Exploring a singly-constrained spatial interaction model for UK general practice

This model of resident allocation to general practice (GP) practices is based on **location** (distance), the total population of Middle le Super Output Areas, and a rough measure of GP **quality** (the percentage of data returned to NHS England under the Quality and Outcomes Framework, which is linked to funding for each practice). The origin-constrained model takes this form:

$S_{ij}=O_i*A_i*W_j \exp(-\beta\ dij)$

Where:
S_{ij} = the usage of a GP in destination *j* from Middle layer Super Output Area (MSOA) *i*
O_i = population of MSOA *i*
A_i = a balancing factor to ensure that $\sum_j S_{ij} = O_i$
Which is calculated as :
$A_i = 1/\sum_j W_j \exp(-\beta d_{ij})$
W_j = the attractiveness of destination *j*
d_{ij} = the distance between origin *i* and destination *j*
-β = the distance decay parameter

Each model includes 4 sheets within one Excel worksheet: **1_exp, 2_Ai, 3_output**, and **4_provision**. All of the information and data needed to run the model is in these four sheets – see comments and colour-coding in worksheets. The numbers indicate the order you should look at the worksheets to understand the calculation as follows:

1_Exp:

- This sheet calculates the *exp (-βdij)* expression for each pair of *i* and *j*. The beta value (distance decay) is given in **C1**, and **if changed here will adjust the entire worksheet**. At the bottom of the sheet, the distances between each *i* and *j* pair are given, as calculated by Pythagoras' theorem.

2_Ai:

- This calculates the A_i value, the balancing factor for each origin MSOA. Note that in the A_i sheet, the exp values are brought over and pasted below.

3_Output:

- includes the O_i values, the total number of people in each origin *i* (2011 MSOA, using 2011 Census data)
- The attractiveness values are included across the top, giving the QOF return percentage (% of possible data returned) for each destination *j* (GP surgery)
- There is a check in place to ensure that all residents are allocated. Column J shows the sum of the patients allocated from each origin *i* across all destinations *j* and this value is subtracted from the O_i values for each MSOA to identify any error in the calculations (shown as SUM in column K).

4_Provision:

- This worksheet takes the provision at GP practices (the facilities) and redistributes back across the origins, based on the modelled flows of patients at the previous steps.

ACTIVITIES:

Task 1: Step through each of the worksheets in turn and see if you can follow the calculations being made. The comments and colour-coding of the worksheets should help you with this.

Task 2: Distance decay often ranges from quite low (ie, minimal effect of distance on accessing a service) to very high (distance is a greater barrier to access). In retail literature the values often range from 0.2-2.0. Experiment with changing the distance decay parameter in the green cell worksheet '1_exp', originally set at 0.2 to see how the population are 'allocated' to GPs differently. If you wish to see how the allocation of population to facilities is varying based on this parameter, you need to look at the pink cells in worksheet '3_output'.

Task 3 (optional – note that this is a more complex task): This is only a small sample of the GPs located in Southampton, however, you may update the model by adding in more of the GPs and their QOF return data. Look in the folder to see an additional dataset (GPSotondataComplete.xlsx). What happens when you add another few GPs to the model? How does the distribution of patients from each MSOA change?

If you were to include all of the GP surgeries in Southampton, you could complete this exercise by mapping the provision of services by each GP, as predicted by the model. In the simplest approach, map of GPs showing the sum of S_{ij} for each (provided in the Output sheet, line 42) would indicate the expected number of patients using distance and QOF scores, along with local populations as variables.

OTHER CONSIDERATIONS AND EXTENSIONS:

To improve the analysis, we would suggest looking beyond the immediate study area. In more traditional SI approaches where retail provision is the main interest, a buffer area around the core study area would be included to acknowledge that people/patients may not be constrained by health-related administrative boundaries (here, these are Clinical Commissioning Groups or CCGs); residents may attend a practice in another CCG. The benefit of SI models over traditional models of resource allocation is the removal of administrative boundaries as barriers to access, when applied well.

In this model, our demand points (the MSOAs that form the origins in the spatial interaction model) are quite aggregated. We could disaggregate our demand points further by using smaller area units, such as lower layer super output areas (LSOAs), output areas, or even unit postcodes.

If we had actual attendance data and information about flows of patients from origins to destinations, we could also go further, for example by optimising the distance decay parameter to fit the available data.