Popul Res Policy Rev (2010) 29:47–63
DOI 10.1007/s11113-009-9144-7

Forecasting the Population of Census Tracts by Age and Sex: An Example of the Hamilton–Perry Method in Action

David A. Swanson · Alan Schlottmann · Bob Schmidt

Received: 23 April 2009 / Accepted: 12 May 2009 / Published online: 10 June 2009

Abstract Small area population projections are useful in a range of business applications. This paper uses a case study to show how this type of task can be accomplished by using the Hamilton–Perry method, which is a variant of the cohort-component projection technique. We provide the documentation on the methods, data, and assumptions used to develop two sets of population projections for census tracts in Clark County, Nevada, and discuss specific factors needed to accomplish this task, including the need to bring expert judgment to bear on the task. Our experience suggests that the Hamilton–Perry Method is an important tool and we advise considering it for small forecasting needs in the private sector.

Keywords Small area · Forecasting · Las Vegas

Background

Small area population estimates and projections are a major staple in both the public and private sectors (George et al. 2004; Swanson and Pol 2008). Private sectors uses of these data include identifying the demand for housing (Mason 1996; Siegel 2002)), business site location (Johnson 1994; Morrison and Abrahamse 1996) identifying changing consumer profiles and preferences (Murdock and Hamm 1994; Thomas 1994), determining market valuation (Billings and Pol 1994) and assessing

D. A. Swanson (✉)
University of California Riverside, Riverside, USA
e-mail: David.swanson@ucr.edu

A. Schlottmann
University of Nevada Las Vegas, Las Vegas, USA

B. Schmidt
Claremont Graduate University, Claremont, USA

profitability of a market (Ambrose and Pol 1994). In addition, Swanson has used small area projections to assess the short and long term effects of Hurricane Katrina on a medical practice (Swanson and Pol 2008)

Small area population projections also are used by governmental and other entities for strategic planning in regard to economic development. In one such instance, the Southern Nevada Regional Planning Coalition issued a Request for Proposals in 2005 on a project to develop sub-county population and labor force projections by age and sex for Clark County to the year 2020. Clark County covers all of southern Nevada from Arizona west to California and contains the cities of Las Vegas, North Las Vegas, Boulder City, Henderson, Searchlight, Mesquite, and Laughlin, along with unincorporated places such as Jean.

The projections were requested in order to meet several needs, of which a primary one was the identification of areas that could be targeted for specific types of business development, in part because of the characteristics of the resident population, both as consumers and as potential workers. The authors responded to this RFP and were selected as the contractor to carry out this project in late 2005. Work commenced in February, 2006 and was completed in October, 2006.

The standard cohort-component approach is the method of choice when age and sex data are desired in a forecast (Smith et al. 2001). However, at the sub-county level, it is extremely difficult to implement. To start with, while it is possible to obtain direct data on age and sex from the 2000 census, corresponding direct data on births and deaths are not routinely available, making corresponding indirect data on migration also not routinely available. Thus, as noted by Smith et al. (2001, p. 160), "…the Hamilton–Perry method (Hamilton and Perry 1962) is often the best cohort-component method to use for sub-county projections." As a consequence, the proposal was based on using the Hamilton–Perry Method as the basis for the sub-county population projections it developed to support the economic development plans of the Southern Nevada Regional Planning Coalition. As will be discussed, there were some obstacles to overcome in this effort, obstacles that led to some simple, but important refinements to the Hamilton–Perry Method.

The Hamilton–Perry Method

The major advantage of this method is that it has much smaller data requirements than the traditional cohort-component method. Instead of mortality, fertility, migration, and total population data, the Hamilton–Perry method simply requires data from the two most recent censuses (Smith et al. 2001, pp. 153–158). The Hamilton–Perry method projects population by age and sex using cohort-change ratios (CCR) computed from data in the two most recent censuses. The formula for a CCR is:

$$ {}_{n}\mathrm{CCR}_{x} = {}_{n}\mathrm{P}_{x+y,l} / {}_{n}\mathrm{P}_{x,b} $$

where

${}_{n}\mathrm{P}_{x+y,l}$ is the population aged x + y to x + y + n in the most recent census (l),
${}_{n}\mathrm{P}_{x,b}$ is the population aged x to x + n in the second most recent census (b),
and y is the number of years between the two most recent censuses (l-b).

