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A spatial microsimulation approach to economic policy analysis in Scotland

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Abstract. Regional scientists have increasingly been playing a very important role in the development and application of spatial microsimulation models for policy analysis. It has long been argued that spatial microsimulation modelling has enormous potential for the evaluation of the socio-economic and spatial effects of major developments in the regional or local economy. This paper aims to add to this rapidly expanding work, by presenting a new spatial microsimulation model (SIMALBA) for Scotland (the development of which was co-funded by the Scottish Government) and by demonstrating how it can be used to perform what-if policy analysis in Scotland. The focus of the paper is on economic aspects of social and spatial inequality in the capital of Scotland, Edinburgh. The paper shows how spatial microsimulation modelling can address previously unanswered research questions in Scotland, particularly those relating to fiscal policy. The SIMALBA model has estimated income data for Scotland at output area level geography and this is the focus of the various 'what-if' policy scenarios. Simulated data has been created using a deterministic reweighing algorithm to build a spatial microsimulation model by combining UK Census data for 2001 and Scottish Health Survey (SHS) data for 2003. The analysis demonstrates the importance of geography by examining trends at OA level in Scotland. The paper concludes with a discussion of the simulated data and resulting policy scenarios as well as the impact of this analysis for policy formation in Scotland.

JEL classification: C5, I3, R1, R28

Key words: geography of income, income inequalities, social security, welfare benefits, fiscal policy

1 Introduction

It has long been argued that there is a need for a geographical approach to social policy and welfare analysis. Although there have been long very important theoretical debates about the relationships between social context, social norms and human needs (e.g., see Runciman 1966; Sen 1987; Townsend 1987; Doyal and Gough 1991; Gordon and Pantazis 1997; Frank 2005; Wilkinson and Pickett 2009; Dorling 2011) there have been relatively limited attempts to add a geographical dimension. Among the first comprehensive attempts to add a geographical dimension to these debates is the seminal work of Smith (1973) exploring the geography of social well-being in the United States and adopting a geographical approach to the analysis of welfare (Smith 1977). In addition, Bennett's (1980) comprehensive work on the geography of public finance strongly argued for a spatial dimension to the traditional public finance analysis by including (with the basic *public finance distribution between people* question) another set of issues concerned with the geographical dimension of this distribution and putting the question of how burden and public expenditure vary as a function of spatial location. Another very good and more recent example of a comprehensive geographical approach to the analysis of social issues is the work of Pacione (1995a, 1995b, 1997). There have also been important attempts to provide evidence-based analysis of social and spatial inequalities (e.g., see Burrows and Rhodes 1998; Madden 1993; Mitchell et al. 2000; Dorling et al. 2007).

Overall, it can be argued that regional scientists are particularly well suited to address these issues. There is a long history of modelling work in geography and regional science that focuses on the assessment of the various short-term and long-term effects of major socio-economic regional or local developments. But, there has been relatively limited work on the development and application of regional science models for the estimation of the geographical impacts of *national* public policy. Nevertheless, over the past thirty years there has been a rapidly increasing number of regional scientists around the world who have been involved in the development and application of spatial microsimulation models (for recent reviews see Ballas and Clarke 2009; Birkin and Clarke 2011). Spatial microsimulation is a methodology that attempts to estimate the demographic and socio-economic characteristics of human behaviour of individual people or households (Clarke 1996; Ballas et al. 2005). Such data, although routinely collected by governments from censuses and population surveys are not typically available to researchers and policy-makers due to privacy and confidentiality concerns. Spatial microsimulation builds on a long successful history of traditional microsimulation models, which have been used widely to analyse re-distributive effects under different policy scenarios. In particular, microsimulation has been broadly developed and used by economists over the last 40 years.[1] Microsimulation methods aim to examine changes in the lives of individuals within households and to analyse the impact of government policy changes for each individual and each household (Hancock and Sutherland 1992; Harding 1996; Mitton et al. 2000). In an economic and social science context, microsimulation can be defined as a type of computer program that simulates how a social policy would operate under proposed changes and how particular types of individuals would be affected or react. Recent examples of using microsimulation for policy analysis in Europe include the EUROMOD microsimulation model used for various types of analysis (Lelkes and Sutherland 2009). Static microsimulation involves the analysis of a population microdata set at one point in time for policy analysis. For instance, economists have been involved in the development of static microsimulation models that are capable of analysing the impacts of a particular social policy scheme upon different types of households and individuals as well as the redistributional impacts of the government budget changes. The results of microsimulation models are widely quoted in the media when covering the possible impact of government budget changes upon different types of households (Clarke 1996; Ballas et al. 2005).

Spatial microsimulation adds a geographical dimension to traditional economic microsimulation models. In particular, adding spatial detail to traditional microsimulation involves creating a microdata set, as well as using it. Such a microdata set refers to a particular locality, to a geographically well-defined and restricted area such as census output areas (OA). There are very few sources of geographically detailed microdata sets, so there is a need to create these datasets

[1] Microsimulation was first introduced by Orcutt (1957.

using static spatial microsimulation techniques. The latter involve the merging of census and survey data to simulate a population of individuals within households (for different geographical units), whose characteristics are very close to the real population. They can then be used to answer questions pertaining to the geographical, as well as the socio-economic impacts of urban, regional or national government policies (Clarke 1996; Ballas et al. 2005). In particular, over the past decade there has been considerable progress in the development and application of spatial microsimulation models for national policy analysis by regional scientists in a wide range of fields including social policy (e.g., Ballas and Clarke 2001; Chin et al. 2005; Ballas et al. 2007), poverty small area estimation and analysis (Ballas 2004; Tanton 2011), health (Tomintz et al. 2008; Morrissey et al. 2008; Edwards and Clarke 2009; Smith et al. 2011), agricultural policy (Ballas et al. 2006a; Hynes et al. 2009), international migration (Rephann and Holm 2004), educational policy (Kavroudakis et al. 2012) and crime analysis (Kongmuang et al. 2006).

The research presented in this paper aims to build on this policy-relevant work by presenting a spatial microsimulation model for the analysis of national public policies in Scotland. This is, to the best of our knowledge, the first attempt to build a spatial microsimulation model specifically for Scotland. It can be argued that efforts to build models, such as the one presented in this paper, would be particularly useful and important in the changing public policy context since devolution and especially given the current debate about a referendum on Scottish independence (for more information on the changing policy context see Keating 2009, 2010; Danson et al. 2012; Danson and Lloyd 2012; Law and Mooney 2012).

This paper presents SIMALBA,[2] a spatial microsimulation model of the Scottish population and it shows how it can be used to model the geographical impacts of national fiscal policies, focusing on the capital of Scotland, Edinburgh. The paper proceeds as follows: Section 2 briefly discusses the UK and Scottish policy context and outlines examples of policies that could be modelled using a spatial microsimulation model. Section 3 presents the data and methods that were used to develop the SIMALBA model. Section 4 shows how SIMALBA was used to estimate the spatial impacts of the policies discussed in Section 2. Section 5 offers some concluding comments.

2 The UK and Scottish policy context

Before discussing our spatial microsimulation model and how it was used for policy analysis it is useful to provide a brief discussion of the current situation of government in the UK and Scotland in particular. It should be noted that there is a multi-level governance system at work, with regional (Welsh, Scottish and Northern Irish) parliaments responsible for devolved matters. The devolved administrations do not have any control over defence or international relations but over specific devolved areas such as health and education for example (Cairney 2006). In addition, there is an unusual situation at present at the national (UK) level, with a coalition government in place with a set of proposals for welfare reforms which have been described as “perhaps the most radical reshaping of the British welfare system since its introduction post-1945” (Hamnett 2011, p.147). Fiscal policy is still driven primarily by the UK government, although the Scottish government does have some tax varying powers. The tax varying powers extend to adjusting the basic rate of income tax by three pence in the pound if desired (Mair and McAteer 1997), the so called ‘tartan tax’.

The economic policy which a government pursues can have real and lasting consequences in people’s lives, as it affects the levels of employment, unemployment benefits, the income

[2] Sim – referring to simulation and Alba meaning “Scotland” in Scottish Gaelic.

distribution and education and training. These consequences also have important geographical dimensions (Ballas and Clarke 2001). A fiscal policy which stimulates demand in areas most adversely affected is likely to improve the level of employment and income in these areas.

It is interesting to provide a brief overview of the policies that have been debated in the last UK parliamentary election drawing on the main three political party manifestos. Prior to the 2010 British general election political parties published a series of manifestos filled with a set of promises in the event that the party concerned are elected to serve in government. It is these manifestos from the Labour Party, the Liberal Democrats, the Conservative party and for Scotland, the Scottish National Party (see The Labour Party 2010; Liberal Democrats 2010; The Conservative Party 2010; The Scottish National Party 2010 respectively) that contain the likely alterations to existing policy or the new policies which could be introduced during a period of government by the respective political party. One of the key proposed policies was to increase the threshold of income tax to £10,000, meaning that the first £10,000 of earned income would not be taxed. In other words the tax rate on earnings up to £10,000 would be 0 per cent. However, there will still be deductions, for example national insurance and so forth. The idea behind this policy proposal was that it would provide an incentive to 'make work pay' over and above the level of state benefits an individual or family would be receiving. This would thereby remove incentives encouraging individuals to remain on benefits, as their absolute income was potentially lower or equal when in employment. Additionally, the effective marginal rates of tax for some individuals moving from benefits to employment are high. Governments in the United States, Canada, UK and New Zealand have resorted to measures such as in work benefits, for example tax credits to try to alleviate poverty without creating adverse incentives for participation (Brewer et al. 2009). Another report notes the problem of working a minimum wage job that, "compared to an income at 40 hours of work, a couple on Jobseeker's Allowance will only be £29.06 better off" (Kay 2010, p.7). This kind of scenario is known as the 'poverty trap' (Kay 2010) in the UK.

At the other end of the income scale the planned rise in the tax rate on those earning over £150,000 will help to address income inequality to some extent, particularly if the goal is to redistribute this wealth towards the 'poorest' in Scotland (or the UK). Other policies, mainly from the Conservative party manifesto, suggest removing the child benefit payments for those earning over a certain limit as well as placing a cap on the level of Housing Benefit by number of bedrooms.

As noted above there is an important geographical dimension to public finance and fiscal policies and there is a need to address the geographical as well as the socio-economic impacts of social policy change. It would be reasonable to expect that geographers would and should be at the forefront of addressing these issues and there has long been strong criticism of the lack of 'policy relevance' of geography as a discipline (Peck 1999; Martin 2001; Dorling and Shaw 2002). Nevertheless and despite such criticisms there have been very few examples of geographers engaging with such issues and it has recently been argued that "not only has the geography of social security and welfare benefits been a much-neglected issue within the subject . . . but the cultural turn within human geography has arguably redirected interest away from the important material basis of economic and social life, towards issues of representation and identity which are arguably far removed from the everyday experiences and problems of most people's lives" (Hamnett 2011, p.147).

