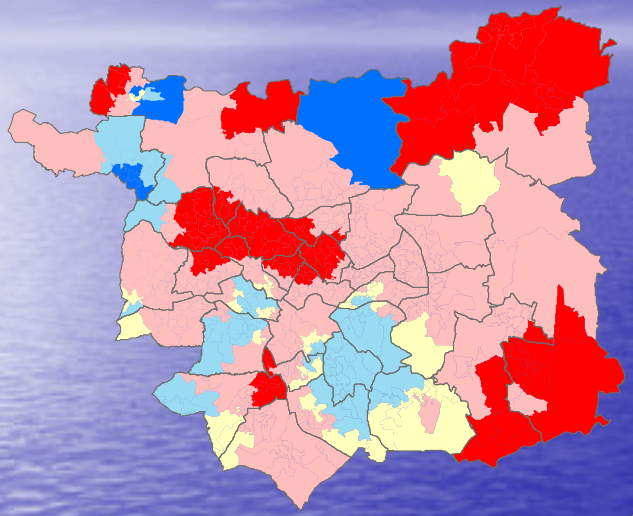


Obesity prevalence
Leeds wards

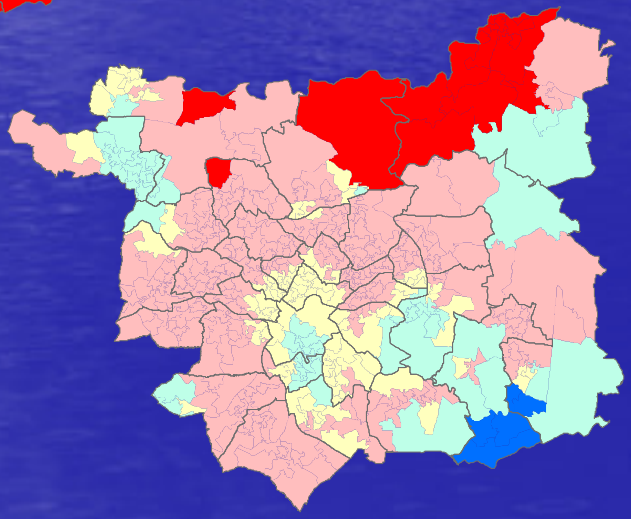


Obesity prevalence
Leeds SOAs

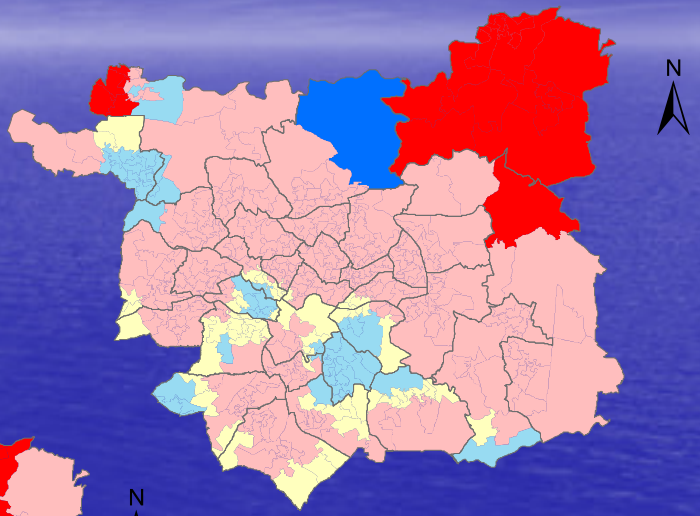
SimObesity: Results "Local"