Using the 1990 and 2000 censuses as an example, the CCR for the population aged 20–24 in 1990 would be:

$$_5\mathrm{CCR}_{20} = {}_5\mathrm{P}_{30,2000}/{}_5\mathrm{P}_{20,1990}$$

The basic formula for a Hamilton–Perry projection is:

$$_n\mathrm{P}_{x+z,t} = {}_n\mathrm{CCR}_x * {}_n\mathrm{P}_{x,l}$$

where

$$_n\mathrm{CCR}_x = \left({}_n\mathrm{P}_{x+y,l}/{}_n\mathrm{P}_{x,b}\right)$$

and, as before,

$_n\mathrm{P}_{x+y,l}$ is the population aged x + y to x + y + n in the most recent census (l),

$_n\mathrm{P}_{x,b}$ is the population aged x to x + n in the second most recent census (b),

and y is the number of years between the two most recent censuses (l-b).

Using data from the 1990 and 2000 censuses, for example, the formula for projecting the population 30–34 in the year 2010 is:

$$_5\mathrm{P}_{30,2010} = \left({}_5\mathrm{P}_{30,2000}/{}_5\mathrm{P}_{20,1990}\right) * {}_5\mathrm{P}_{20,2000}$$

The quantity in parentheses is the CCR for the population aged 20–24 in 1990 and 30–34 in 2000.

Given the nature of the CCRs, 10–14 is the youngest age group for which projections can be made (if there are 10 years between censuses). To project the population aged 0–4 and 5–9 one can use the Child Woman Ratio (CWR). It does not require any data beyond what is available in the decennial census. For projecting the population aged 0–4, the CWR is defined as the population aged 0–4 divided by the population aged 15–44. For projecting the population aged 5–9, the CWR is defined as the population aged 5–9 divided by the population aged 20–49. Here are the CWR equations for males and females aged 0–4 and 5–9, respectively.

$$\begin{aligned}
\text{Females } 0{-}4: &\quad {}_5\mathrm{FP}_{0,t} = \left({}_5\mathrm{FP}_{0,l}/{}_{30}\mathrm{FP}_{15,l}\right) * {}_{30}\mathrm{FP}_{15,t} \\
\text{Males } 0{-}4: &\quad {}_5\mathrm{MP}_{0,t} = \left({}_5\mathrm{MP}_{0,l}/{}_{30}\mathrm{FP}_{15,l}\right) * {}_{30}\mathrm{FP}_{15,t} \\
\text{Females}5{-}9: &\quad {}_5\mathrm{FP}_{5,t} = \left({}_5\mathrm{FP}_{5,l}/{}_{30}\mathrm{FP}_{20,l}\right) * {}_{30}\mathrm{FP}_{20,t} \\
\text{Males } 5{-}9: &\quad {}_5\mathrm{MP}_{5,t} = \left({}_5\mathrm{MP}_{5,l}/{}_{30}\mathrm{FP}_{20,l}\right) * {}_{30}\mathrm{FP}_{20,t}
\end{aligned}$$

Where

FP is the female population,

MP is the male population,

l is the launch year,

and t is the target year

The formula for projecting the youngest age groups using the CWR approach, is according to that shown below using, as an example, females 0–4 in 2010:

$$_5\mathrm{FP}_{0,2010} = \left({}_5\mathrm{FP}_{0,2000}/{}_{30}\mathrm{FP}_{15,2000}\right) * {}_{30}\mathrm{FP}_{15,2010}$$

Projections of the oldest age group differ slightly from projections for the age groups from 10–14 to the last closed age group (e. g., age group 80–84). For

example, if the final closed age group is 80–84, with 85+ as the terminal open-ended age group, then calculations for the CCR require the summation of the three oldest age groups to get the population age 75+:

$$CCR_{75+} = P_{85+,1}/P_{75+,b}$$

Using data from the 1990 and 2000 censuses, for example, the formula for projecting the population 85+ in the year 2010 is:

$$P_{85+,2010} = \left(P_{85+,2000}/P_{75+,1990}\right) * P_{75+,2000}$$

The quantity in parentheses is the CCR for the population aged 75+ in 1990 and 85+ in 2000.