As noted in the introduction, there have been considerable efforts by a small but growing number of quantitative geographers and regional scientists to address the geographical implications of public policies at different spatial scales. The work reported in this paper aims to contribute further to these efforts with the development and use of spatial microsimulation techniques to model some of the policy scenarios outlined above. In particular, the focus of the analysis is on two proposed taxation policy changes as well as proposed amendments to child benefit and housing benefits. In particular, one of the policies that we explore is the proposal to increase the threshold of income tax to £10,000. The result is that the first £10,000 of earned income is not taxed (in other words the tax rate on earnings up to £10,000 would be 0%). The second policy under investigation is at the other end of the income scale, the highest earners. The rise in the tax rate on those earning over £150,000 to 50 per cent (from 40%) could arguably help to address income inequality to some extent. There is some debate over the efficacy of such a tax, with a UK Treasury report estimating the amount (HM Treasury 2009) that could potentially be collected. This could be the case if the goal is to redistribute this increased tax towards the 'poorest' in Scotland (or the UK). It is also worth noting that this tax is currently under review and it is very likely that it will be reduced to 45 per cent in 2012 (BBC News 2012). We also explore the geographical impacts of proposed welfare policy changes pertaining to housing and child benefits. In particular, we model and map the geographical impact of the current coalition government's proposals for a maximum level of housing benefit of differing levels depending on the size of the property. We also model the proposed changes to child benefit entitlement for households with earnings over a given income threshold.

3 The SIMALBA model

Our model, SIMALBA is based on data from the Scottish Health Survey and the UK Census of population in 2001. The Scottish Health Survey is a cross sectional survey of the Scottish population which began in 1995 and includes extensive information not only on health related variables but also comprehensive data on income and other socio-economic and demographic variables. As it is the case with most spatial microsimulation models, SIMALBA is underpinned by the idea that by using data from a relatively small number of people (for example from the SHS survey) and combining it with unrelated information from an extensive large-scale enumeration (such as the decennial Census of Population) it is possible to add value to the survey microdata set and extrapolate its findings (Ballas et al. 2007). The SIMALBA model was based on a deterministic reweighting methodology similar to approaches underpinning models such as SimBritain (Ballas et al. 2005, 2007) and SimObesity (Edwards and Clarke 2009) and involves reweighting of an existing microdata set (such as the SHS) in order to fit small area descriptions such as census small area data, also known in the spatial microsimulation literature as small area constraints (Williamson et al. 1998; Ballas et al. 2005). Once the constraints have been set-up for both the SHS and census data the process of deterministic reweighting can begin, which creates the new weights. In general terms this takes the form shown in the equation below whereby the Newweight (*NW*) for individual i, is calculated by multiplying the weight (*W*) for individual *i* by element *ij* of the Census table divided by element ij of the SHS table:

$$NW_i = W_i \times CEN_{ij} \big/ SHS_{ij}$$

The weight (*W*) in this case is set to 1, rather than the survey weight. Sensitivity analysis of iterations with a starting weight of 1 for each individual in the SHS, compared with the SHS survey weight also were trialled with negligible difference in the outputs, but marginally in favour of the former approach.

A simple two constraint example of microsimulation is outlined in Tables 1–4, showing how the process works. What has been done is that the original survey weights seen in Table 1 have been adjusted to new (re)weighted survey weights that now form the microsimulated microdata set (see Table 4). Using the formula the first new weight is calculated by multiplying the weight (W_i), which is 1, by the old owners (CEN_{ij}) of whom there are 3 (i.e., Table 2 row 2, column 1), divided by the corresponding number (SHS_{ij}) which is 2 (i.e., Table 3 row 2, column 1). So in

Table 1. A simplified microdataset (SHS)

Serial number	Tenure	Age	Survey weight
001	Own	Old	1
002	Own	Old	1
003	Own	Young	1
004	Rent	Old	1
005	Rent	Young	1

Table 2. Census cross tabulation for output area

Age	Own	Rent
Young	3	5
Old	3	1

Table 3. Microdata (SHS) cross tabulation

Age	Own	Rent
Young	1	1
Old	2	1

Table 4. A simplified microdataset (SHS)

Serial number	Tenure	Age	Survey Weight	Re-weight
001	Own	Old	1	1 * 3 / 2 = 1.5
002	Own	Old	1	1 * 3 / 2 = 1.5
003	Own	Young	1	1 * 3 / 1 = 3.0
004	Rent	Old	1	1 * 1 / 1 = 1.0
005	Rent	Young	1	1 * 5 / 1 = 5.0

summary that is $1 \times 3/2 = 1.5$, which is the new weight shown in Table 4. This process is completed iteratively until a suitable level of convergence is reached.

The above process was followed to adjust the weights of all records in the SHS to match a selection of small area descriptions (on the so called census Output Areas(OAs), which, on average, have a population of around 125 households), which is shown in Table 5.[3]

It should be noted that the development of the SIMALBA model was part-funded by the Scottish Government and one of the key aims of the model was to explore the geographical and socio-economic impact of public policies in Scotland and to also investigate linkages between socio-economic issues and health inequalities. This influenced the decisions on the choice of datasets that formed the basis for the model and hence the SHS was selected. Another key reason for selecting the SHS is that it has a relatively large sample size for Scotland compared to other surveys typically used in a spatial microsimulation models in Britain (e.g., see Ballas et al. 2007) such as the British Household Panel Survey (BHPS). As Boyle et al (2009, p. 386) point out: "studies that encompass the whole of Britain rarely have sample sizes that allow for Scotland-

[3] The SIMALBA was developed in the free statistical software package R and in order to enhance transparency and encourage further development, the code is available by the authors upon request on an open source basis.

Table 5. Input data: UK Census of Population

Variable	Table	Description
Age	CS02	Age by sex and marital status: all
Sex	CS02	Age by sex and marital status: all
NSSEC	UV31	NS-SeC: ages 16 to 74
Long Ill	UV22	Limiting long-term illness: all
Tenure	CS17	Tenure and age by health and LLTI: HH
Qualifications	KS13	Qualifications and students: ages 16 to 74
Marital status	CS02	Age by sex and marital status: all
Economic activity	CS28	Sex and age by EA: ages 16 to 74

specific research". An alternative that was considered was the UK Household Sample of Anonymised Records (also used in spatial microsimulation applications in the UK, such as MoSeS; see Wu et al. 2008) which has a very large sample size for Scotland and overall is a very high quality data set. But this did not include information on income, which is a key policy relevant variable (and this was included in the SHS). It should be noted that in the UK the census does not provide any information on variables such as household income, wealth and taxation.

With regards to the choice of small area constraint variables, we used a combination of demographic and socio-economic variables that are thought to be correlated with income (a key variable in our model) and overall quality of life, as it is also the case with other spatial microsimulation studies of this kind (e.g., see Ballas et al. 2007; Hynes et al. 2009; Kavroudakis et al. 2012).

This process resulted in the creation of a small area microdata set that can be used for what-if policy analysis. This dataset has also been proved to be a reasonably robust estimate of the data (see Figure 1) to within 5 per cent to 10 per cent of the actual census data. Following the conventional approach to validating the outputs of spatial microsimulation models, the SIMALBA outputs were extensively compared against known census totals for both variables that were used as constraints (and which matched extremely well) as well as variables which were not used as small area constraints, using scatter plots such as that shown in Figure 1. In particular, what can be seen from Figure 1 is that an unconstrained variable, ethnicity, has been simulated using the SIMALBA algorithm and then compared with the 6,637 census output areas in Lothian HB as a direct comparison. The figure shows the variability of the estimates, plus or minus 5 per cent and 10 per cent lines. The fit of the data is reasonably robust given the model was not designed to predict ethnicity, most estimates within 10 per cent with a few output areas over predicting non-white ethnicity and therefore under predicting white ethnicity in these same areas, similar to models elsewhere (Smith et al. 2011).

4 Using SIMALBA for what-if economic policy analysis

In this section we show how the SIMALBA model was used to simulate the geographical impacts of some of the key policy changes discussed in Section 2. In particular, we simulate the impacts of a raise in the bottom income tax threshold, the 50 pence tax rate for every pound earned over £150,000 (which was an increase on the tax rate of 40 per cent and was introduced by a previous Labour government), as well as proposed changes in the housing and child benefit. We also created maps showing the geographical distribution of these impacts at the small area (census output area) level for the greater Edinburgh city region (see Figure 3 and 4), with a reference map of some key areas within Edinburgh city (see Figure 2).

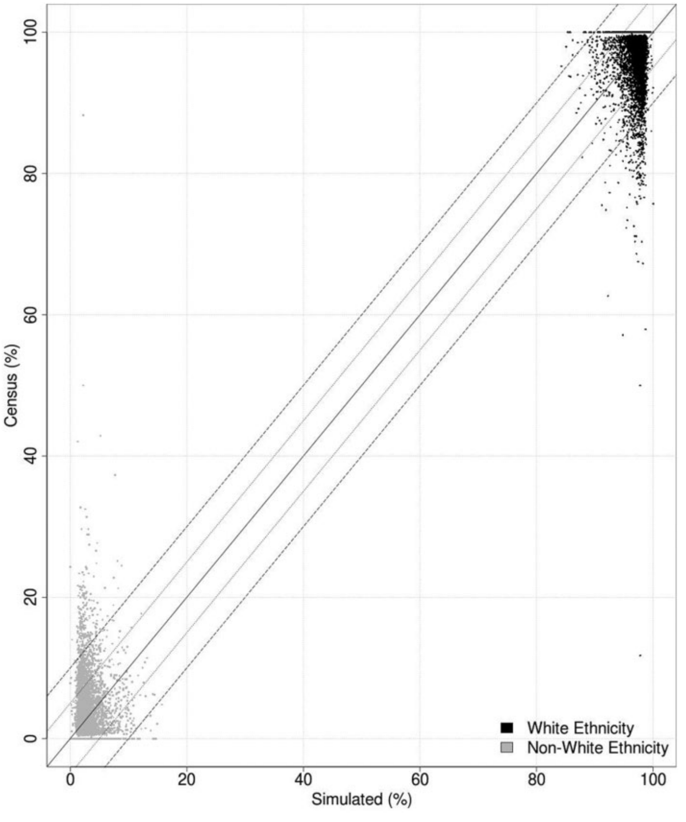

Fig 1. Constraint validation for Lothian Health Board

4.1 Modelling income tax: raising the income tax threshold

As noted in Section 2, there has been some discussion about the advantages and disadvantages of raising the income tax threshold for individuals in the UK as well as more general taxation issues which have been outlined by several different bodies with varying viewpoints. In general, the consensus is that raising the tax threshold will provide an incentive whereby employment will be preferable to living on benefits as the first £10,000 of income earned will be received by the individual directly. It could be argued that this addresses situations whereby an individual is in a more financially secure position in choosing not to be in employment and continue to support him or herself using the welfare entitlements provided to them by the state. The current rules stipulate that the personal allowance is £6,475 for 2009–2011 and will rise to £7,475 by 2011-12 (see HMRC[4]). As discussed previously there is a compromise in the microsimulated dataset in that there is only categorical data for microsimulated income. Therefore, the policy analysis presents a case for assessing people currently in the income categories up to £7,800 compared with those who are in the income categories up to £10,400 to show the effect of the policy if the income tax threshold was raised to the £10,400 level from £7,800. It therefore must be noted that it is a compromise that the cut-off point has been chosen as £10,400 due to the categorical nature of the estimated income distribution from SIMBALBA. The remainder of this

[4] http://www.hmrc.gov.uk/rates/it.htm.

