Subnational Population Projections in the United Kingdom: Progress Report

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Central, local governments, research organizations, citizens are interested in what directions their local populations are headed.

There is interest in “now-casts” (forecasts from base period to present (e.g. 2002 to 2005).

Most interest in the short term (next 10-25 years).

Medium term forecasts (up to 50 years) are important for labour force planning.

Longer term forecasts (up to 100 years) are important for pensions and care planning.
Aims of this presentation

- To review sub-national population projection activity in the UK
- To describe a model called UKPOP developed by Tom Wilson for his PhD, that uses 1998 “jump-off” populations and component information for 1991-98, and projects for all Local Authorities in the UK
- To describe progress with updating this model to use new information (e.g. from the 2001 Census) with a jump-off in 2002 (to be revised to 2003) by Phil Rees and John Parsons, the model to be embedded into a water demand forecasting system
The Government Actuary’s Department (GAD) produce projections for four parts of the UK: England, Wales, Scotland, Northern Ireland. The model is a single year of age model with net international migration distributed to the four parts plus net migration matrix between them. These are used to control four sets of sub-national projections.
Sub-national Population Projection Activity in the United Kingdom (2)

- England Sub-national Model:
  - Developed in 1980s by consultants (MVA, GLA) and improved in late 1990s
  - Latest 2003 based, released Nov 2004 (previous 1996 based)
  - Multistate, deals with special populations, constrained to GAD projections for England, uses 2001 Census migration data, widely used
  - General methods and assumptions explained but not much technical detail

- Wales Sub-national Model:
  - ESP model is being adapted for use with Welsh sub-national areas

- Scotland Sub-national Model
  - Have a simple spreadsheet model (single region, net migration) which the General Register Office wish to revise

- Northern Ireland Sub-national Model
  - 2002 based, uses single region model with net migration assumptions
Sub-national Population Projection Activity in the United Kingdom (3)

- Local authority projections
  - Large number of authorities do projections
  - Most popular are housing based methods or single region cohort-component with net migration
  - Best projections are by the Greater London Authority (Demographic Methods and Analysis Group): 33 borough, multistate, but with migration adjusted to fit constraints set by a housing capacity study
  - Projections services offered by CHELMER group (East Anglia Polytechnic University, led by Dave King)
  - POPGROUP software offered by Local Government Association, Andelin Associates and CCSR, University of Manchester (led by Ludi Simpson)
A model to project Local Authority populations for the whole UK, 1998-based with input components from 1991 (internal migration) and 1996-98 (other components)

- Multistate model for 434 LAs, single year, with choice of method

Developed by Tom Wilson for his doctoral dissertation 1997-2001


Used to compare constant rates and migration model alternatives


Used to investigate Scotland’s population future

UKPOP2002

- This is a revision of the UKPOP1998 model and database by Phil Rees and John Parsons for use in a project on water demand forecasts and scenarios.
- Jump off currently 2002, but can be revised to 2003, with input data on components from 1998-2002, internal migration from the 2001 Census.
- Code now runs on PC under Linux with 2Mb RAM.
- We are producing forecasts but not yet happy with all component estimations or model equations.
- We are validating the results against GAD projections.
- In May-July we will validate/revise the model and fully document its inputs, its methods and its code.
The model provides top-level constraints for a water demand model at small area scale.

We need to add a household model to the population model.

The results will be used to generate water demand estimates (households → size by type → water demand).

The LA household and people forecasts will also be used in aligning the results of a microsimulation model.

The microsimulation model will use relationships from domestic water consumption monitors (surveys) to forecast water demand for households.
Why produce another sub-national population projection model?

- No model/database covers whole UK
- Cannot assess changes in National Projections for local areas across UK
- Cannot run alternative assumptions or scenarios unless you have your own model
- Cannot test alternative models unless you have your own code
- The previous model needed specialised hardware and software (workstation, Unix) to run
- Lots of new information now available for a stable set of areas (includes LA level annual migration data)
**UKPOP Methods**

<table>
<thead>
<tr>
<th>Type of migration data</th>
<th>Iterative model&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Matrix model&lt;sup&gt;b&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Movement&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Transition&lt;sup&gt;d&lt;/sup&gt;</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

- a: developed by Rees & Wilson in 1970s
- b: developed by Rogers, Ledent & Willekens in 1970s
- c: counts of moves between regions in interval
- d: changes of region between start & end of interval
### Movement accounts for a period-cohort

<table>
<thead>
<tr>
<th>To</th>
<th>Region 1</th>
<th>Region 2</th>
<th>...</th>
<th>Region n</th>
<th>Abroad</th>
<th>Death</th>
<th>Totals</th>
</tr>
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<tbody>
<tr>
<td>From</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Region 1</td>
<td>R^1</td>
<td>M^{12}</td>
<td>...</td>
<td>M^{1n}</td>
<td>E^1</td>
<td>D^1</td>
<td>K^{1}(t)</td>
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<tr>
<td>Region 2</td>
<td>M^{21}</td>
<td>R^2</td>
<td>...</td>
<td>M^{2n}</td>
<td>E^2</td>
<td>D^2</td>
<td>K^{2}(t)</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
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<td>...</td>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>Region n</td>
<td>M^{n1}</td>
<td>M^{n2}</td>
<td>...</td>
<td>R^n</td>
<td>E^n</td>
<td>D^n</td>
<td>K^{n}(t)</td>
</tr>
<tr>
<td>Abroad</td>
<td>I^1</td>
<td>I^2</td>
<td>...</td>
<td>I^n</td>
<td>0</td>
<td>0</td>
<td>I'</td>
</tr>
<tr>
<td>Total</td>
<td>K^{1}(t+1)</td>
<td>K^{2}(t+1)</td>
<td>...</td>
<td>K^{n}(t+1)</td>
<td>E'</td>
<td>D'</td>
<td>T'</td>
</tr>
</tbody>
</table>
The movement model (model 1)

