Institution: The University of Edinburgh/Heriot-Watt University

Unit of Assessment: B10, Mathematical Sciences

Title of case study: Impact of a mathematical model of housing allocation on governmental policies to ameliorate homelessness

1. Summary of the impact

In 1996 Byatt-Smith, Lacey and Parker (all Maxwell Institute, MI) and co-workers developed a mathematical model of housing allocation to examine the impact of housing policies on homelessness in England and Wales. The model was subsequently adapted to the Scottish context by Lacey and Waugh (MI). Since 2008, it has been used by the Scottish Government to help inform its housing policy, enabling it to target development funding for new build to areas of greatest homelessness need and meet its 2012 homelessness commitment. The model has provided quantitative underpinning for major policy changes enacted in Scotland during the period from 2008: the right to buy public-sector housing has been limited, and regions where private rented sector housing has the potential to provide housing for homeless households have been identified. This has resulted in a marked increase of public-sector house builds between 2005/06 (6 starts) and 2009/10 (538 starts). The research informed the allocation of £644M in 2009/10 contributing to a 14% reduction in homelessness in Scotland between 2008/09 and 2012/13.

2. Underpinning research

Mathematical model. Following a court ruling (the Awua judgement, 1995), the duty of local authorities in England and Wales towards housing families deemed to be homeless was reduced. It became imperative to investigate the impact of these changes on homeless families and others on local authorities' waiting lists. The problem was brought to the attention of a European Study Group with Industry in 1996 by Don Simpson, a housing consultant and trustee of the housing charity Shelter. It was tackled by Byatt-Smith, Lacey, Parker (all Maxwell Institute) and others [1]. They developed a mathematical model in which the population of a local-authority area in private- or public-sector accommodation, whether on a housing waiting list or not, and the homeless is modelled by a deterministic system of five ODEs. Analytical and numerical solutions were obtained after using decoupling to reduce the model to three differential equations [2]. These solutions predicted that reducing the relative priority given to re-housing homeless households would have little effect on other households on the housing list, but would have a major impact on the number of homeless families in temporary accommodation. Moreover, because of the multiple time scales exhibited by its dynamics – including one of around 30 years – the model predicted that changes in policy could take decades, or several electoral cycles, to have full effect. The model also highlighted the sensitivity of levels of homelessness to availability of public-sector housing, showing that any decrease in supply, say through right-to-buy, can lead to markedly increased housing lists and homelessness.

Extended models. The original model was extended by Lacey and his MSc and PhD student Waugh in order to represent the housing allocation and other relevant administration procedures that operate in Edinburgh and Glasgow. Edinburgh Council operated a points-based allocation system to determine the priority of individuals on its waiting list, with the number of points determined in part by the time spent on the list. It proved therefore necessary to use a first-order hyperbolic PDE in combination with the ODE-based population model in order to represent the system adequately. In the case of Glasgow a purely ODE model, with rate laws based on 'goodness of fit' between applicants and available housing, was sufficient. These extensions are

documented in Waugh's PhD thesis [3]. The model was further developed by Waugh while he worked for a housing charity and a housing consultancy, and while on secondment to the Scottish Government in 2007/08.

Attribution. A. A. Lacey (MI since 1982), D. F. Parker and J. G. Byatt-Smith were Professors and Senior Lecturer at the Maxwell Institute during their contributions to the research. A. J. Waugh was an MSc then PhD student at the Maxwell Institute until his graduation in 2001. He continued to develop the model in his subsequent employments in a charity, a consultancy and the Scottish Government.

3. References to the research.

References marked (*) best indicate the quality of the research.

[1]* Byatt-Smith J.G. *et al.,* Homeless Populations (Final report, 29th European Study group with Industry) Oxford, March 1996. http://www.maths.ed.ac.uk/~mthdat25/housing/Homeless-populations-final-report-29th-European-Study-group-with-industry

[2]* Byatt-Smith, J.G., Lacey, A.A., Parker, D.F., Simpson, D. Smith W.R. and Wattis J.A.D., Mathematical Modelling of Homeless Population, *Math. Scientist*, **28**, 1–12, (2003). http://www.maths.ed.ac.uk/~mthdat25/housing/Mathematical-modelling-of-homeless-population

[3]* Waugh, A.J., *The Mathematical Modelling of Council House Allocation and its Effect on Homeless Applicants*, Doctoral Thesis, Heriot-Watt University, (2001). http://www.maths.ed.ac.uk/~mthdat25/housing/The-mathematical-modelling-of-council-house-allocation-and-its-effect-on-homeless-applicants

4. Details of the impact

The model initially developed in the Maxwell Institute was used by Waugh to assess the impact of proposed housing policy on homelessness in Scotland. Waugh's results based on what became known as *the Waugh model* gained influence in the Scottish Government [4-6]: it was included in a paper to the then Minister for Communities and Support (Stewart Maxwell) in 2008 and has been used since to provide advice to the Scottish Government on the interpretation of homelessness statistics and on the impact of policy changes.

Policy impact. The model has had a clear and ongoing impact on the Scottish Government's housing policy by providing a quantitative underpinning to proposed policies. By characterising and quantifying the interaction between the availability of public-sector housing and homelessness levels the model has motivated several changes in policy [6]. These include a change in the Scottish Government's Affordable Housing Investment Programme, massively increasing public-sector house build; the removal of right to buy for new lets, and the targeted use of private-sector rented accommodation. The following impacts have been achieved.