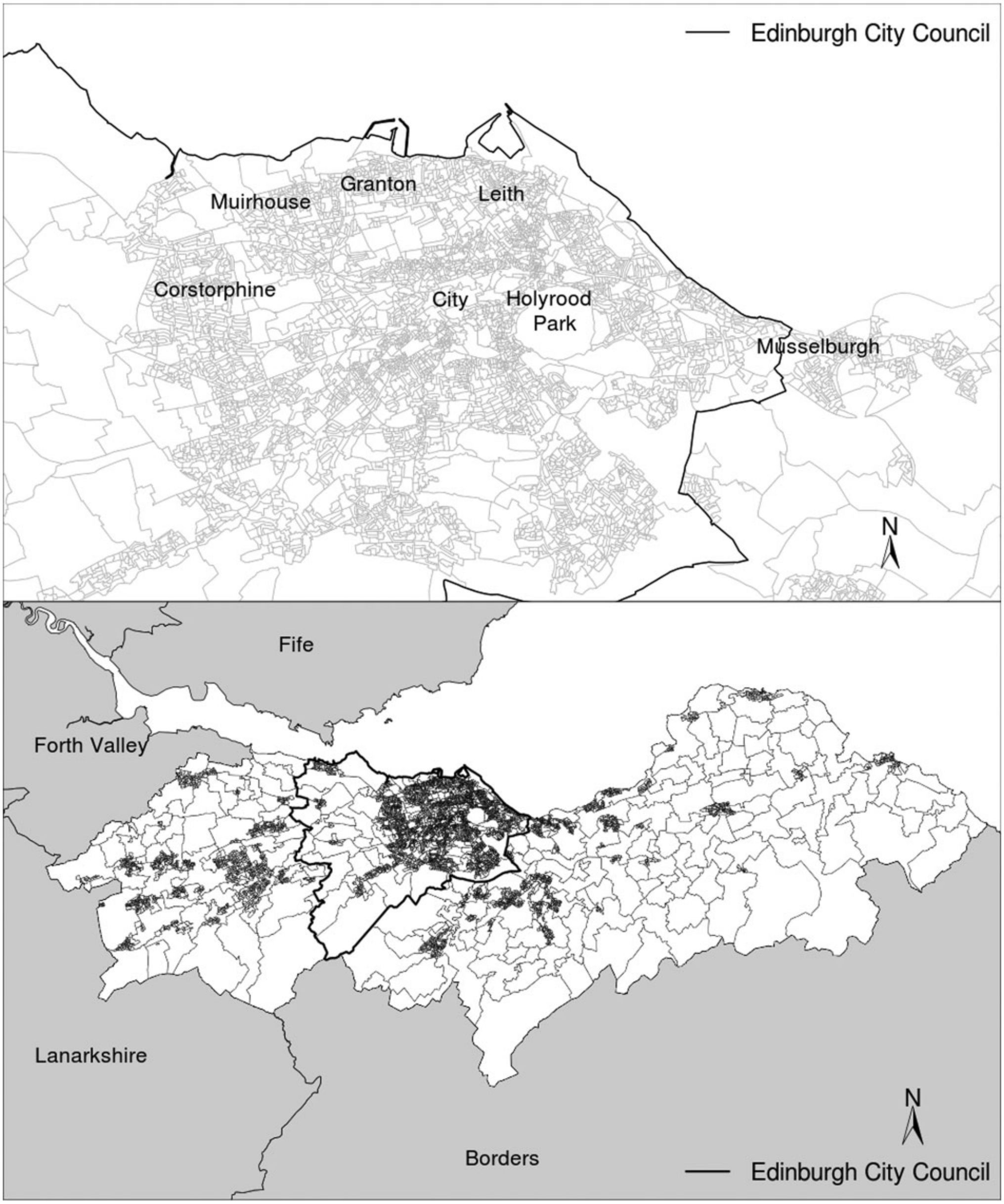

Fig 2. Reference map

section explores the spatial distribution of the individuals live who will ‘gain’ most from the increase in the income tax threshold to a hypothetical position of £10,400.

Figures 4 and 5 show the situation in the Lothian region and in Edinburgh City OAs within the Lothian region and those who will benefit most from the changes. The darkest colour, represents the highest proportions (the areas with proportions in the highest fifth of the distribution) of low income earners, that is up to £10,400 in each OA and the lightest colour represents the least low income earners as a proportion of total population in that OA. The distribution of areas has been split into quintiles, so Q5 represents the areas with the highest proportions of low

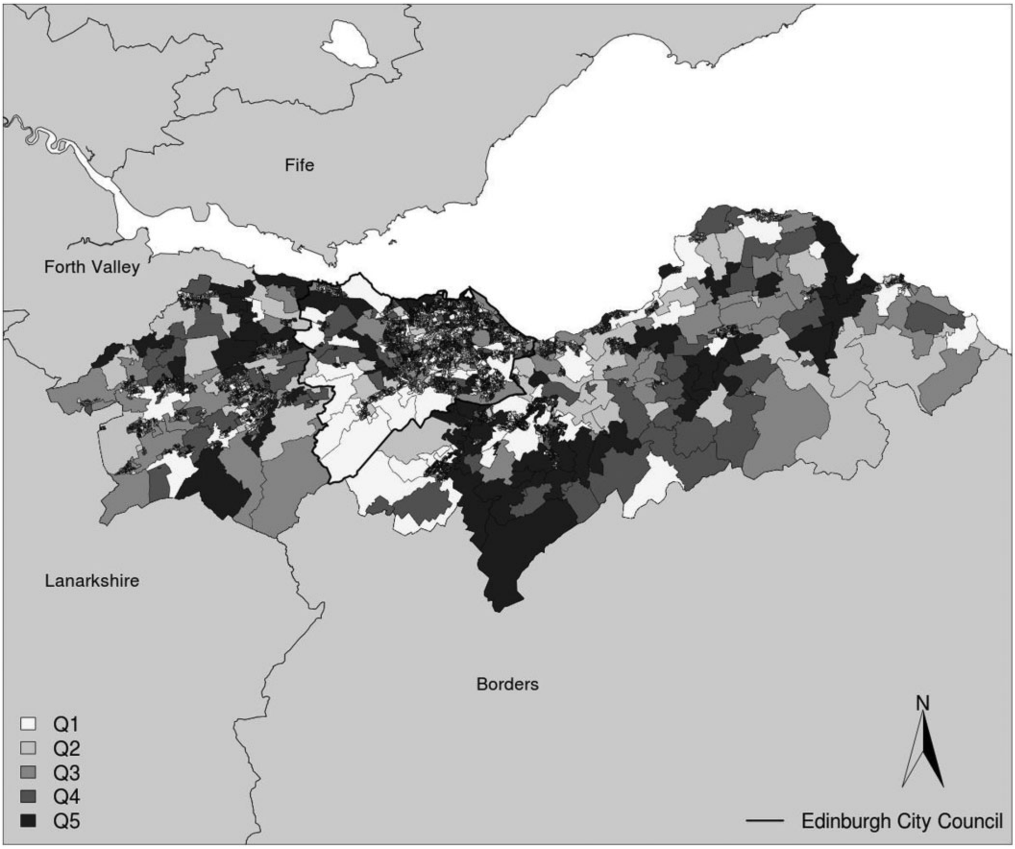

Fig 3. Percentage earning up to £10,400 Lothian region: quintiles

earners, Q1 the areas with the lowest concentrations. The wider Lothian region exhibits a general trend of those areas with the highest proportion of low income earners being located in OAs around Edinburgh (in the middle of the region) or around urban areas. At the other end of the distribution, the areas with the lowest proportion of low earners are generally speaking, located in the more rural areas of the Lothian region, for example in the east, near North Berwick and to the south west of Lothian region also. It is also interesting to explore the distribution at smaller area level within Edinburgh City. It can be argued that within Edinburgh there is a slight clustering effect, particularly around Muirhouse and Leith (to the north) where there is a concentration of low income persons. There is also some clustering of (Q5) areas to the western edges of the figure. The power of a simple map is that we can see where it is likely that individuals who will benefit most will reside and target particular policies or resources to those areas if desired.

4.2 Modelling the 50 pence tax rate change

The introduction of a tax rate of 50 per cent on personal income in the UK is discussed in detail. SIMALBA allows the spatial distribution of people who will be affected by this change to be mapped at OA geography (or any other spatial scale) for the Lothian region. First, the percentage of people who earn over £150,000 must be calculated in each OA. This can then be mapped as

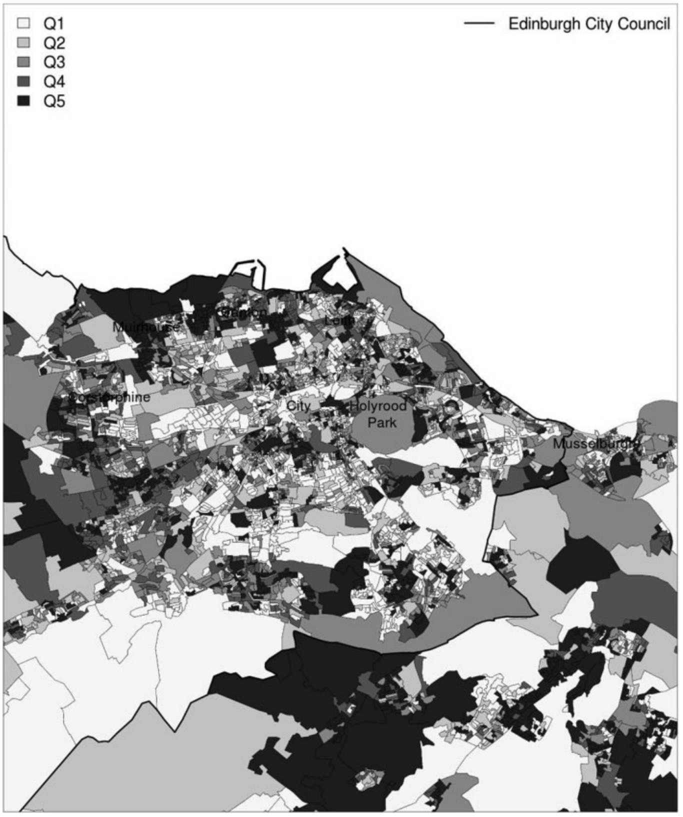

Fig 4. Percentage earning up to £10,400 Edinburgh: quintiles

shown in Figures 5 and 6 respectively. What each map represents is the percentage of people in each OA that would be liable for a 50 per cent rate of income tax if it were to be introduced in Scotland.

Figure 5 shows the Lothian OA model outputs and Figure 6 shows a version of the same model, but focused in on Edinburgh City. What can be deduced from Figure 5, is that the pattern would appear to be fairly random, such that those parts of Lothian where the microsimulated data has estimated the highest concentrations of those earning £150,000 and therefore will be liable for a new 50 pence tax rate on those earnings is not immediately obvious other than to highlight it is mainly the polar opposite of the figure showing those earning up to £10,400. There are smaller clusters to the south of Edinburgh and the eastern side of Lothian region also has some concentrations, but overall a clear pattern is difficult to deduce. This may be due to the small proportions in each area.

Looking within Edinburgh the main concentration of these individuals is around the southern edges of the city. There is also a clustering effect of the highest proportions of areas with those earning £150,000 or more around the financial and central western districts of Edinburgh and Holyrood Park. There are also notable gaps, with areas in the lowest quintile mainly to the north of Edinburgh. The spatial pattern then is not particularly easy to categorize for this particular microsimulated data. It is the areas in the darkest shade of the colour that will be affected by an increase in the tax rate on individuals earning over £150,000 most severely.