Supermarkets difficult to access



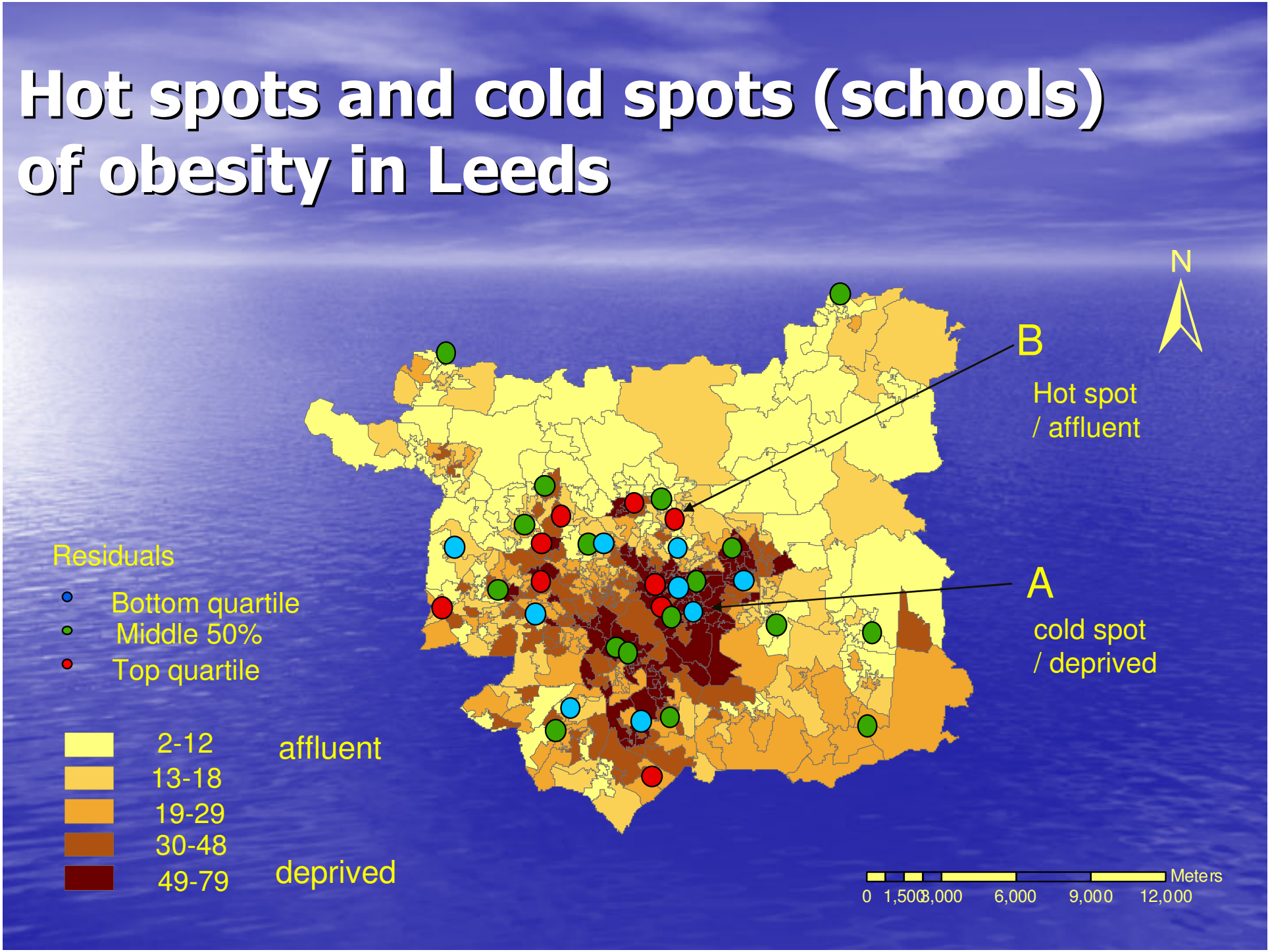
Sedentary children

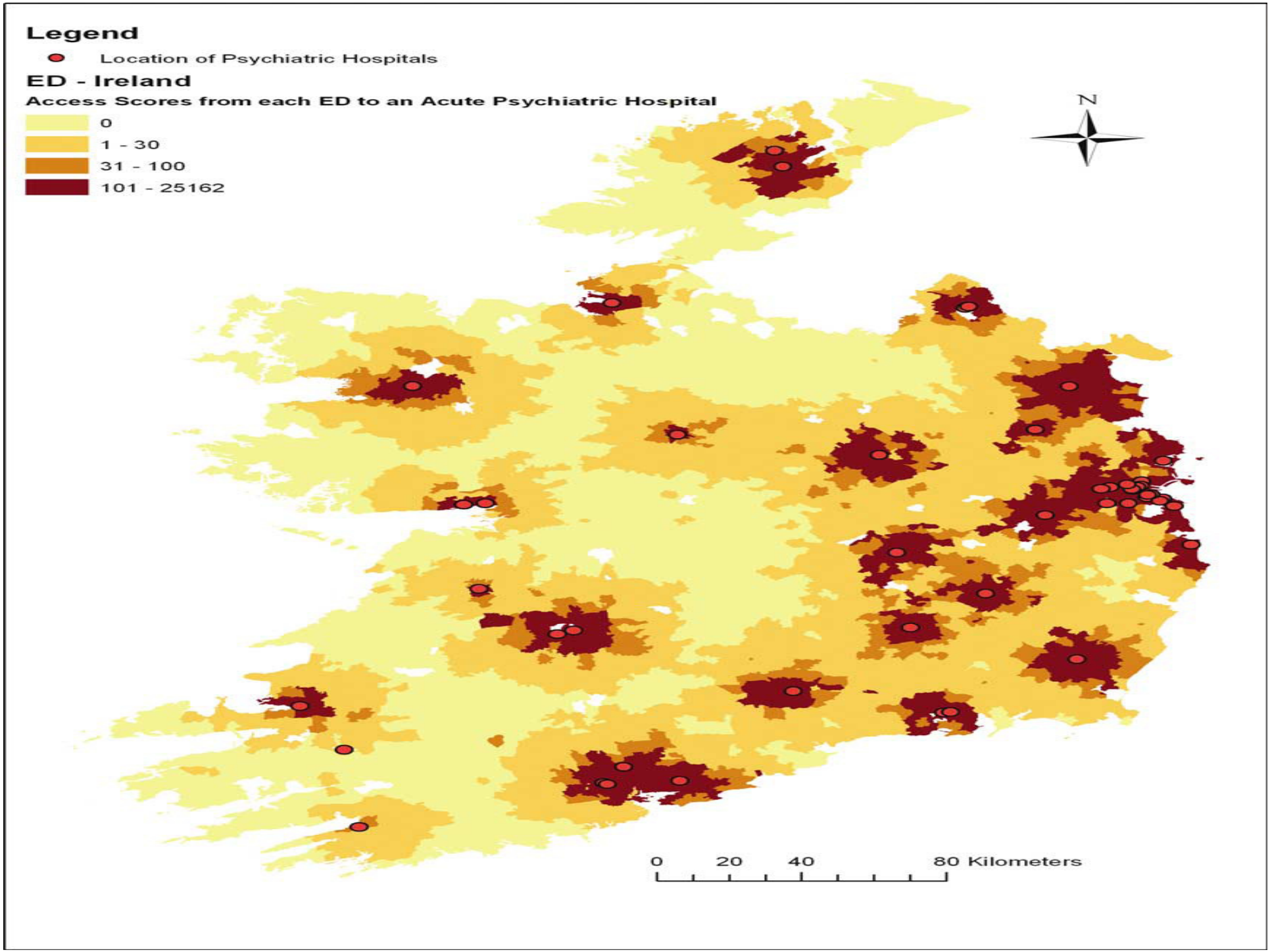


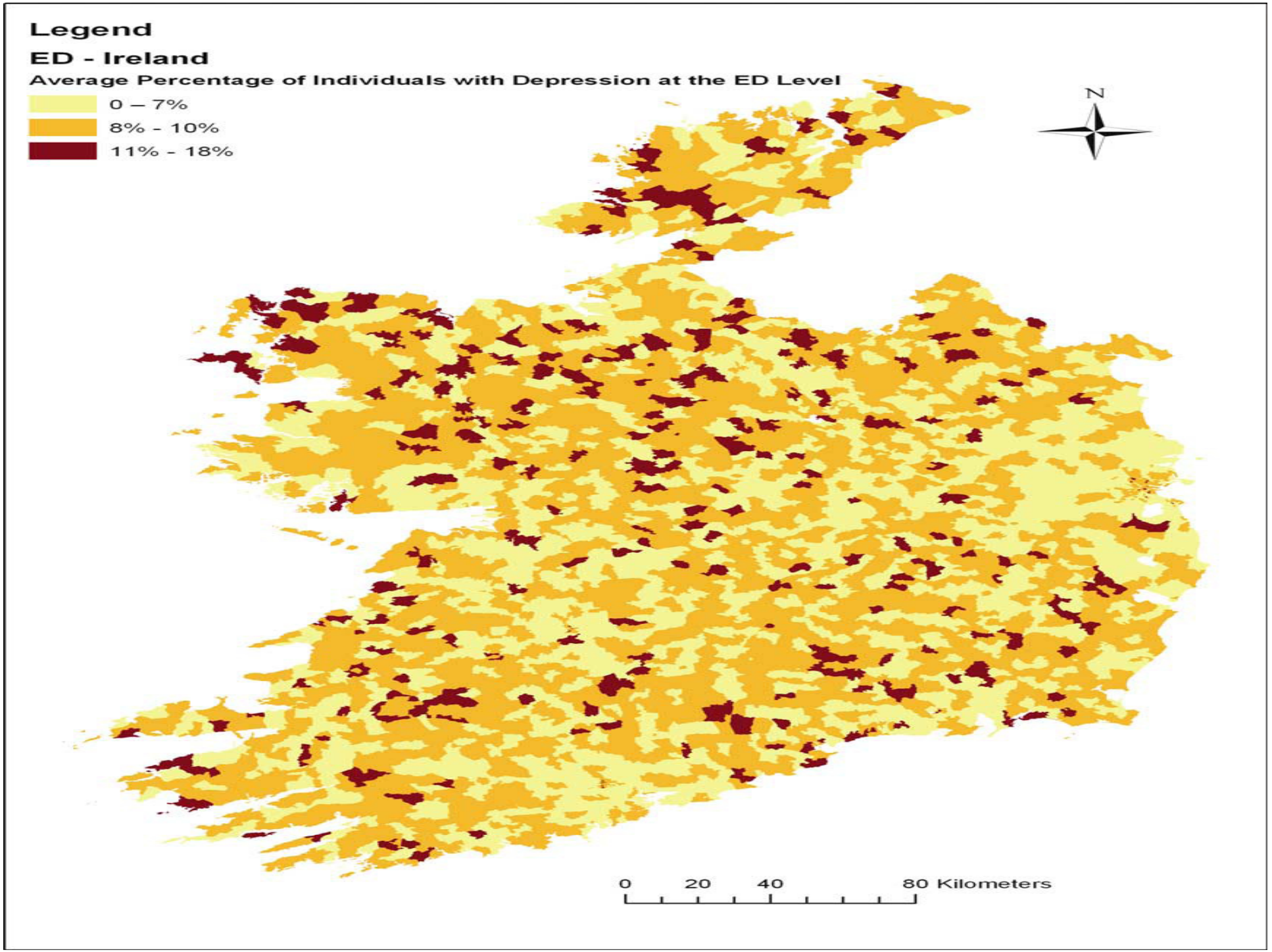
