

Commuting in Northern Ireland: Exploring Spatial Variations through Spatial Interaction Modelling

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1. Introduction

This paper is concerned with spatial variation in commuting flows and their relations with other variables across Northern Ireland (NI). Knowledge about such patterns is of interest in setting the context for employment policy (Blumenberg and Shiki, 2004) as well as in understanding more about the spatiality of everyday life. The analysis is based on a spatial interaction model used to relate flows between wards to a variety of potentially important explanatory variables. Spatial variations in residuals from the model are explored, and potential ways of developing the model and alternative approaches are suggested.

Previous research has explored spatial variations in commuting in NI using data (reported in wards) from the 1991 Census of Population. This research assessed the relations between mean commuting distance per ward and other variables including the degree of deprivation (using the Robson Index of Multiple Deprivation), the percentage of households with no car, the number of people in SOC (Standard Occupational Classification) groups 1 to 3 and the percentage of residents who were Catholic, among other variables (Shuttleworth and Lloyd, 2005; Lloyd and Shuttleworth, 2005). The relations between these variables were assessed using global regression, moving window regression (MWR) and geographically weighted regression (GWR). The present analysis employs a different methodological framework to explore other aspects of ward-to-ward travel-to-work patterns in NI. It also makes use of spatial interaction data (flow data), rather than area based counts used previously. Firstly, flows are explored using the FlowMapper routine of Waldo Tobler¹, although the results are not presented here. Secondly, a Poisson gravity model, defined below, is used to explore the relations between the number of people commuting between wards and a set of other variables.

2. Data and methods

The main component of the analysis is a gravity (spatial interaction) model, used to model movement of workers between wards. Both data and the model applied are detailed below.

¹ <http://www.csiss.org/clearinghouse/FlowMapper/>

2.1 Data

The analysis makes use of flow data provided as an output from the 2001 NI Census of Population. The variables used are (i) flow between wards, (ii) the number of workers resident per origin ward, (iii) the number of jobs per destination ward and (iv) the road distance between wards. In addition, a religion variable specified as the absolute difference between the percentage residents in the sending and the receiving wards who are Catholic (by community background, i.e., religion or religion brought up in) is generated. Note that the Protestant case is almost the inverse as the numbers of people who list their community background as either another religion or 'no religion' is proportionately small.

2.2 Spatial interaction modelling: the Poisson gravity model

A widely-used approach to spatial interaction modelling is to calibrate the model using log-linear regression (Haynes and Fotheringham, 1984; Fotheringham and O'Kelly, 1989). Flowerdew and Aitkin (1982) demonstrate several limitations of such an approach, and propose the use of Poisson regression to help overcome some of the problems they identify. Given that the number of people moving from one place (i) to another (j) must be a nonnegative integer, the Poisson distribution is appropriate. For a Poisson distribution with a mean λ_{ij} , then the probability that k people moved is given by:

$$\Pr(n_{ij} = k) = \frac{e^{-\lambda_{ij}} \lambda_{ij}^k}{k!} \quad (1)$$

It is assumed that λ_{ij} is logarithmically linked to a linear combination of the logged independent variables:

$$\lambda_{ij} = \exp(\beta_0 + \beta_1 \ln P_i + \beta_2 \ln P_j + \beta_3 \ln d_{ij}) \quad (2)$$

where P_i and P_j are the populations of zones i and j . The logarithmic link function means that it is unnecessary to log the number of the number of individuals who have moved (Lovett and Flowerdew, 1989). The model was implemented using S-PLUS® software.

3. Results

Two models were specified. Firstly, a model with the dependent variable flow between wards and independent variables number of workers resident per ward (RESTO), number of jobs per ward (WRKTO) and distance between wards (DIST). The second model comprised, in addition to the independent variables described above, the religion variable (REFDF) described in Section 2.1. The models have null deviance 4254829 on 338723 degrees of freedom. The coefficients for model 1 are given in Table 1, and those for model 2 are given in Table 2. Model 1 has residual deviance 1,206,890 on 338,720 degrees of freedom and model 2 has residual deviance 1,110,044 on 338,719 degrees of freedom.

	Value	Std. Error	t value
Intercept	-1.517	0.020237	-74.981
LOG DIST	-1.331	0.000807	-1648.130
LOG RESTO	0.143	0.002820	50.838
LOG WRKTO	0.769	0.000991	776.667

Table 1. Model 1 coefficients.