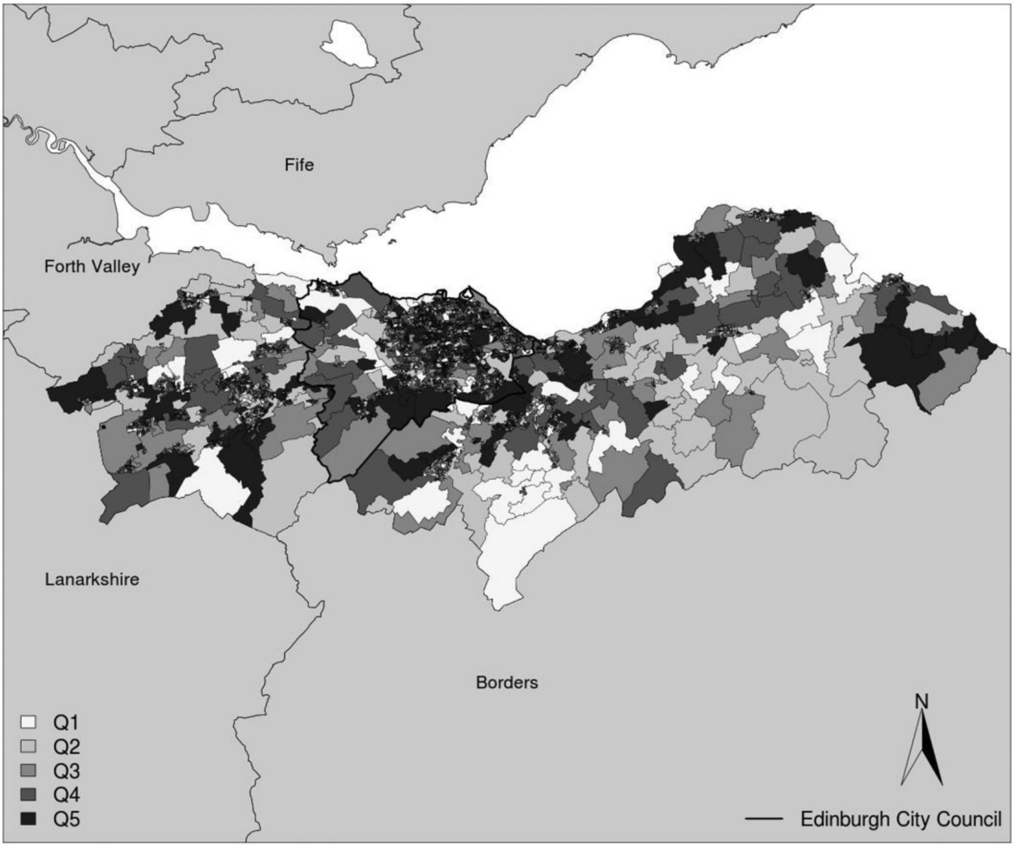

Fig 5. Percentage earning over £150,000, Lothian region: quintiles

4.3 Modelling changes in the housing benefit

We now move to another major application area for the SIMALBA model, that of welfare policy change. The focus of this subsection is on the potential changes to housing benefit. The current situation is also modelled where possible to show the 'before' and 'after' results. Both will be explored in more detail in the subsections that follow. The previous analysis on income tax is used as a template for the analysis of policy on welfare, with analyses involving welfare changes described here. The results are of particular relevance for policy debates surrounding issues of who will bear the burden of the cuts most acutely including which areas (and which people) the cuts will effect most directly.

The aim of housing benefit is to provide those on low incomes or in receipt of welfare with a way in which to pay their full housing costs, for example rent is the most obvious cost. It is therefore a means tested benefit. In practice, this can be beneficial to both the tenant receiving this benefit, but also to those private landlords who will potentially gain financially from providing accommodation.

The rules surrounding the eligibility for housing benefit are complex as when eligibility is established there are varying rates that can be paid as well as for different reasons (Child Poverty Action Group 2003). Briefly, there are several key criteria. Income must be low (which is defined as below a certain threshold) and savings and capital must also be below a certain limit (usually under £16,000). An individual is not normally eligible for housing benefit if a full time student or

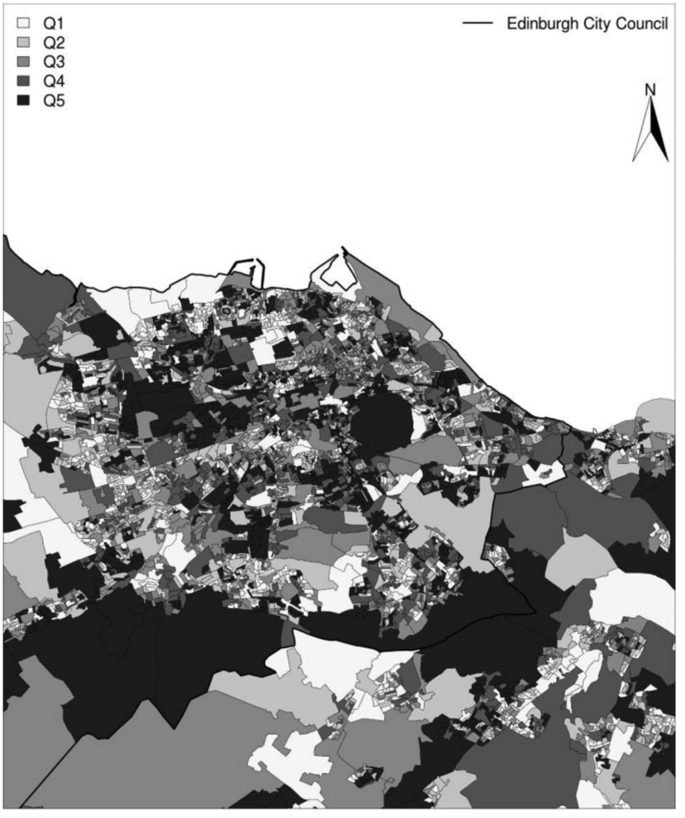

Fig 6. Percentage earning over £150,000, Edinburgh: quintiles

from abroad. The individual (or their partner) must be liable for rent and occupy the property in question as their home. The amount that can then be claimed will depend on individual circumstances, for example if a person is receiving job seekers allowance or other benefits.

The current coalition government has proposed a maximum level of housing benefit of differing levels depending on the size of the property. The most likely levels (per week) are around £250 for a one-bedroom property, £290 for a two-bedroom property, £340 for a three-bedroom property rising to £400 for a four-bedroom property at the highest level. This could cause an issue for individuals (or families) that are currently receiving a level of housing benefit which is higher than the new levels to be implemented. The cost difference would have to be made up somehow. This is set against the context of the local housing allowance, which sets rates by geographical area for different parts of the UK. As housing benefit entitlement is complex to model given the dataset, the most efficient and pragmatic approach is to determine the spatial location of housing benefit claimants (and therefore individuals) who will be affected and in which areas. This allows the areas where the likely impacts are greatest to be identified as well as which 'types' of individuals. The assumption underlying this policy analysis is that changes will be felt greatest where there are the greatest number of claimants.

If housing benefit caps such as those above are introduced, those who currently rent property at a rate over and above this threshold will have to make up the difference from their own income or else choose to relocate to a property which is within the threshold for the size of property if this change affects that individual or a particular family. SIMALBA can be used to show likely places where those individuals currently receiving housing benefit reside and therefore those

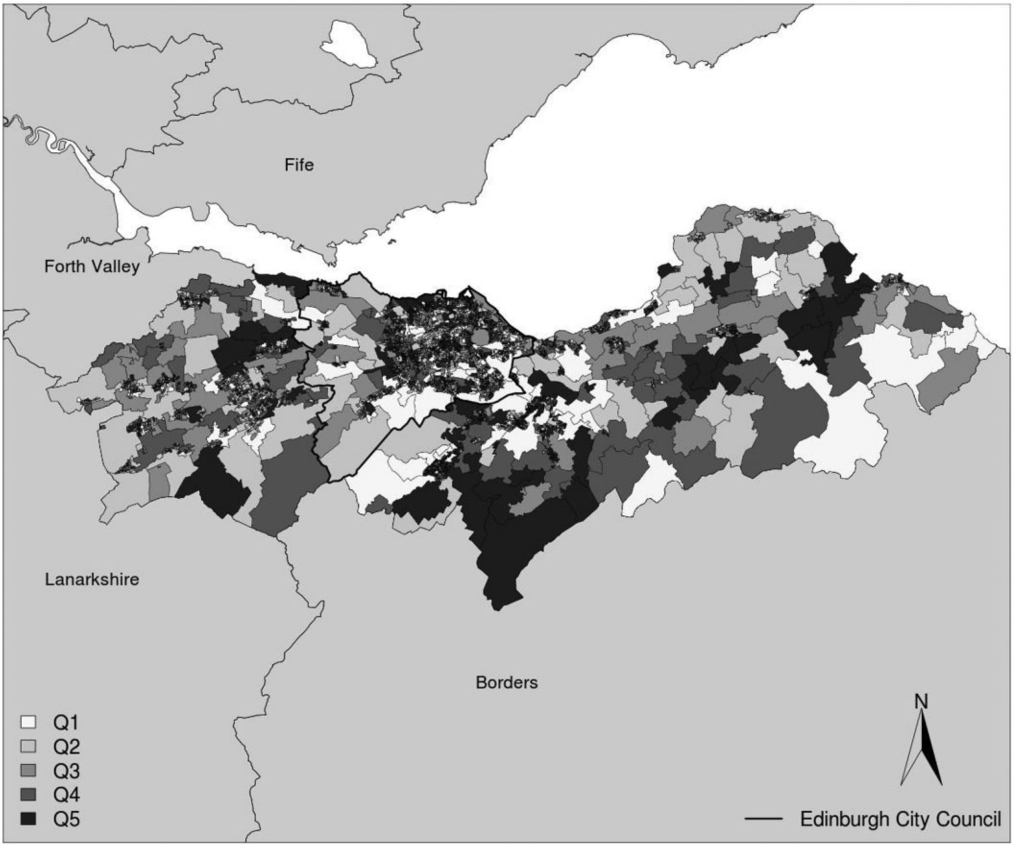

Fig 7. Housing benefit recipients (%), Lothian region: quintiles

most likely to be directly affected by any change to this particular benefit. In order to assess this policy SIMALBA has simply modelled whether or not an individual receives housing benefit. This is a compromise in the dataset as ideally the exact amount is more appropriate but it is not possible to model this with the data available in SIMALBA. On the other hand the model does offer some insights into which people and places could experience the effects of changes in this policy. It is important to issue a health warning with a variable such as receipt of housing benefit. In this type of scenario where external factors have a large influence on the variable the microsimulation model is less robust.

Figure 7 shows the spatial distribution of housing benefit claimants in the Lothian region. It can be argued that the spatial pattern is more clustered than perhaps income, particularly those areas in the bottom quintile (Q1). There is less of a rural urban split with this variable and it would appear to be more clustered than income. Figure 8 depicts the spatial patterns within Edinburgh city. At this level, the expectation is that the location of housing benefit would be determined to an extent by the location of either local authority rented housing locations, or potentially of suitable private sector housing rental alternatives. The model simulates large numbers of housing benefit claimants in the central area of Edinburgh in the areas surrounding Holyrood Park. There is also a series of large clusters on the outer edges of Edinburgh. Additionally, there is a clustering to the north around Leith, Granton and Muirhouse. An interesting future research question which is beyond the scope of this study would be to determine the accuracy of microsimulated housing benefit against the actual housing benefit (official) if this data could be obtained without breaching confidentiality.