No daily fruit or vegetables

Red: ⇧ risk of obesity
Blue:⇩ risk of obesity

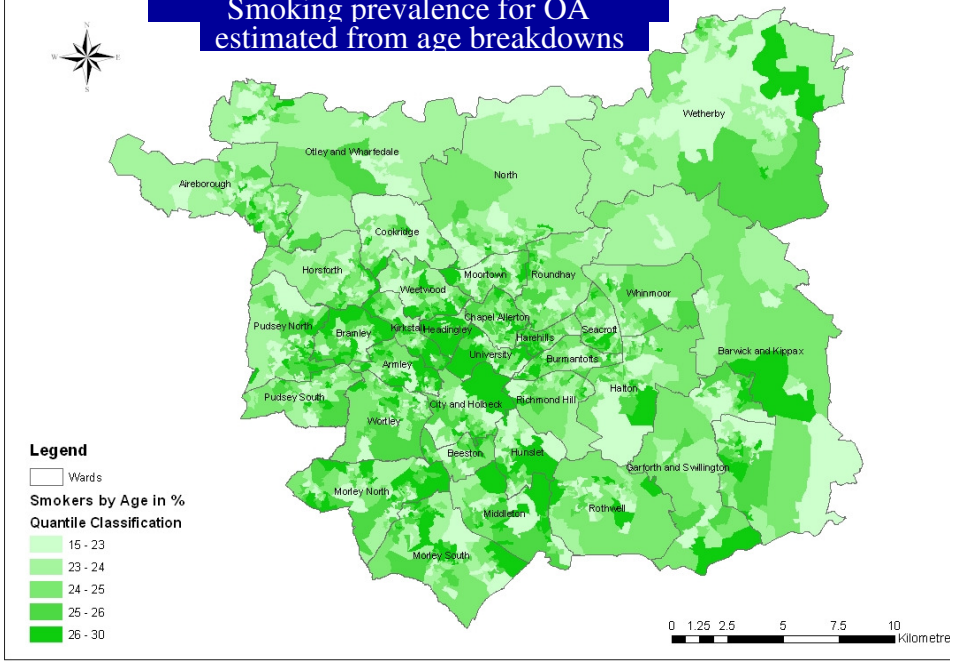
Hot spots and cold spots (schools) of obesity in Leeds