	Value	Std. Error	t value
Intercept	-2.830	0.020970	-134.943
LOG DIST	-1.123	0.001048	-1071.620
LOG RESTO	0.233	0.002861	81.525
LOG WRKTO	0.815	0.001005	810.584
LOG RELDF	-0.107	0.000340	-313.758

Table 2. Model 2 coefficients.

The signs of model 1 (Table 1) are as may be expected. That is, the coefficient for distance is negative, indicating that flows become smaller as the distance between wards increases. The sign of the coefficient for the number of workers resident per ward (RESTO) is slightly positive, as the number of flows increases with an increase in the number of workers resident per ward. The coefficient for number of jobs per ward (WRKTO) has a larger positive value, indicating that large flows correspond to more jobs per destination ward. The coefficients for the common variables in model 1 and 2 have the same signs. The coefficient for the religion variable (RELDF) in model 2 is negative, indicating that as differences between sending and receiving wards by community background decrease, worker flows increase, other factors in the model being equal. This is interesting given the extensive literature on the possible effects of the religious ‘chill factor’ in NI (see, for example, Smith and Chambers, 1991), and will be explored further in future work.

	Flows	Model 1 pred.	Model 2 pred.	Model 1 error	Model 2 error
Min.:	0	0.0124	0.0141	-1678.6950	-1576.9550
1st Qu.:	0	0.1861	0.2219	0.1374	0.1652
Mean:	1.9836	1.9836	1.9836	0.0000	0.0000
Median:	0	0.3641	0.4224	0.2761	0.3227
3rd Qu.:	0	0.8354	0.9248	0.5806	0.6556
Max.:	1727	2652.2470	5896.9090	2068.2470	5312.9090
Std. Dev.:	15.7124	15.6687	21.8352	14.3274	18.7486
Skewness:	23.6236	50.1388	102.2684	6.7590	97.3740
Kurtosis:	1028.659	4995.6630	19847.7100	3012.9370	23096.6700

Table 3. Summary of flows, predicted flows and prediction errors. Pred. is prediction, Qu. is quartile.

Table 3 summarises the residuals from models 1 and 2. The addition of the religion variable increases the size of the errors and this is perhaps counter-intuitive. One possible explanation is that, while religion may have an important influence on work flows overall, the relationship is not straightforward, and it may not be an important factor for all places, workers, or employment sectors. Figures 1 and 2 show,

respectively, the residuals from estimates made by each model of total flow into each ward. In both cases, the marked over-estimation of total flows in urban areas is apparent. There are some instances of marked under-estimation of total flows, including the Aldergrove ward (the location of Belfast International Airport), to the east of Lough Neagh. An obvious next step is to account for urban/rural differences, and various approaches are being explored.

Shuttleworth and Lloyd (2005) and Lloyd and Shuttleworth (2005) demonstrated the marked spatial variation in relations between average commuting distances and a range of other variables in 1991 in NI. The inadequacy of a global regression model was highlighted, and the value of local regression approaches such as GWR was stressed. In the present research, the global model clearly fails to explain much of the variation in commuting flows. While the addition of further explanatory variables may improve the explanatory power of the global model, it is likely that significant spatial variations in the residuals from such an expanded model will remain, and that such variations are due to more than simply model misspecification. The paper will therefore assess spatial variations in flows by applying origin and destination specific gravity models. Nevertheless, the preliminary analysis presented here has enabled some initial ideas to be developed about the factors influencing ward-to-ward flows of workers in NI. It seems clear that there is much room for increasing the explanatory power of the model and the spatial patterns revealed by the residuals suggest some possible approaches.

4. Conclusions and future work

The analyses of interactions between wards presented in this paper are limited to the use of an unconstrained Poisson gravity model. Additional work will extend to other models. These will include various origin and destination specific models to allow the assessment of locational variations of commuting flows. More specifically, the potential benefits of applying variants of such models, as detailed by Nakaya (2001), will be explored as part of future work.

5. Acknowledgements

The Northern Ireland Statistics and Research Agency (NISRA) are thanked for the provision of 2001 Northern Ireland Census of Population data. The ward-to-ward road distances were calculated using data provided by NISRA.