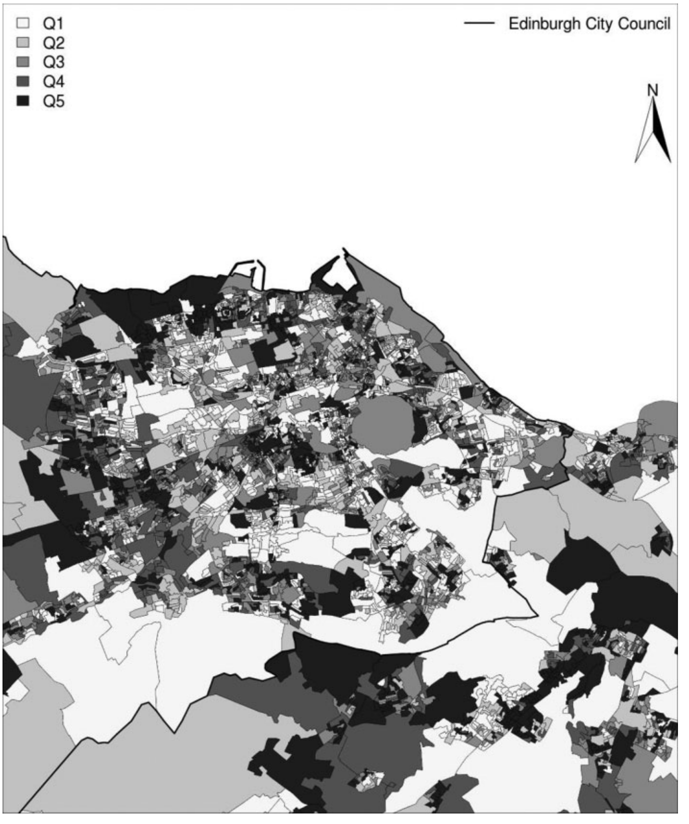

Fig 8. Housing benefit recipients (%), Edinburgh: quintiles

4.4 Modelling changes in child benefit

This subsection presents the analysis conducted using SIMALBA to microsimulate child benefit. Eligibility for child benefit is reasonably straightforward. The benefit is paid "to people who are responsible for a child" (Child Poverty Action Group 2003, p. 1). There is of course a slight anomaly in that the amount paid differs for the eldest child who receives a higher amount of child benefit, than subsequent children. A child is defined in the entitlement criteria as someone who is "under 16" or "16 or over but under 19 who is receiving full-time non-advanced education" (Child Poverty Action Group 2003, p.1) where full-time education is for more than 12 hours a week. So it becomes obvious that even a simple universal benefit like child benefit which appears straightforward can be complex to administer and also as a consequence to model using microsimulation. The rates of child benefit (per week) in April 2003 were £16.05 for the eldest child, £10.75 for subsequent children and £17.55 for lone parents (instead of eldest child rate).

The microsimulated data allows a cross tabulation to be made of those who are receiving child benefit as a source of income, but also earning over £41,600. This means that if government policy were to switch so that it was a means tested benefit (as opposed to a universal benefit) which would be withdrawn for higher rate taxpayers, SIMALBA can map the spatial consequences of such a decision. This builds on the previous section which merely maps one variable, by combining it with a further variable and allowing cross tabulations, demonstrating

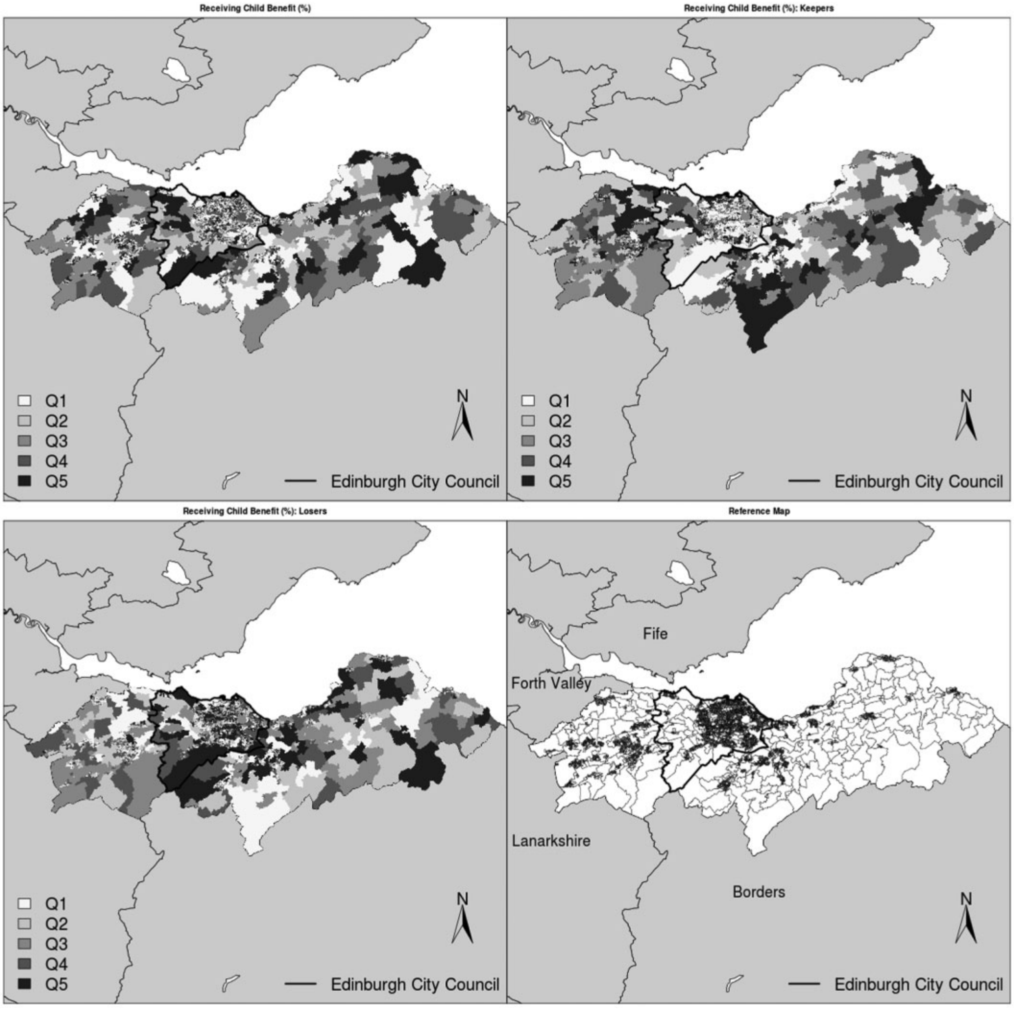

Fig 9. Microsimulated child benefit, Lothian region: quintiles

the power of spatial microsimulation models such as SIMALBA. This data is novel in the sense that the census does not contain such information, either on income or child benefit, therefore neither simultaneously either.

What effect would a policy such as this have at the OA level geography? There is a slightly clustered pattern to the distribution of child benefit as a source of income across the Lothian region (see Figure 9). To the south of Edinburgh as well as other parts of rural fringes feature in the top fifth of areas with individuals claiming child benefit. There are also pockets to the north-eastern extremes and southern of Lothian HB. In terms of a policy change which would affect higher rate tax payers, there is clustering of people who could be adversely effected by a potential change in policy in the more rural parts of the Lothian region. Conversely, there is almost no effect on the areas which are in the lowest quintiles of 'Keepers' as this is a mirror image of the 'Losers' map.

If Edinburgh, shown in Figure 10, is looked at in greater detail it also has clusters of child benefit claimants mainly around the western and north western edges of the city, with notable 'holes' towards the centre, stretching southwards. It is difficult to deduce this pattern visually

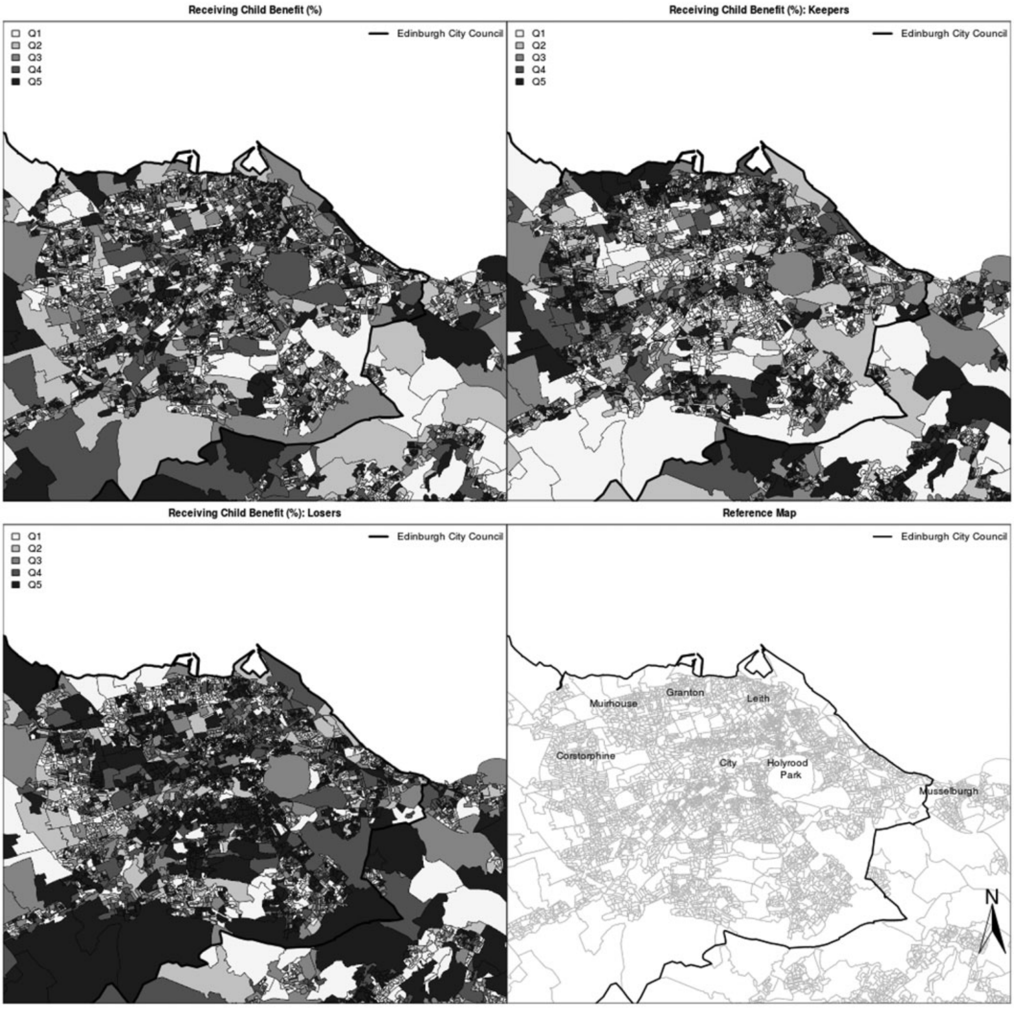

Fig 10. Microsimulated child benefit, Edinburgh output areas: quintiles

due to the differing sizes of output area. There are also various 'clusters' dotted throughout Edinburgh, but no particular location(s) where there is a large concentration except a more general western trend. In terms of the change in policy to child benefit, how would Edinburgh change? Within Edinburgh City there are pockets of 'losers' mainly on the fringes of the city map to the south and west. Whereas those 'keepers' are concentrated to a large extent around the north of Edinburgh as well as just outside the city on the southern edge interspersed with 'losers'.

So, changes to child benefit policy (in terms of who and who will not receive it) could have important spatial consequences, with areas experiencing very different outcomes due to the interaction between income and benefit take up. The main drawback of this type of analysis is that the different areal size of unit makes clusters hard to determine on visual inspection. Overall the analysis presented above gives a useful indication of the consequences of changing child benefit from a universal to a means tested benefit in Scotland. The patterns of 'keepers' and 'losers' does vary from place to place, so this is important to bear in mind when making decisions which alter the entitlement to child benefit.