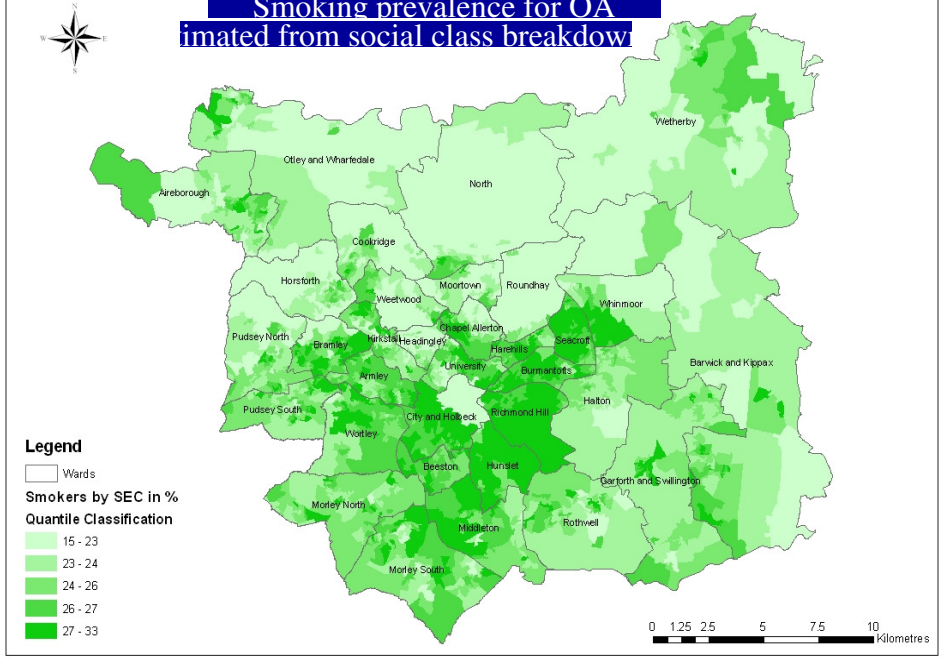

Legend
Location of Psychiatric Hospitals
ED - Ireland
Access Scores from each ED to an Acute Psychiatric Hospital
0
1 - 30
31 - 100
101 - 25162
N
0 20 40 80 Kilometers


Legend
ED - Ireland
Average Percentage of Individuals with Depression at the ED Level
0 – 7%
8% - 10%
11% - 18%
N
0
20
40
80 Kilometers

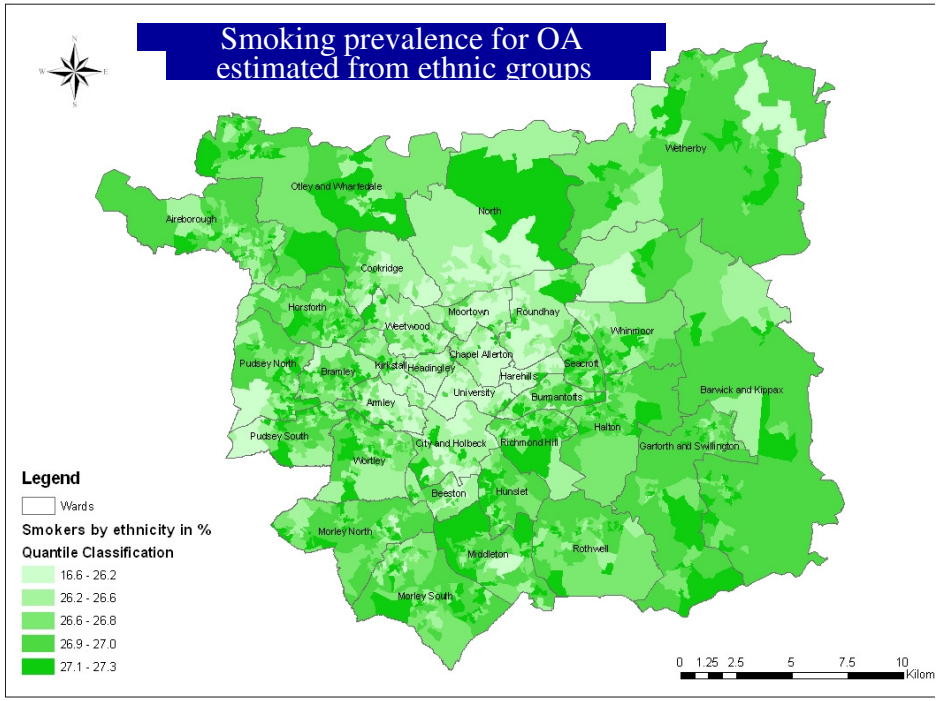
Smoking prevalence for OA estimated from age breakdowns



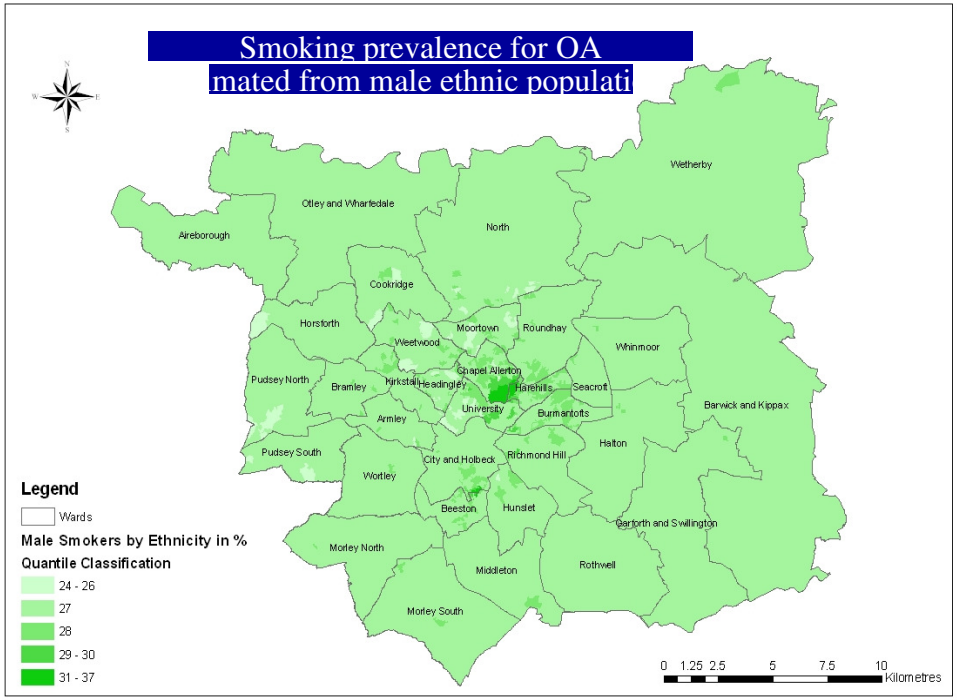
Smoking prevalence for OA imated from social class breakdowr