- For a period-cohort:
  \[ K^i(t+1) = K^i(t) \]
  \[- (e^i + d^i + \sum_j m^i_j) \times \frac{1}{2} [K^i(t) + K^i(t+1)] \]
  \[+ \sum_j (m^i_j \times \frac{1}{2} [K^i(t) + K^i(t+1)]) \]
  \[+ I^i \]

The equation is solved iteratively
Transition accounts for a period-cohort

<table>
<thead>
<tr>
<th></th>
<th>End Start</th>
<th>Survive Region 1</th>
<th>Survive Region 2</th>
<th>Survive Abroad</th>
<th>Die Region 1</th>
<th>Die Region 2</th>
<th>Die Abroad</th>
<th>Totals</th>
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<tr>
<td>Exist</td>
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<td>$K_{e1s2}$</td>
<td>$K_{e1sr}$</td>
<td>$K_{e1d1}$</td>
<td>$K_{e1d2}$</td>
<td>$K_{e1dr}$</td>
<td>$K_{e1**}$</td>
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<tr>
<td>Exist</td>
<td>Region 2</td>
<td>$K_{e2s1}$</td>
<td>$K_{e2s2}$</td>
<td>$K_{e2sr}$</td>
<td>$K_{e2d1}$</td>
<td>$K_{e2d2}$</td>
<td>$K_{e2dr}$</td>
<td>$K_{e2**}$</td>
</tr>
<tr>
<td>Exist</td>
<td>Region n</td>
<td>$K_{ens1}$</td>
<td>$K_{ens2}$</td>
<td>$K_{ensr}$</td>
<td>$K_{end1}$</td>
<td>$K_{end2}$</td>
<td>$K_{endr}$</td>
<td>$K_{en**}$</td>
</tr>
<tr>
<td>Exist</td>
<td>Abroad</td>
<td>$K_{ers1}$</td>
<td>$K_{ers2}$</td>
<td>0</td>
<td>$K_{erd1}$</td>
<td>$K_{erd2}$</td>
<td>0</td>
<td>$K_{er**}$</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>$K_{e+s1}$</td>
<td>$K_{e+s2}$</td>
<td>$K_{e+sr}$</td>
<td>$K_{e+d1}$</td>
<td>$K_{e+d2}$</td>
<td>$K_{e+dr}$</td>
<td>$K_{e***}$</td>
</tr>
</tbody>
</table>
The transition model (model 2)

- For a period-cohort:
  \[ K^i(t+1) = K^i(t) \]
  
  \[ - (\sum_{j \neq i} h_{eisj} + \sum_{j} h^{eidj}) \times [K^{e1**}] \]
  
  \[ + \sum_{j \neq i} h^{ejsi} \times \frac{1}{2} K^{ej**} \]
  
  \[ + K^{ersi} \]

The transition probabilities, h, are estimated iteratively
Data and assumptions for UKPOP2002 (1): population

- 434 Local authorities with an average population in 2001 of 136 thousand people
- No harmonisation issues in period 1998-2003
- Population estimates were revised several times after the 2001 census (12 LAs objected to the results) and 1991-2001 population estimates were revised also
Data and assumptions for UKPOP2002 (2): fertility

- Local fertility rate estimates based on adjustment of national rates to local births:
  \[ f_a = f_n^a \times r^i \]
  \[ r^i = B_i / \{ \sum_a f_n^a \times \frac{1}{2} [K^i(t) + K^i(t+1)] \} \]
  where  \( f = \) fertility rate
  \( r = \) local to national ratio

- The ratios can be used to factor national scenarios to local rates on a constant or time varying basis
Data and assumptions for UKPOP2002 (2): mortality

- The same technique can be used for mortality
- We have not got the conversion from period-age deaths to period-cohort mortality probabilities right yet
- We need to generate local life tables to effect the conversion and for checking against published local life tables
- Currently, the infant and 90+ mortality probabilities are too low
- We will revise the GAD mortality assumptions (which I will talk about to-morrow)
Data and assumptions for UKPOP2002 (3): international migration

- We are using 2001 Census immigration data to give local immigration estimates, which will be adjusted in line with national scenarios (more to-morrow)
- Emigration rates/probabilities are estimated by adjusting internal out-migration intensities to emigration for regions from International Passenger Survey
Data and assumptions for UKPOP2002 (4): internal migration

- We use 2001 Census migration flow data from CIDS: [http://cids.census.ac.uk](http://cids.census.ac.uk)

- Array:
  - 434 origins by 434 destinations by 2 sexes by 24 ages
  - National sya rates used to get sya estimates
  - Rather sparse and unstable
Conclusions

- Next tasks involve getting UKPOP2002 working reliably
- We will run a standard GAD projection
- We will document the model and database, and make it available for use
- Then we will run different scenarios
  - different mortality, fertility and international migration
  - different local factors
- Feed the results into a household model
- Use those results in forecasting water demand by local authority
- Use the household and population results to align a microsimulation model