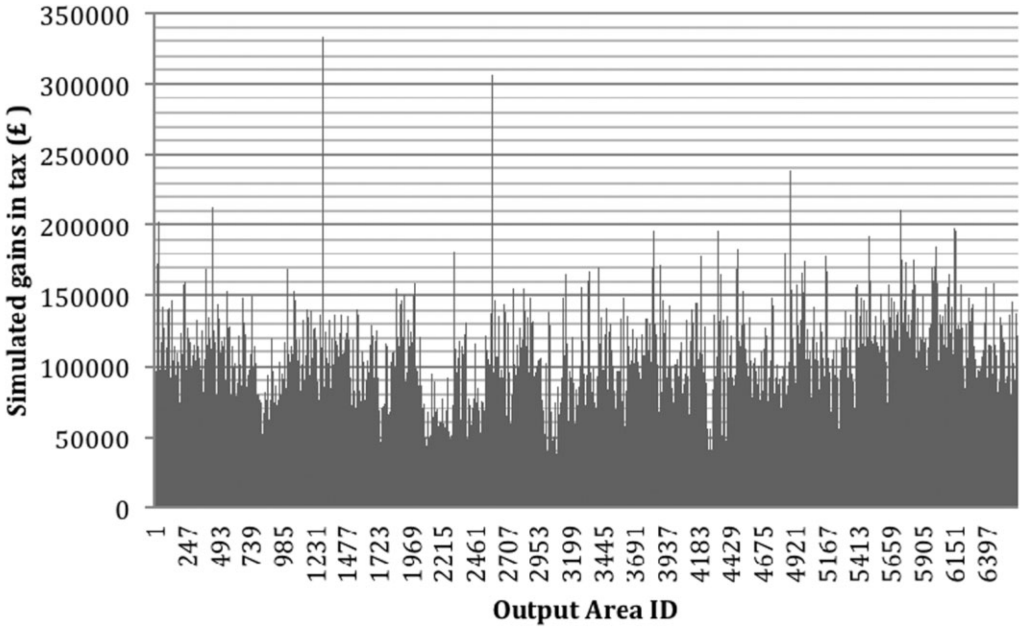

Fig 11. Distribution of policy impacts across Lothian output areas

5 Further analysis of the outputs: area analysis and microsimulated individual case study examples and potential extensions

5.1 Area analysis

So far we used SIMALBA to demonstrate how spatial microsimulation can be used to estimate and map the geographical impacts of different national social policy changes. This analysis can be taken a step further by calculating and mapping the total microsimulated benefits and loss across areas in absolute monetary terms. Here we illustrate how the spatial distribution of the overall effect of the first policy change that we modelled: raising the income tax threshold.

Raising the threshold to £10,400 from £7,800, the mean area gain in Lothian is £65,748.36, the maximum gain is £333,117.90 and the minimum gain is £1,284.08. In other words all areas ‘win’, as every area has people in the bottom categories of income who are lifted out of paying tax. Figure 11 shows how the simulated gains are distributed across all output areas in Lothian, whereas Figures 12 and 13 show these are distributed geographically in Lothian and Edinburgh.

It could be argued that this will have differential, but important local multiplier effects in each area. Within Edinburgh, the areas to the north (Leith) feature with a notable absence of areas in the central areas of Edinburgh itself. There are pockets clustered to the south of Edinburgh city as well as larger clusters to the west and on the coast to the east. This exercise shows how spatial microsimulation outputs can be used to provide an indication of the spatial and distributional effects of increasing the tax free threshold. This kind of analysis may also be of considerable benefit to politicians (and especially local government politicans and officials) who may be interested to see whether areas considered to be desirable places to live in with high quality amenities or, in contrast, deprived, are affected by national social policy change and to offset or ehnahnce any politically undesirable (e.g., reduction of income of households in deprived areas with poor access to services) or desirable outcomes by taking area-based policy initiatives (e.g., targeted area grants to enhance the quality of services and amenitities in

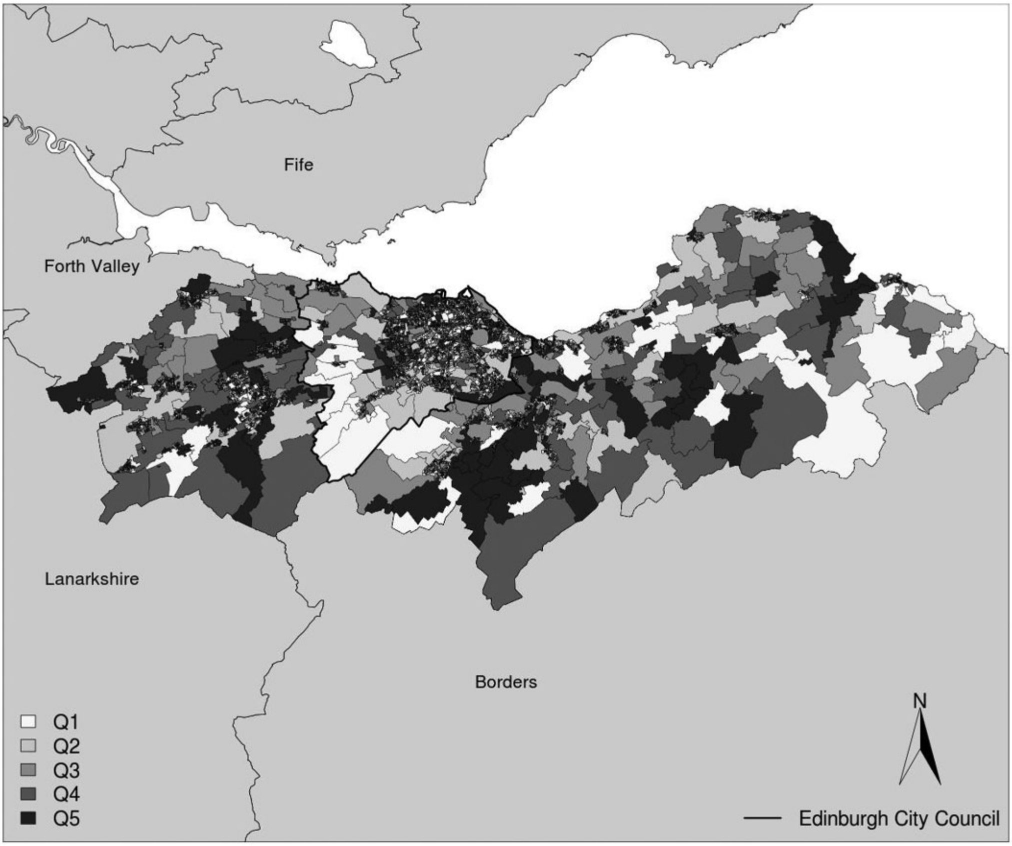

Fig 12. Tax gain, Lothian region: quintiles

particular localities affected by recession fueled budget cuts). The microsimulated welfare policy outcomes could also be used to rank the areas shown in Figure 11 and identify winners (e.g., top ten areas that benefit from a policy change) and losers of a particular social policy change and to also compare this to area-based deprivation scores and geodemographic classifications.

It is also interesting to further explore the model outputs with the use of measures of spatial association (spatial autocorrelation) in order to examine the degree to which there are spatial clusters of areas benefiting the most from a particular policy (and this could also be relevant to area-based policy debates). Table 6 presents the Moran *I* statistics calculated on the basis of the microsimulated change in income tax threshold discussed above. This geographical measure gives an indication of the extent to which, neighbouring areas are similar with respect to a particular variable (e.g., income, tax gain from a policy change, etc.). Positive spatial autocorrelation implies that there is clustering in the features of a variable, namely, neighbours are similar, whereas, the opposite is true for negative spatial autocorrelation; neighbours are dissimilar. A Moran statistic summarizes which pattern exists, either negative values corresponding to negative spatial autocorrelation or positive values to positive spatial autocorrelation. The values of the Moran statistic in Table 6 show us that all the variables are statistically significantly spatially autocorrelated. It is particularly noteworthy that those on the lowest incomes are the most spatially autocorrelated (or clustered) with a positive value indicating areas of low income being close to each other. There is also a similar story for those on the highest (over £150,000)

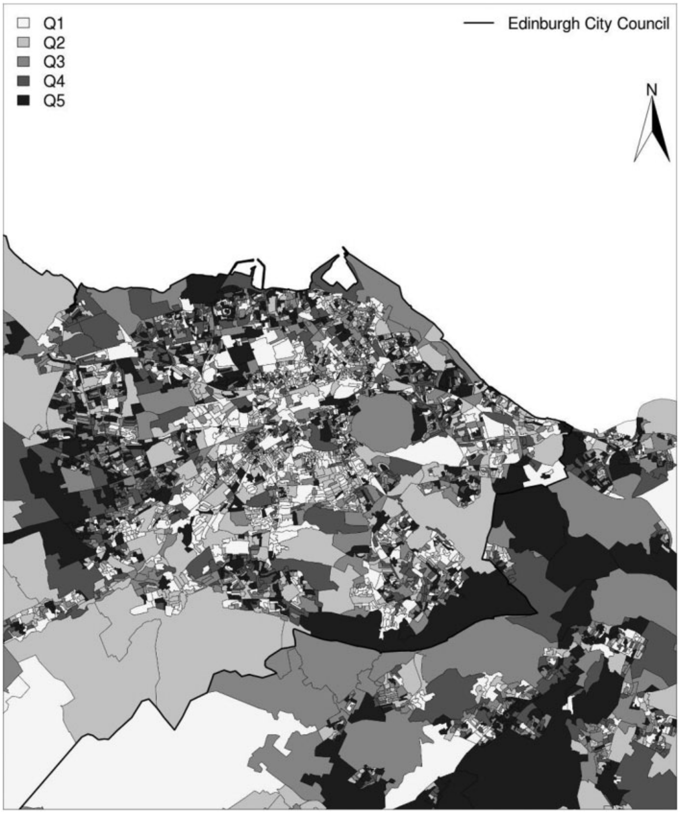

Fig 13. Tax gain, Edinburgh output areas: quintiles

Table 6. Moran *I* statistics

	Moran *I* statistic	Expectation	P Value
up to 10, 400	0.238759	−0.000151	0
over150,000	0.218704	−0.000151	0
Housing benefit	0.219935	−0.000151	0
Child benefit	0.095238	−0.000151	0
Tax gain	0.174841	−0.000151	0
Total area income	0.135313	−0.000151	0

incomes. This suggests a degree of spatial polarization within the Lothian areas in terms of incomes: those with high incomes are close to areas of a similar income, whereas those areas with lower incomes are also spatially concentrated. The figures reported in Table 6 also suggest that child benefit claimants are more randomly spatially distributed, with a very low Moran statistic, whereas housing benefit is more clustered. The gains in tax are weakly positively correlated across the Lothian Health Board (HB) area. This is likely to be due to the spatial autocorrelation of areas with low incomes would benefit from this change. Overall, it can be argued that these statistics suggest that spatial effects of policy are clustered in space across Lothian.