Smoking prevalence for OA estimated from ethnic groups



Smoking prevalence for OA mated from male ethnic populati



Microsimulation – total demand

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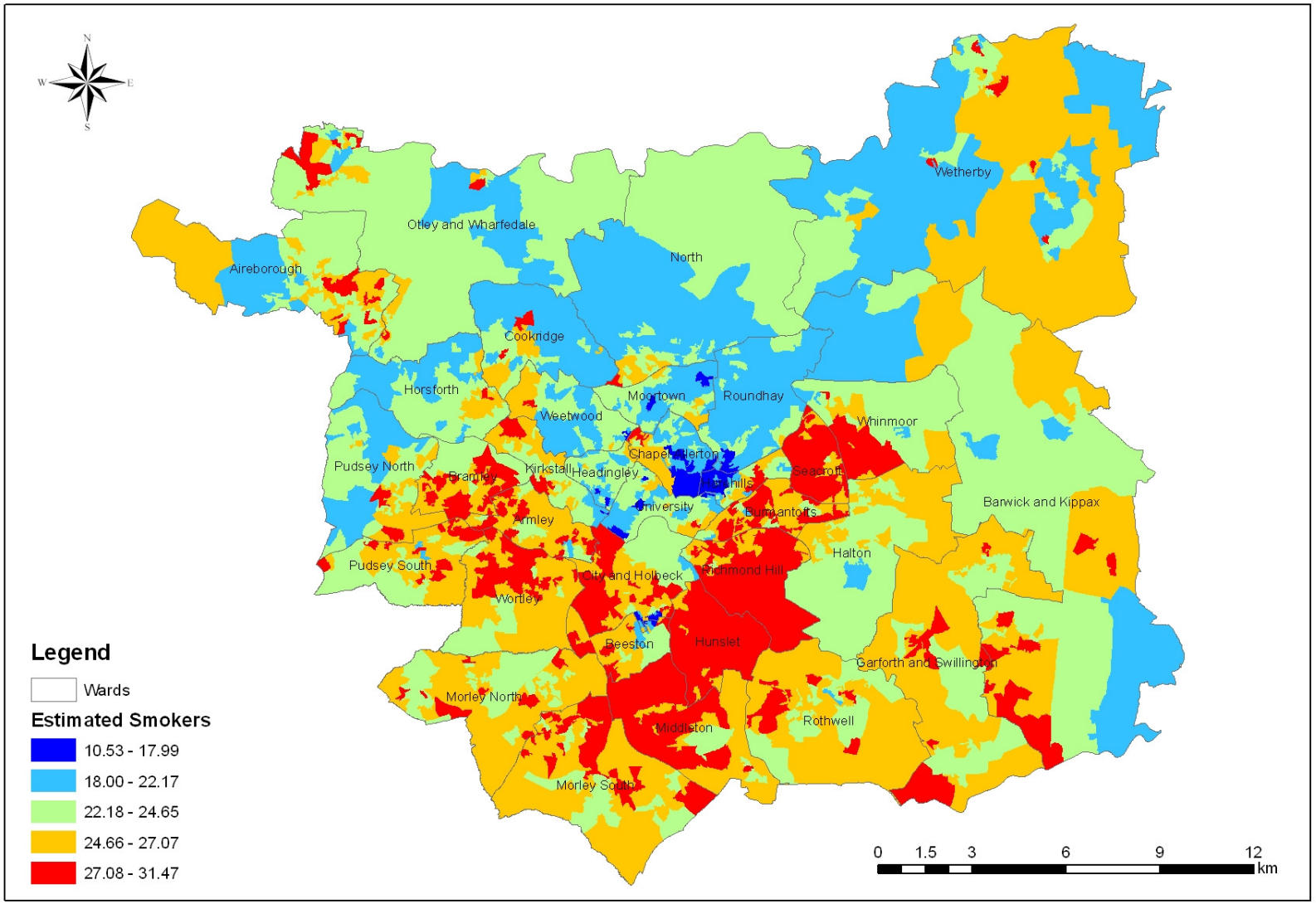
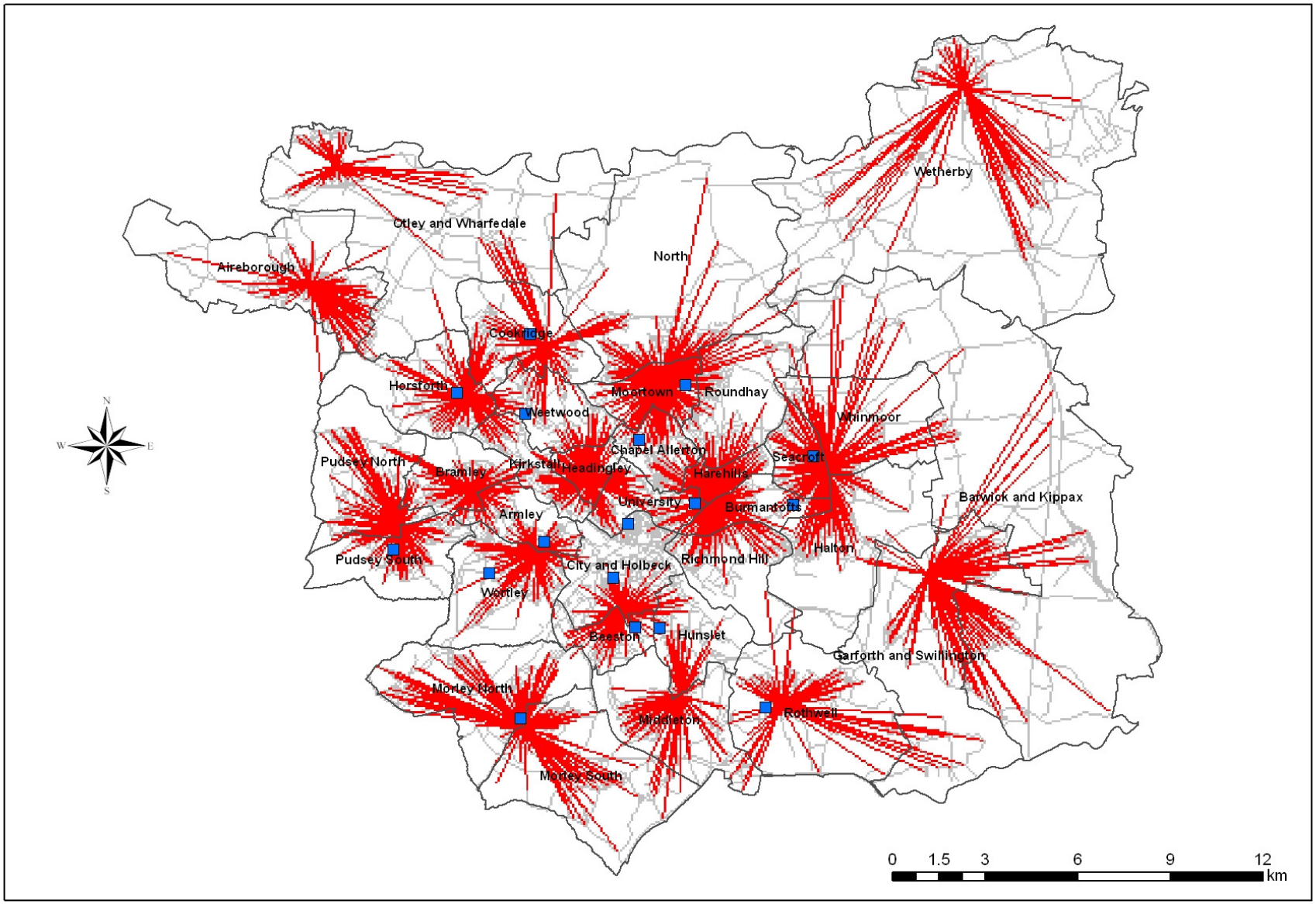
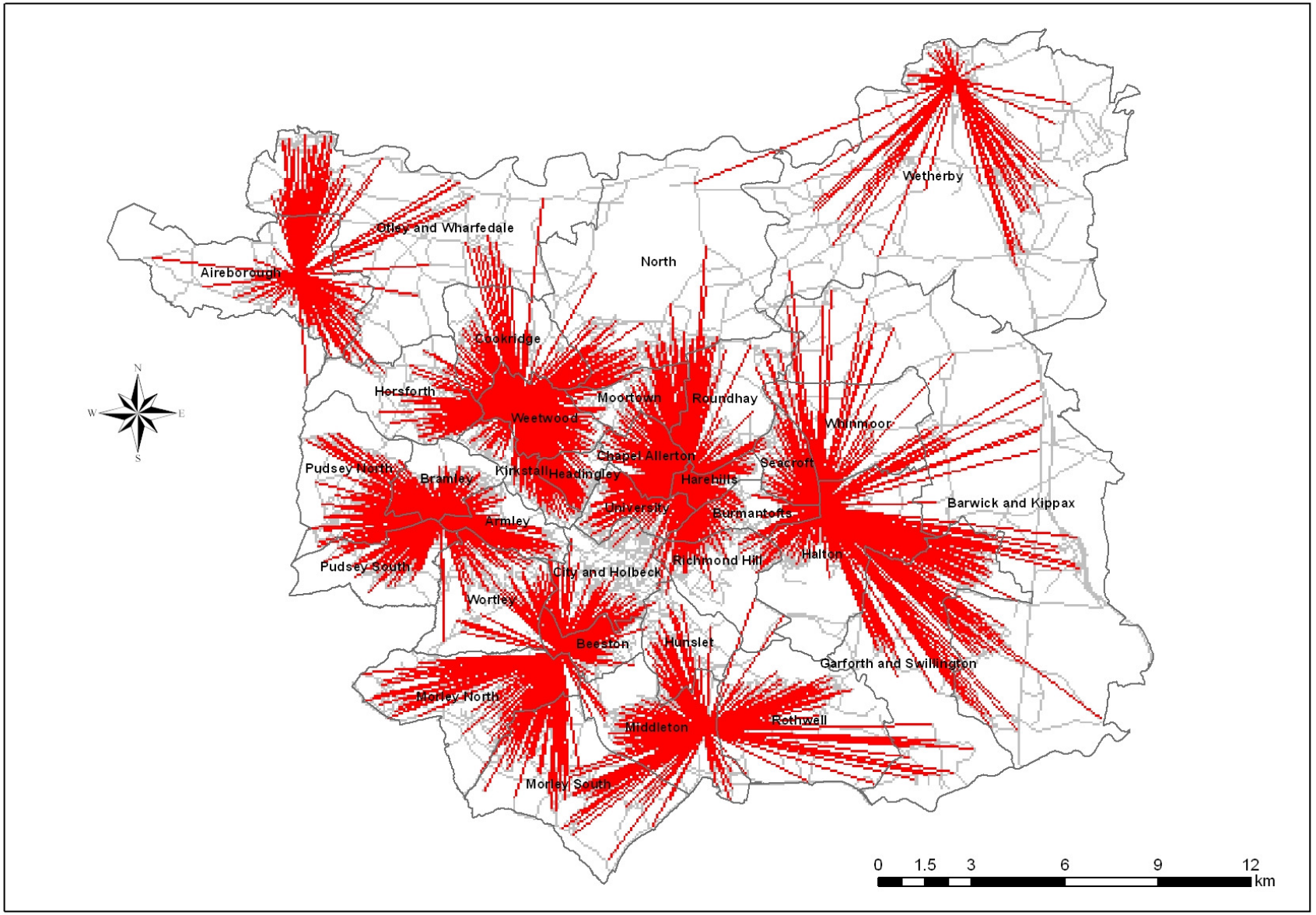