1. Through its continuing use of the model the Scottish Government now assesses – on a systematic, quantitative basis – the implications of key aspects of the implementation of homelessness policy for each of Scotland's 32 local authorities.
2. The work influenced the distribution of £644M of funding allocated by the Affordable Housing Investment Programme in 2009/10 [7,8].
3. The model informed the analysis by the Scottish Government policy team, senior officials and Ministers of the relative impact of different policy levers on homelessness and influenced the Government's response to dealing with the problems of the size of homeless populations and the limited ability of local authorities to respond to the need. In particular it had a significant

influence on the design of policies relating to: (a) the right to buy (RTB); (b) the role of the private rented sector (PRS); (c) interaction with the Scottish Housing Quality Standard; (d) the potential role of housing associations in meeting homelessness need.

For (3a) the model highlighted the long-term impact of RTB on eroding the supply of social lets. In particular, the model in [2] quantified the long-term adverse effects on homelessness levels and waiting-list sizes of reducing public housing stock, suggesting that a reduction in RTB sales would secure the future supply of social housing and encourage building by local authorities. Consequently, RTB was removed from all new tenancies and new-build properties on 11 March 2011, under the Housing (Scotland) Act 2010 [9] which overturned a major piece of 1980s legislation. As a result of this change of policy, new build by local authorities has increased from 6 units in 2006/07 to 583 units in 2010/11 [10].

Regarding (3b), the model was instrumental in identifying areas of Scotland where a significant private rented sector enabled an effective use of PRS to house homeless households, and areas where the PRS was too small to make a difference. Whilst the model predictions dispelled the view that the PRS would be a 'magic bullet' to address homelessness across Scotland, they demonstrated its potential value in some areas. Consequently, greater use of the PRS was enabled though The Homeless Persons (Provision of Non-permanent Accommodation) (Scotland) Regulations 2010 [11]. As a result of the policies introduced with the support of the model, the number of cases assessed as homeless or threatened with homelessness in Scotland has decreased by 10,000 (24%) between 2008/09 and 2012/13 [12].

4. The model has been applied to understand the potential impact of a key policy initiative – the Scottish Housing Quality Standard – on the 2012 Homelessness commitment. As local authorities work towards meeting the Scottish Housing Quality Standard by April 2015, properties without any long-term future are earmarked for demolition and a need arises to re-house tenants of the demolition stock within the local authority's core stock. Consequently, fewer lets are available to other households on the waiting list, including homeless households. Moreover, demolition stock is most frequently located in higher turnover areas. Demolishing these properties often results in a disproportionate reduction in available lets. These impacts on supply can potentially make meeting the Scottish Government's 2012 homelessness commitment more difficult. The aim of the 2012 homelessness commitment is to give all unintentionally homeless households permanent accommodation, typically a let from a local authority or housing association landlord, and this may lead to increased pressure for social housing in some areas. The model has been adapted to investigate the supply of social lets in each local authority area, taking account of demolition programmes, and highlighted the reduction in supply of social lets that can occur.

Other developments. Local authorities have a duty to provide temporary accommodation until permanent accommodation is secured. Continuing work within the Scottish Government, is using the model to identify whether there exists a sufficient supply of social housing in each local-authority area in order for: lets to homeless households to account for no more than say, a certain proportion of all available lets; and the number of households in temporary accommodation does not increase from its current level. Where supply is deemed to be insufficient to meet these criteria, the minimum amount of new build is calculated to ensure that both are met. The model has therefore enabled local authorities to reduce the risk of a financial shortfall through having substantial numbers of homeless households in more expensive forms of temporary accommodation. The model is also attracting international attention, with Waugh presenting his results at a conference on homelessness hosted by the EU Committee of Regions [13].

5. Sources to corroborate the impact

[4] The use of the model by the Scottish Government is described in the report *Background to the Homelessness Capacity Model* (The Waugh Model) Communities Analytical Services, February (2009), http://www.scotland.gov.uk/Resource/Doc/1033/0084078.doc

[5] *Homelessness and Affordable Housing Need* is a 2009 presentation by the Scottish Government's Communities Analytics Services that makes extensive use of the prediction of the Waugh model, www.scotland.gov.uk/Resource/Doc/1125/0076878.ppt

[6] The impact of the model on decision making in the Scottish Government can be confirmed by a senior economist and a former Senior Statistician of the Communities Analytical Services.

[7] The Scottish Government Affordable Housing Investment Programme is described at http://www.scotland.gov.uk/Topics/Built-Environment/Housing/investment1/ahip

[8] The funding allocation in 2007-10 is detailed at http://www.scotland.gov.uk/Topics/Built-Environment/Housing/investment/ahip/ahip-2009-10

[9] The changes to the RTB enacted in the Housing (Scotland) Act 2010 are described at http://www.scotland.gov.uk/Publications/2011/02/02164100/2

[10] Statistics on local authority new build housing are available at http://www.scotland.gov.uk/Topics/Statistics/Browse/Housing-Regeneration/HSfS/NewBuildLA

[11] The Homeless Persons (Provision of Non-permanent Accommodation) (Scotland) Regulations 2010 is available at http://www.legislation.gov.uk/ssi/2010/2/contents/made

[12] Statistics on the number of homeless are in Table 8 of http://www.scotland.gov.uk/Topics/Statistics/Browse/Housing-Regeneration/RefTables/adhoc-analysis/annualreferencetables201213

[13] Details of the EU conference *Homelessness in public and private spaces: Mind the policy gap!* (2010) are at http://www.feantsa.org/spip.php?article164&lang=en

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