Another way of exploring the degree of spatial clustering and concentration of the micro-simulated outputs is to plot the results on a graph also showing the distance of each area from

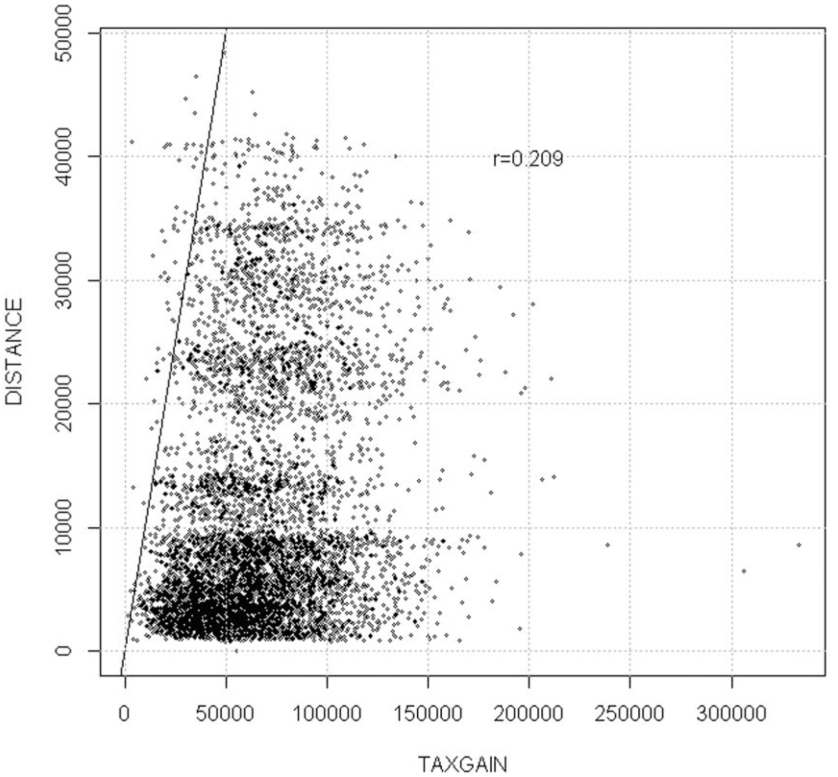

Fig 14. Simulated tax gains versus distance from Holyrood Park

a particular reference point. Figure 14 plots all output areas in Lothian, showing the total tax gain and distance from Holyrood Park (around the middle of Edinburgh city) in metres. There do not seem to be any linear patterns, but it is interesting to see that two of the areas with the highest microsimulated tax gain (a total of over £300,000) are very centrally located, near Holyrood Park. Again, this kind of information may be useful to local politicians who may wish to consider current or new proposed area-based policies and the overall spatial planning in the wider metropolitan area in relation to total income loss or gains resulting from a national policy change.

5.2 Microsimulated individual case study examples and potential extensions

One of the key advantages of microsimulation and spatial microsimulation is the ability to perform analysis at the micro-level and therefore further focus on the impacts of public policy change upon particular types of individuals or households. In this subsection we demonstrate this capability by exploring the estimated impacts of the policy changes upon different types of households or individuals. In order to do so, households which meet specific socio-economic or demographic characteristics have been randomly chosen from the microdata set to serve as example cases. As income has been explored there are low, middle and high income individuals chosen. Additionally, to cover the changes to housing benefit and child benefit, individuals who both receive and do not receive this benefit have been chosen. There are several ‘types’ of individuals shown in Table 7.

Table 7. Micro-level individual case studies for Lothian Health Board

Type	Scottish Parliamentary Constituency	Sex	Marital status	Tenure	Income	Age	nssec8	Qualification	Dep	HB	CB
Low	Edinburgh Pentlands	M	M	OO	1	36	2	1	1	N	Y
Low	Edinburgh Central	F	S	HA	6	50	6	1	7	Y	N
Mid	Edinburgh North and Leith	M	S	OO	12	28	1	4	9	N	N
Mid	Edinburgh South	F	M	RF	12	54	1	4	6	N	N
High	Edinburgh East and Musselburgh	M	M	OO	31	27	2	2	5	N	N

Abbreviations: CB = child benefit, dep = area of deprivation level, HA = renting from housing association, HB = in receipt of housing benefit, nssec8 = UK National Statistics Socio-economic Classification, OO = owner occupier, RF = rent free.

The first individual is a married male aged 36 who lives in Lothian HB, in the Edinburgh Pentlands Scottish Parliamentary constituency (SPC). He owns his house with a mortgage (OO), has level 1 qualifications and would normally work in a lower managerial or professional occupation. He also receives child benefit as a source of income and lives in the least deprived type of area.

The second person is a single female aged 50 who also lives in Edinburgh Central SPC, but in a more deprived area and rents her house from a housing association (HA). She is receiving housing benefit, but not child benefit. Her job is semi-routine and she has level 1 qualifications as well as having income is between £5,200 and £7,800 (category 6).

The third person is a single male aged 28. He has level 4 qualifications and has a higher managerial or professional occupation, which earns him between £20,800 and £23,400 per year (category 12). The area he lives in is a deprived part of the Lothian HB, Edinburgh North and Leith. He does not receive child or housing benefits.

The fourth case study is a 54 year old married woman living in an area of Lothian HB, Edinburgh South SPC which is neither deprived nor affluent. She does not receive child or housing benefit and is living rent free (RF). Her job is similar to the third person, as she has level 4 qualifications, a higher managerial or professional occupations and earnings between £20,800 and £23,400 per year.

The final case study is a married 27 year old man earning over £150,000 per year (category 31) and not receiving any benefits. He lives in an area that is in the middle of the deprivation spectrum, Edinburgh East and Musselburgh SPC. He is a lower managerial or professional occupations worker, with level 2 qualifications. This individual will be affected by the change to the policy scenario that increases tax on those earning over £150,000.

The above brief discussion demonstrates the power of spatial microsimulation to perform micro-level ‘winner’ and ‘loser’ policy analysis, by giving examples of the micro-level typical case studies of ‘types’ of people who could be affected by any change in the policies mentioned in the analysis above. For example the last individual would be liable for a 50 pence tax rate. The first individual would be a ‘keeper’ of child benefit and so their income from this source will not change, while the second individual may or may not lose some housing benefit depending on the rent caps that could be imposed. The first and second individuals would benefit under the policy scenario which raises the income tax threshold to £10,000. Person 2 could now earn at least £1,200 extra without paying income tax, or potentially up to £4,800 extra, depending on the specific income of the individual.

This gives the reader an idea of the power of microsimulation in bringing a wealth of information to bear on policy issues as well as demonstrating the impact of changes to government policy.

The next step in the analysis would be to explore the possible multiplier effects that would be generated from the policy changes. In particular, the effects of policy changes at the micro-level as discussed above could lead to changes in the disposable income of individuals and households. This could lead to changes in expenditure, which depending on consumption patterns and propensities to spend on locally produced goods and services, could lead to further changes and multiplier effects in the local economy. For instance, a decrease of household income could trigger a fall of household expenditure on groceries and possible changes of preferred retail location (such as moving to less expensive stores), etc. These could be seen as micro-level events in the local economy the aggregate impact of which would in turn lead to new developments, such as the possible closure of supermarkets in an area with the subsequent loss of jobs, which in turn could lead to further multiplier effects. Therefore, there is a challenge to estimate not only the direct effects of changes in government policy but also the indirect and induced effects at the micro-scale. There has been some relevant work aimed at the micro-analysis of the socio-economic impacts of major area-based investment or disinvestment (e.g., see Rephann et al. 2005; Ballas et al. 2006b), but there is a need and potential for more research in this field. To that end it is also worth exploring further the possibilities of combining spatial microsimulation models with agent-based modelling, building on relevant simulation work in the social sciences (e.g., see Gilbert and Troitzsch 2005; Gilbert 2008) and on-going efforts to make such a link within a geographical context (see Wu et al. 2008).

6 Concluding comments

Spatial microsimulation methods can be used to examine the changes resulting from public policy change in the lives of individuals within households at different geographical levels, ranging from the smallest area for which any socio-economic and demographic data is available to whatever spatial level deemed appropriate. As noted in the introduction, the aim of this paper was to add to a still relatively small but rapidly expanding literature on how regional science and quantitative geography methods and data can be used to perform socio-economic impact assessment and analysis of the geographical as well as socio-economic impacts of national public policies. It is hoped that this work will stimulate further debate on the possibilities of economists, geographers and regional scientists working closely together to add a geographical dimension to very successful *aspatial* microsimulation work such as the EUROMOD model briefly discussed in the introduction (for more details see Lelkes and Sutherland 2009).

The analyses presented in this paper have demonstrated how a spatial microsimulation model can be used to explore and highlight the heterogeneous geographical impact of national policies at the local (OA) level. This is perhaps the clearest conclusion that can be drawn, as the 'local' impact of national policies can be different across Scotland. This can clearly be illustrated, as shown in this paper, with the use of spatial microsimulation. Of course this should be intuitive, but it has been demonstrated in this context and adds an original contribution to policy debates in Scotland. Furthermore, the power of spatial microsimulation over and above aspatial modelling has been demonstrated and this original contribution to the policy debate in Scotland adds a worthwhile spatial dimension to the debates which can have important consequences and may potentially alter a policy decision. The advantage is that both types of microsimulation (spatial or aspatial) can be conducted simultaneously. The policies considered, fiscal and welfare based, have shown how the effects and unintended consequences could be judged prior to implementation, with a multitude of options being considered before choosing the most suitable. The change in the threshold of tax has shown those who would 'gain' most in contrast to those who would 'lose' most with an introduction of a 50 pence tax rate in Scotland.

In addition, it can be argued that the microsimulation of income has been useful in exploring the potential changes to income tax rules. The 'value added' of the microsimulated data is made clear and provides a new and original perspective in this area in Scotland as well as allowing exploration of trends at the microlevel. Furthermore, the microsimulation of child benefit and the subsequent analysis has shown the power of the microsimulation method in creating 'new' data which can be used to assess the consequences of policy. A key strength of spatial microsimulation is the ability to create customized cross-tabulations which would not be available from either the Census or the SHS; as the raw microdata is not readily available.

Overall, this paper aimed to further demonstrate the power and usefulness of spatial microsimulation models such as SIMALBA and their potential for the analysis of geographical as well as socio-economic impacts of public policy. This has been shown using by the case studies, showing the wealth of information in the microdataset. Additionally, the extra dimension of a spatial microsimulation model is made obvious through the use of maps as well as tables which provides a new viewpoint for policy-makers from which to judge the consequences of a particular course of action, both by 'type' of individual and by area simultaneously, providing further proof that geography matters! Nevertheless, a very important challenge for regional scientists and quantitative geographers is to further refine and extend tools such as SIMALBA to enable the geographical analysis of multiplier effects at the small area level as well as to model individual level transitions, which could also involve the combination and enhancement of spatial microsimulation with agent-based models.