Actual compared with ‘optimal’ locations



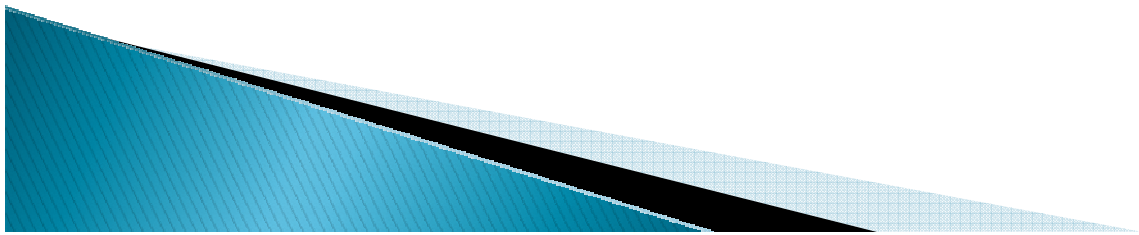
Best locations to target heavy smokers



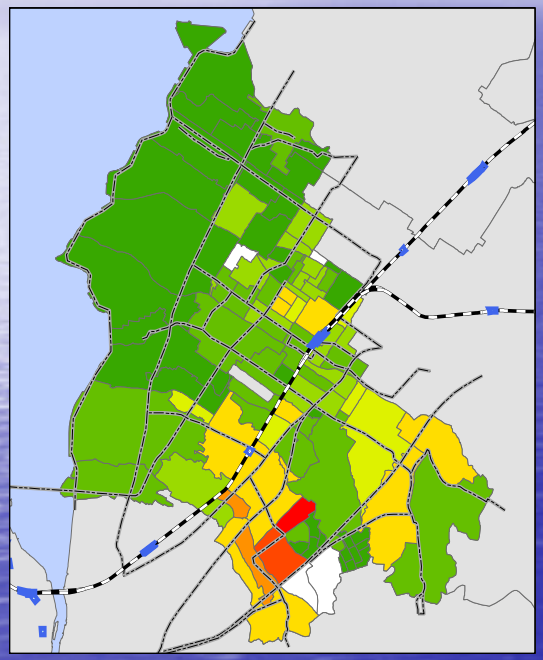
Lifestyle groups: Japan survey

Lifestyle Household Category h

		Household Size	Age of Household Head
1.	*Younger single*	*single*	*18-39*
2.	*Older single*	*single*	*40+*
3.	*Younger couple*	*two*	*18-39*
4.	*Older couple*	*two*	*40+*
5.	*Younger family*	*more than two*	*18-39*
6.	*Older family*	*more than two*	*40+*

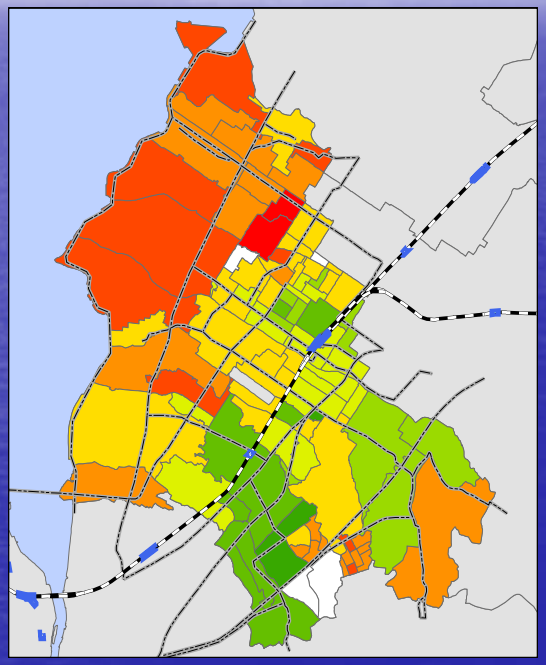


Estimated Distribution of households by lifestyle



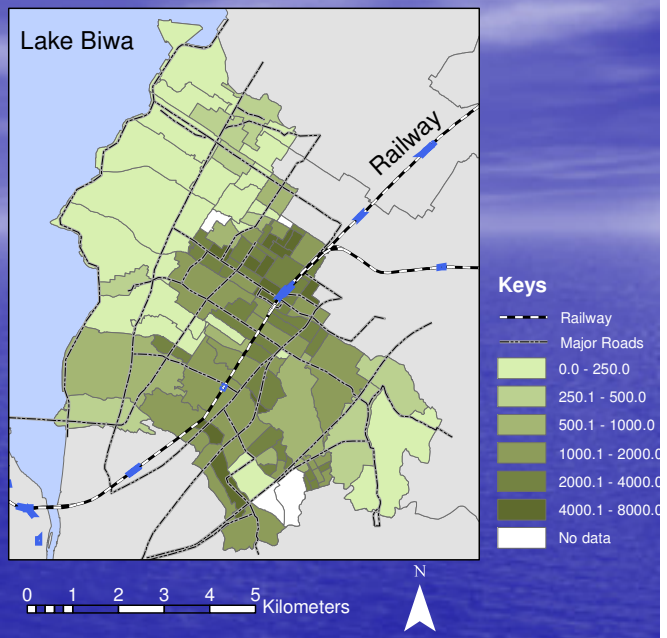
Proportion of Younger Single

12,386 households (28.4%)

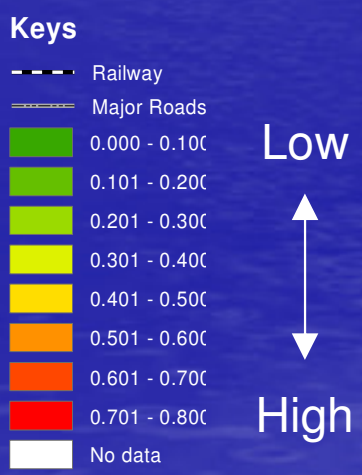


Proportion of Older family

14,886 households (34.1%)



Household Density



Low

High

Estimating Expenditure Flow

Expenditure flow from households living in area i to store j

Number of households in area i

choice rate of store j in area i

$$F(h)_{ij} = E(h)_i N(h)_i p(h)_{ij}$$

$$= E(h)_i N(h)_i \frac{A(h)_j \exp(-\beta(h) D_{ij})}{\sum_k A(h)_k \exp(-\beta(h) D_{ik})}$$

Average household expenditure in area i

From Microsimulation

From Spatial interaction modelling

Expenditure flow
= average expenditure x
number of households x
store choice rate

for each household lifestyle group, *h*

Drawbacks of microsimulation

- Difficulties in calibrating the model and validating the model outputs
- Constraints will be reproduced well – others not so well – so which do you use?
- Cloning misses 'extreme' households and misses difference geography can make!