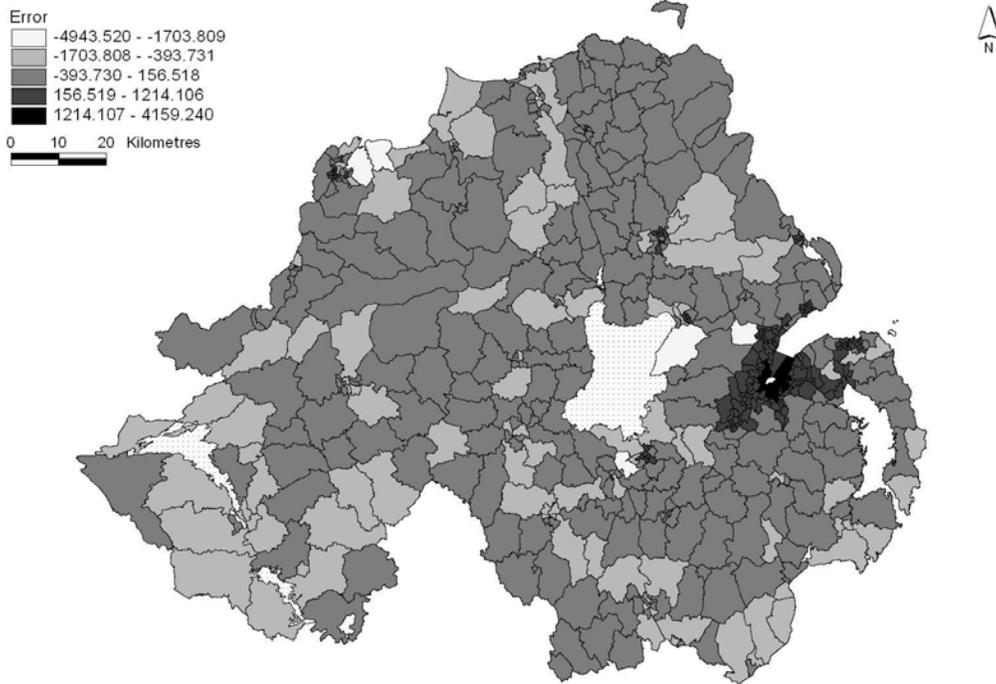


Figure 1. Model 1: estimated total flow into wards minus observed total flow into wards. NI Census of Population data — © Crown Copyright. Reproduced under the terms of the Click-Use Licence.

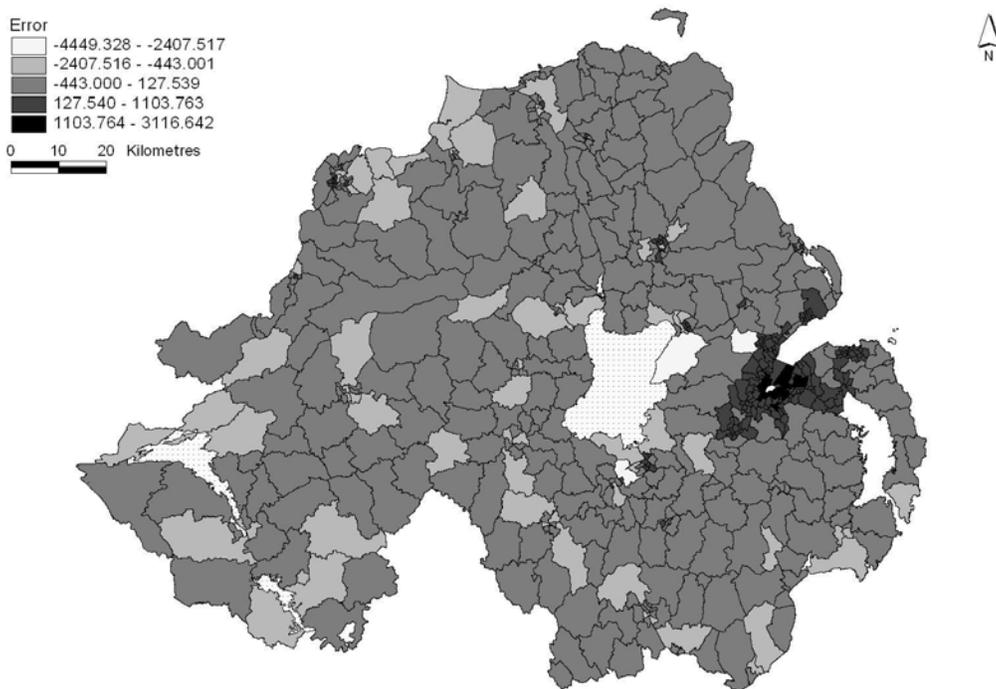


Figure 2. Model 2: estimated total flow into wards minus observed total flow into wards. NI Census of Population data — © Crown Copyright. Reproduced under the terms of the Click-Use Licence.

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Biography

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