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References

Ballas D (2004) Simulating trends in poverty and income inequality on the basis of 1991 and 2001 census data: A tale of two cities. *Area* 36: 146–163

Ballas D, Clarke GP (2001) Modelling the local impacts of national social policies: A spatial microsimulation approach. *Environment and Planning C: Government and Policy* 19: 587–606

Ballas D, Clarke GP (2009) Spatial microsimulation. In: Fotheringham AS, Rogerson PA (eds) *Handbook of spatial analysis*. Sage, London

Ballas D, Clarke G, Dewhurst J (2006b) Modelling the socio-economic impacts of major job loss or gain at the local level: A spatial microsimulation framework. *Spatial Economic Analysis* 1: 127–146

Ballas D, Clarke G, Dorling D, Eyre H, Thomas B, Rossiter D (2005) SimBritain: A spatial microsimulation approach to population dynamics. *Population, Space and Place* 11: 13–34

Ballas D, Clarke GP, Dorling D, Rossiter D (2007) Using SimBritain to model the geographical impact of national government policies. *Geographical Analysis* 39: 44–77

Ballas D, Clarke GP, Wiemers E (2006a) Spatial microsimulation for rural policy analysis in Ireland: The implications of CAP reforms for the national spatial strategy. *Journal of Rural Studies* 22: 367–378

BBC NEWS (2012) Budget 2012: George Osborne cuts 50p top tax rate. URL: http://www.bbc.co.uk/news/uk-politics-17450719

Bennett R (1980) *The geography of public finance*. Methuen, London
Birkin M, Clarke M (2011) Spatial microsimulation models: A review and a glimpse into the future. In: Stillwell J, Clarke M (eds) *Understanding population trends and processes*. Springer, London
Boyle PJ, Feijten P, Feng Z, Hattersley L, Huang Z, Nolan J, Raab G (2009) Cohort profile: The Scottish Longitudinal Study (SLS). *International Journal of Epidemiology* 38: 385–392
Brewer M, Francesconi M, Gregg P, Grogger J (2009) Feature: In-work benefit reform in a cross-national perspective – introduction. *The Economic Journal* 119: F1-F14
Burrows R, Rhodes D (1998) *Unpopular places? Area disadvantage and the geography of misery in England*. Policy Press, Bristol
Cairney P (2006) Venue shift following devolution: When reserved meets devolved in Scotland. *Regional & Federal Studies* 16: 429–445
Child Poverty Action Group (2003) *Welfare benefits and tax credits handbook*. Child Poverty Action Group, London
Chin S-F, Harding A, Lloyd R, McNamara J, Phillips B, Vu QN (2005) Spatial microsimulation using synthetic small-area estimates of income, tax and social security benefits. *Australasian Journal of Regional Studies* 11: 303–335
Clarke GP (1996) *Microsimulation for urban and regional policy analysis*. Pion, London
Danson M, Lloyd G (2012) Devolution, institutions, and organisations: Changing models of regional development agencies. *Environment and Planning C: Government and Policy* 30: 78–94
Danson M, Macleod G, Mooney G (2012) Devolution and the shifting political economic geographies of the United Kingdom. *Environment and Planning C: Government and Policy* 30: 1–9
Dorling D (2011) *Injustice: Why social inequality persists*. Policy Press, Bristol
Dorling D, Rigby J, Wheeler B, Ballas D, Thomas B, Fahmy E, Gordon D, Lupton R (2007) *Poverty, wealth and place in Britain 1968 to 2005*. Policy Press, Bristol
Dorling D, Shaw M (2002) Geographies of the agenda: Public policy, the discipline and its (re)'turns'. *Progress in Human Geography* 26: 629–646
Doyal L, Gough I (1991) *A theory of human need*. London, Macmillan
Edwards KL, Clarke GP (2009) The design and validation of a spatial microsimulation model of obesogenic environments for children in Leeds, UK: SimObesity. *Social Science and Medicine* 69: 1127–1134
Frank R (2005) Falling behind: how rising inequality harms the middle class. Wildavsky Forum Series, 4
Gilbert N (2008) *Agent-based models*. Sage, London
Gilbert N, Troitzsch KG (2005) *Simulation for the social scientist*. Open University Press, Buckingham
Gordon D, Pantazis C (1997) Measuring Poverty: Breadline Britain in the 1990s. In: Gordon D, Pantazis C (eds) *Breadline Britain in the 1990s*. Ashgate, Aldershot
Hamnett C (2011) The reshaping of the British welfare system and its implications for geography and geographers. *Progress in Human Geography*, 35: 147–152
Hancock R, Sutherland H (1992) *Microsimulation models for public policy analysis: New frontiers*. STICERD, London School of Economics, London
Harding A (1996) *Types and structures of microsimulation models. Microsimulation and Public Policy*. Elsevier Science, Amsterdam
HM Treasury (2009) *Budget 2009: Economic and fiscal strategy report and financial statement and budget report*. The Stationery Office, London
Hynes S, Morrissey K, O'Donoghue C, Clarke G (2009) Building a static farm level spatial microsimulation model for rural development and agricultural policy analysis in Ireland. *International Journal of Agricultural Resources, Governance and Ecology* 8: 282–299
Kavroudakis D, Ballas D, Birkin M (2012) A spatial microsimulation approach to the analysis of social and spatial inequalities in Higher Education attainment. *Applied Spatial Analysis and Policy* 3: 1–23
Kay L (2010) *Escaping the poverty trap: How to help people on benefits into work*. Policy Exchange, London
Keating M (2009) *The independence of Scotland: Self-government and the shifting politics of union*. Oxford University Press, Oxford
Keating M (2010) *The government of Scotland: Public policy-making after devolution*. Edinburgh University Press, Edinburgh
Kongmuang C, Clarke GP, Evans AJ, Jin J (2006) SimCrime: A spatial microsimulation model for the analysing of crime in Leeds. Working Paper. The School of Geography, University of Leeds, Leeds
Law A, Mooney G (2012) Competitive nationalism: State, class, and the forms of capital in devolved Scotland. *Environment and Planning C: Government and Policy* 30: 62–77
Lelkes O, Sutherland H (2009) *Tax and benefit policies in the enlarged Europe: Assessing the impact with microsimulation models*. Ashgate, Farnham
Madden M (1993) Welfare payments and migration in nonlinear, extended input-output model with an application to Scotland. *Papers in Regional Science* 72: 177–199

Mair C, McAteer M (1997) Scotching the myth: Analysing the relations between a Scottish Parliament and Westminster. *Scottish Affairs* 19: 1–13
Martin R (2001) Geography and public policy: The case of the missing agenda. *Progress in Human Geography* 25: 189–210
Mitchell R, Shaw M, Dorling D (2000) *Inequalities in life and death: What if Britain were more equal?* Policy Press, Bristol
Mitton L, Sutherland H, Weeks M (2000) Microsimulation modelling for policy analysis : Challenges and innovations. Occasional papers 65.University of Cambridge Department of Applied Economics
Morrissey K, Clarke G, Ballas D, Hynes S, O'Donoghue C (2008) Examining access to GP services in rural Ireland using microsimulation analysis. *Area* 40: 354–364
Orcutt G (1957) A new type of socio-economic system. *Review of Economics and Statistics* 58: 116–123
Pacione M (1995a) *Glasgow: The socio-spatial development of the city*. Wiley, Chichester
Pacione M (1995b) The geography of multiple deprivation in Scotland. *Applied Geography* 15: 115–133
Pacione M (1997) *Britain's cities: Geographies of division in urban Britain*. Routledge, London
Peck J (1999) Grey geography? *Transactions of the Institute of British Geographers* 24: 131–135
Rephann T, Holm E (2004) Economic-demographic effects of immigration: Results from a dynamic spatial microsimulation model. *International Regional Science Review* 27: 379–410
Rephann T, Mäkilä K, Holm E (2005) Microsimulation for local impact analysis: An application to plant shutdown. *Journal of Regional Science* 45: 183–222
Runciman W (1966) *Relative deprivation and social justice*. Routledge, London
Sen A (1987) *On ethics and economics*. Blackwell, Oxford
Smith D (1973) *The geography of social well-being*. McGraw-Hill, New York
Smith D (1977) *Human geography: A welfare approach*. Hodder & Stoughton Educational
Smith DM, Pearce JR, Harland K (2011) Can a deterministic spatial microsimulation model provide reliable small-area estimates of health behaviours? An example of smoking prevalence in New Zealand. *Health & Place* 17: 618–624
Tanton R (2011) Spatial microsimulation as a method for estimating different poverty rates in Australia. *Population, Space and Place* 17: 222–235
The Conservative Party (2010) *The Conservative manifesto: Invitation to join the government of Britain*. The Conservative Party, London
The Labour Party (2010) *The Labour party manifesto. A future Fair for All*. The Labour Party, London
The Liberal Democrat Party (2010) *Liberal Democrat manifesto 2010*. The Liberal Democrat Party, London
The Scottish Nationalist Party (2010) *The Scottish National party panifesto: Elect a local champion*. The Scottish Nationalist Party, Edinburgh
Tomintz MN, Clarke GP, Rigby JE (2008) The geography of smoking in Leeds: Estimating individual smoking rates and the implications for the location of stop smoking services. *Area* 40: 341–353
Townsend P (1987) Deprivation. *Journal of Social Policy* 16: 125–146
Walsh D, Taulbu M, Hanlon P (2008) *The aftershock of deindustrialisation*. Glasgow Centre for Population Health and NHS Health Scotland, Glasgow
Wilkinson R, Pickett K (2009) *The spirit level: why equality is better for everyone*, Penguin Books, Limited, London
Williamson P, Birkin M, Rees PH (1998) The estimation of population microdata by using data from small area statistics and samples of anonymised records. *Environment and Planning A* 30: 785–816
Wu BM, Birkin MH, Rees PH (2008) A spatial microsimulation model with student agents. *Computers, Environment and Urban Systems* 32: 440–453

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Resumen. Los investigadores de ciencias regionales llevan tiempo jugando un papel cada vez más importante en el desarrollo y aplicación de modelos de microsimulación espacial para el análisis de políticas. Durante mucho tiempo se ha argumentado que la modelización de microsimulación espacial tiene un potencial enorme para la evaluación de los efectos socioeconómicos y espaciales de los principales cambios en la economía regional o local. Este artículo tiene por objeto contribuir a esta corriente de estudio en rápida expansión, mediante la presentación de un nuevo modelo de microsimulación espacial (SIMALBA) para Escocia (cuyo desarrollo fue co-financiado por el Gobierno de Escocia) y una demostración de su utilización para realizar un análisis ‘what-if’ para políticas en Escocia. Este artículo se centra en los aspectos económicos de las desigualdades sociales y espaciales de Edimburgo, la capital de Escocia. El artículo muestra cómo la modelización de microsimulación espacial puede abordar cuestiones de investigación hasta ahora sin responder en Escocia, en particular las relativas a las políticas fiscales. El modelo SIMALBA ha estimado los datos de ingresos de Escocia a nivel geográfico de área de salida (OAC en inglés) y éste es el objetivo principal de los diferentes escenarios de políticas ‘what-if’. Los datos de simulación se crearon utilizando un algoritmo de reponderación determinista para construir un modelo de microsimulación espacial mediante la combinación de datos del censo de 2001 del Reino Unido y datos de 2003 de la Encuesta de Salud de Escocia (SHS por sus siglas en inglés). El análisis demuestra la importancia de la geografía mediante el examen de tendencias a nivel de área de salida en Escocia. El artículo concluye con una discusión de los datos de simulación y los escenarios políticos resultantes, así como del impacto de este análisis para la formulación de políticas en Escocia.

要約：政策分析ツールとしての空間的マイクロシミュレーションモデルの開発と応用において、地域科学者の役割はますます重要になってきている。これまで長きに渡り、地域あるいは地方経済の大きな発展による社会経済的効果と空間的効果の評価には、空間的マイクロシミュレーションのモデリングには膨大な可能性が秘められていると論じられてきた。本論文では、スコットランドの新しいマイクロシミュレーションモデルであるSIMALBA（このモデルはスコットランド政府が一部出資して開発された）を例に取り上げ、スコットランドにおける「what-if」政策分析を行うにあたりこのモデルがどのように使用されるかを例証することで、急速に拡大するこの研究分野への一助となることを目的とする。本論文では、スコットランドの首都エジンバラの社会格差および空間的格差における経済的な側面に焦点を当てる。本論文はスコットランドのこれまでに解決されていない研究課題、特に財政政策に関する問題を、空間的マイクロシミュレーションのモデリングにより解決される仕組みを提示する。SIMALBAモデルを使用してアウトプット地域レベルでのスコットランドの所得データを推計したが、この推計結果が様々な「what-if」政策のシナリオの中心である。2001年の英国の国勢調査のデータと、2003年のスコットランド健康調査（SHS）のデータの統合による空間的マイクロシミュレーションモデルを構築するため、決定論的再加重アルゴリズムを使用してシミュレーションデータを作成した。本分析はスコットランドのOAレベルのトレンドを調査し地理的条件の重要性を示す。最後に、シミュレーションデータ、結果として得られる政策シナリオ、本分析がスコットランドの政策立案に与える影響を考察する。