Initial estimates of birth statistics for a selection of wards in Leeds: (source: Tomintz 2009): model development(1)

Ward	Actual 2000-6	Predicted	Difference
Cookridge	294	298	4
Halton	187	195	8
Roundhay	229	232	3
Harehills	471	375	-96
Richmond Hill	272	214	-58
Seacroft	272	219	-53
Headingley	103	880	778

Model development

- (2) vary constraints geographically

cluster 1: aged, deprived;

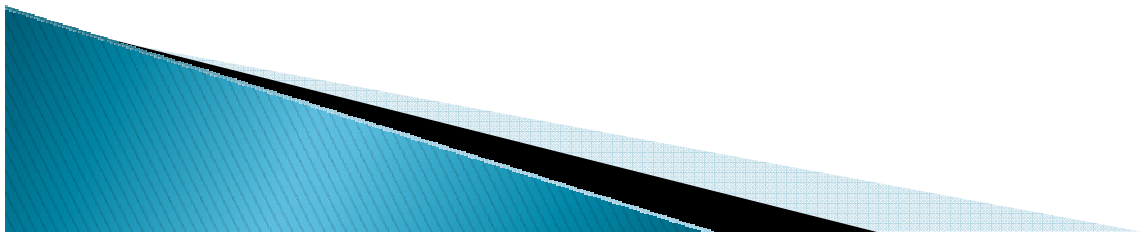
cluster 2: affluent;

cluster 3: low ethnic diversity;

cluster 4: young, ethnically diverse, more deprived;

cluster 5: similar to cluster 4 but less ethnically diverse

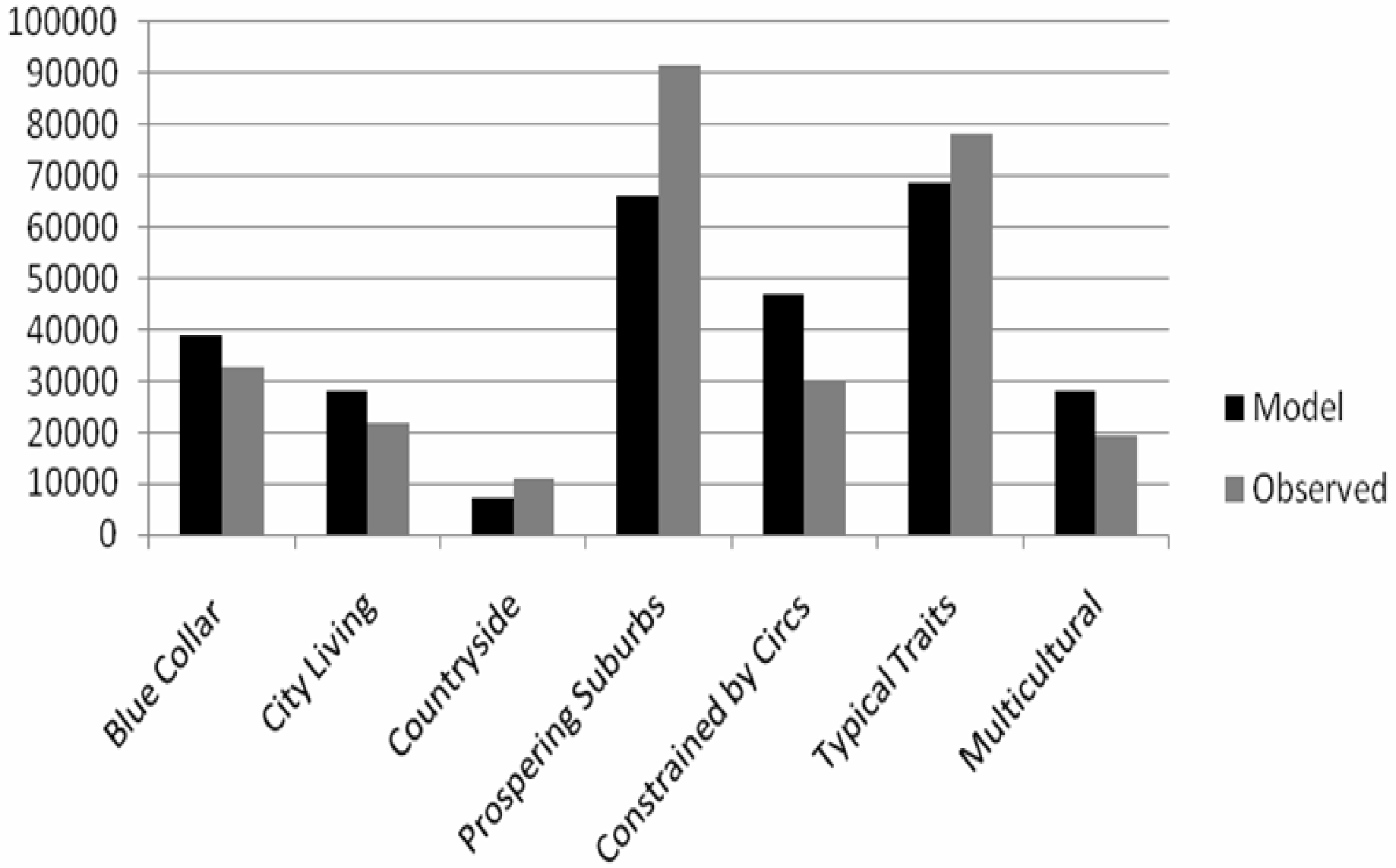
- (3) add geodemographics formally



Car ownership by distance

Distance	Model	Observed	Performance
0 to 2 km	15148	10265	48%
2 to 4 km	44560	31674	41%
4 to 6 km	69691	61091	14%
6 to 8 km	68640	73851	-7%
8 to 10 km	34596	41085	-16%
Over 10 km	51608	66277	-22%
Mean Absolute Error			25%

Figure 4: Car Ownership by OAC



Adding geodemographics

OAC Group	Model	Observed	Performance
Blue Collar	35775	32869	9%
City Living	20116	21917	-8%
Countryside	9981	10805	-8%
Prospering Suburbs	85491	91511	-7%
Constrained by Circs	36368	29668	23%
Typical Traits	73927	77971	-5%
Multicultural	22775	19502	17%

Mean Absolute Error 11%

Conclusions

- Microsimulation useful tool to estimate ‘missing data’
- Capacity to analyse policy change at small area level: spatial implications of policy change
- Link to meso/macro models: i.e spatial interaction models; GWR; Econometric models?