Sub-national Stochastic Population Projections with Highly Volatile International Migration: the Case of New Zealand

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1. Introduction

Due to its transparency and simplicity, the cohort component method of projecting future populations is still commonly used by forecasting agencies in many countries, particularly at the sub-national level. The assumptions used in such projection exercises can be derived from available statistical information, but they may also be informed by local-level expert consultation. An example of the latter is given by Cameron et al. (2007). The variability of possible future demographic outcomes is with this methodology signalled by the formulation of a range of scenarios that either yield relatively high or relatively low future population levels. These projection exercises tend to give policymakers the misimpression that the future population trajectory will be deterministically determined within the broadly calculated bounds (Dharmalingam and Pool, 2005).

Stochastic population projection techniques that allow for probabilistic formulation of the parameters of the underlying demographic processes are increasingly important as the observed variability about such processes increases spatially and temporally, but also when the parameters are likely to be correlated (Bryant, 2005). A population component that is of growing importance in either deterministic or stochastic projection techniques is international migration, given the increase in population mobility globally and the growing complexity and volatility in international migration flows (Poot et al., 2008).

Hybrid methods that combine cohort-component techniques of national population projections with econometric modelling of volatile international migration already exist (e.g. Gorbey et al., 1999). However, international migration is strongly spatially selective, affecting some regions (predominantly metropolitan ones) more than others (provincial and rural ones). Probabilistic sub-national population projections therefore ideally combine spatially-varying degrees of uncertainty with respect to international migration, with endogenous – but relatively more stable – patterns of internal population redistribution.

The present paper considers the case of New Zealand, which has had in recent years the highest immigration and emigration rates, and the greatest variability in population growth among OECD countries (Poot, 2008). Probabilistic population projections are generated for territorial authorities within the Waikato region of the North Island of New Zealand. Internal and international migration are considered separately. Consistency in the multi-regional context is ensured, i.e. the sub-regional projections are obtained jointly. Assumptions are informed by demographic trends and regional-level expert consultation. The results are compared to official sub-national projections obtained with the conventional cohort component methodology. Unlike the latter methodology, in which net migration levels are projected, the key parameters of our stochastic methodology are net migration rates.

2. Setting

This paper presents an application of the stochastic cohort component method to several small sub-national populations in the Waikato region of New Zealand. The Waikato region is

composed of all or part of 14 Territorial Local Authorities (TLAs), with an estimated total population of 383,716, or 9.5 percent of the New Zealand population at the time of the 2006 Census. It is a region of significant demographic diversity (see Table 1), including New Zealand's fourth largest city by population (Hamilton), peri-urban districts with close urban ties (such as Franklin District on the edge of Auckland, New Zealand's largest city), a coastal district with a small permanent population but large transient population flows (Thames-Coromandel District), and several small and predominantly rural districts. Some TLAs have recently experienced significant population growth, while others are experiencing a general decline in population. International migration is particularly affecting the metropolitan area of Hamilton city and its surrounding areas, but far less so rural and peripheral areas such as South Waikato and Waitomo (see Table 1). This diversity makes the Waikato region an ideal subject area for a study into the results and implications of sub-national stochastic population projections under a variety of initial and future conditions.

Current sub-national population projections for New Zealand are subject to considerable uncertainty, particularly in terms of future migration (Cameron *et al*., 2008a). This is generally in line with the experience of other similar countries in population projections generally (Shaw, 2007; Wilson, 2007). The uncertainty of net migration is a key feature of sub-national population projections in New Zealand, which are subject to both uncertain and highly volatile international migration flows and uncertain internal migration flows.

Table 1. Total Population (5 years and over), Inward International Migration and Internal Migration, Waikato Constituent Territorial Authority Areas and Waikato Region, 1996-2001

Territorial Authority	2001 population aged 5+ (000s)	Of which: In migration from within NZ (%)	In migration from Overseas (%)	Stayed within Same Area (%)	Not Specified (%)	Net Internal Migration as % of population
Part Franklin	13.2	28.6	3.3	57.0	11.1	7.2
Thames-Coromandel	14.1	24.6	3.6	64.5	7.3	2.3
Hauraki	15.5	25.2	2.4	66.1	6.3	-0.2
Waikato	36.5	24.6	3.1	65.1	7.2	0.6
Matamata-Piako	27.2	19.0	2.8	72.3	5.9	-1.9
Hamilton City	106.2	22.6	7.9	64.2	5.3	2.8
Waipa	37.4	23.2	4.2	67.7	4.9	0.8
Otorohanga	8.6	25.6	2.7	64.1	7.5	-2.0
South Waikato	21.3	15.6	2.5	74.9	7.0	-9.9
Waitomo	8.7	17.8	2.4	72.3	7.6	-3.0
Taupo	29.0	22.3	3.5	64.4	9.8	1.3
Part Rotorua	3.1	28.8	3.5	57.5	10.2	-2.9
Waikato Region	**320.8**	**13.4**	**4.7**	**75.4**	**6.6**	**0.4**

Source: Statistics New Zealand, 2001 Census of Population and Dwellings.

3. Method

Stochastic projections techniques are far less commonly applied to the case of national projections than to regional projections. Wilson (2005) provides an example of national probabilistic projections in New Zealand. Even when the regional level is considered, the application tends to be for a single region (see, e.g. the case study of Queensland, Australia, by Wilson and Bell, 2007). This paper presents an application of the stochastic cohort

component method to several territorial local authorities in the Waikato region. This represents an extension of the simple cohort component model applied in Cameron *et al.* (2008b) for the Thames-Coromandel District. In Cameron *et al.* (2008b), the 'medium' age-specific fertility and survivorship assumptions of Statistics New Zealand (SNZ) were used, but an alternative approach was adopted for the estimation of net migration. For sub-national projections, the projection methodology employed by SNZ involves the estimation of net migration for each territorial authority in each year. The alternative approach involves the estimation of gender- and age-specific net migration *rates*. Under this method, the projected net migration reflects a combination of the projected net migration rates which vary over time, population which also varies over time, in a similar way to the way fertility and survivorship rates affect births and deaths respectively.

This paper extends that method by applying assumptions about the *distribution* of projected fertility, survivorship, and migration rates. Internal and international migration are considered separately. This allows stochastic projections to be computed, by repeatedly drawing at random different combinations of fertility, survivorship, and net migration rates from their respective distributions. The distributions were generated using a combination of time series models and expert judgement. Data for developing the distributions were obtained from Statistics New Zealand.

4. Expected Results

This paper will present results of stochastic projections for Hamilton City, Franklin District, Thames-Coromandel District, Otorohanga District, and South Waikato District. The results are compared to official sub-national projections obtained with the conventional cohort component methodology. We expect to show that the considerable uncertainty in net migration rates (and hence net migration flows) creates considerable uncertainty in the projected population. Naturally, this uncertainty is increasing in the length of the projection horizon. The uncertainty in international migration will particularly affect those regions most affected by international migration. However, relatively variability is on the other hand inversely related to population size. Generally, the identified and modelled uncertainty makes the traditional 'point estimate' sub-national population projections of little use for policy analysis or planning beyond a relatively short projection horizon.

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