Subnational Population Projections in the United Kingdom: Progress Report

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Context

- 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

Sub-national Population Projection Activity in the United Kingdom (1)

- 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 distrributed 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) URL=http://www.statistics.gov.uk/STATBASE/Product.asp?vlnk=997
  - 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)

UKPOP1998

- 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
  - Wilson, T. (2001) A new subnational projection model for the United Kingdom. PhD dissertation, University of Leeds
  - Wilson, T. and Rees, P. (2001) A new subnational projection model for the United Kingdom. Paper presented at the European Association for Population Studies Conference, 7-9 June Helsinki.
- Used to compare constant rates and migration model alternatives
  - Wilson, T., Hollis, J. and Rees, P. (2002) Providing a population projection framework. Appendix 8 in Champion, T., Fotheringham, S., Rees, P., Bramley, G. and others (2002) *Development of a Migration Model*. The University of Newcastle upon Tyne, The University of Leeds and The Greater London Authority/London Research Centre. Office of the Deputy Prime Minister, London. ISBN 1 85112 583 3. Pp.239-249. (http://www.odpm.gov.uk/stellent/groups/odpm_housing/documents/page/odpm_house_601865.pdf)
- Used to investigate Scotland's population future
  - Wilson, T. and Rees, P. (2003) Why Scotland needs more than just a new migration policy. *Scottish Geographical Journal*, 119(3), 191-208.

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

UKPOP2002 Context

- 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

Type of migration data	Iterative model[a]	Matrix model[b]
Movement[c]	1	2
Transition[d]	3	4

- 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

To / From	Region 1	Region 2	…	Region n	Abroad	Death	Totals
Region 1	R^1	M^{12}	…	M^{1n}	E^1	D^1	$K^1(t)$
Region 2	M^{21}	R^2	…	M^{2n}	E^2	D^2	$K^2(t)$
:	:	:		:	:	:	
Region n	M^{n1}	M^{n2}	…	R^n	E^n	D^n	$K^n(t)$
Abroad	I^1	I^2	…	I^n	0	0	I^*
Total	$K^1(t+1)$	$K^2(t+1)$	…	$K^n(t+1)$	E^*	D^*	T^*

The movement model (model 1)

- For a period-cohort:

$$K^i(t+1) = K^i(t) - (e^i + d^i + \sum_j m^{ij}) \times \tfrac{1}{2} [K^i(t) + K^i(t+1)] + \sum_j (m^{ji} \times \tfrac{1}{2} [K^i(t) + K^i(t+1)] + I^i$$

The equation is solved iteratively

Transition accounts for a period-cohort

End / Start	Survive Region 1	Survive Region 2	Survive Abroad	Die Region 1	Die Region 2	Die Abroad	Totals
Exist Region 1	K^{e1s1}	K^{e1s2}	K^{e1sr}	K^{e1d1}	K^{e1d2}	K^{e1dr}	K^{e1**}
Exist Region 2	K^{e2s1}	K^{e2s2}	K^{e2sr}	K^{e2d1}	K^{e2d2}	K^{e2dr}	K^{e2**}
:	;	:	:	:	:	:	:
Exist Region n	K^{ens1}	K^{ens2}	K^{ensr}	K^{end1}	K^{end2}	K^{endr}	K^{en**}
Exist Abroad	K^{ers1}	K^{ers2}	0	K^{erd1}	K^{erd2}	0	K^{er**}
Total	K^{e*s1}	K^{e*s2}	K^{e+sr}	K^{e*d1}	K^{e*d2}	K^{e+dr}	K^{e***}

The transition model (model 2)

- For a period-cohort:

$$K^i(t+1) = K^i(t) - (\sum_{j \neq i} h^{eisj} + \sum_j h^{eidj}) \times [K^{e1**}] + \sum_{j \neq i} h^{ejsi} \times \tfrac{1}{2} K^{ej**} + K^{ersi}$$

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:

$$f^i_a = f^n_a \times r^i$$

$$r^i = B^i / \{\sum_a f^n_a \times \tfrac{1}{2} [K^i(t) + K^i(t+1)]\}$$

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
- Array:
  - 434 origins by 434 destinations by 2 sexes by 24 ages
  - National sya rates used to get sya estimates
  - Rather sparse and unstable
  - Will switch to OD+OA+DA model recommended by van Imhoff, E., van der Gaag, N., van Wissen, L. and Rees, P.H. (1997) The selection of internal migration models for European regions. *International Journal of Population Geography*, 3, 137-159.

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