The Hamilton–Perry Method can be used to develop projections not only by age, but also by age and sex, age and race, age, sex and race, and so on (Smith et al. 2001, p. 156).

On disadvantage of the Hamilton–Perry method, is that it can lead to unreasonably high projections in rapidly growing places and unreasonably low projections in places experiencing population losses (Smith et al. 2001, p. 159). Geographic boundary changes are an issue, even with census tracts. Since the Hamilton–Perry and other extrapolation methods are based on population changes within a given area, it is essential to develop geographic boundaries that remain constant over time. For some sub-county areas, this presents a major challenge, however. Fortunately, there are ways of overcoming these limitations of the Hamilton–Perry Method. They include:

1. Control Hamilton–Perry projections to independent projections produced by some other method;
2. Calibrate Hamilton–Perry projections to post-censal population estimates
3. Set limits on population change (i.e., establish "ceilings" and "floors"); and
4. Account for all boundary changes;

Data

In 2000, the population of Clark County was enumerated at 1,375,765. By 2005, it was estimated by the U.S. Census Bureau to be at 1,691,213, an increase of 22.9%. It has been one of the fastest growing counties in the country for over the past 20 years.

Clark County's major city, Las Vegas, had an enumerated population of 478,434 in 2000; by 2005 it was estimated at 538,653, an increase of 12.6%. To give you an idea of the magnitude of the change affecting Clark County, note that Las Vegas went from being the 63rd largest city in the US in 1990 to the 32nd largest in 2000.

As of the 2000 census, there were 356 census tracts in Clark County. They contained 3,318 block groups. These tracts and block groups are the geographies for which the projections are done. However, in 1990 there were only 120 census tracts in Clark County and they contained less than 1,200 block groups. Thus, to get to the projections, census tract changes between 1990 and 2000 had to be taken into account in order to calculate CCRs correctly. To do this, the Census Bureau's "Census Tract Relationships" file for Nevada was employed.

The Census Tract Relationship Files show how 1990 census tracts relate to Census 2000 census tracts. As described by the U.S. Census Bureau (2001), the files consist of one record per each 1990 census tract/2000 census tract spatial set. A spatial census tract set is defined as the area that is uniquely shared between a 1990 census tract and a 2000 census tract. The Census Tract Relationship Files consist of four sets of files. Two of these files are state-level entity- based census tract relationship files. One file provides a measurement of change based on population; a second measures change using street-side mileage. The other two files specifically list census tracts that have experienced significant change: one file from the perspective of 1990 census tracts, the other from the perspective of Census 2000.

In our implementation, we used the Population-based Census Tract Relationship File. This file is comprised of a record for each unique spatial 1990/2000 census tract area combination within Nevada. In addition to the 1990 and 2000 census tract codes, each record contains three population figures: (1) the Census 2000 population for the record; (2) the Census 2000 population for the entire 2000 census tract; and (3) the actual or estimated Census 2000 population for the area of the 1990 census tract (not the 1990 population for the 1990 census tract).

The record includes "part" indicators for both the 1990 and 2000 census tracts, and the percent of the Census 2000 population represented for the 1990 and 2000 census tracts represented in that record. The Census Bureau rounded the Census 2000 tabulation block population data for some of the blocks that are split by 1990 census tract boundaries. This rounding procedure may create individual census tract, county, and/or state population totals that are slightly different from the official Census 2000 population totals. Also, the Census 2000 population for the 1990 census tract and for the record is an estimate for each 1990 census tract that had a 1990 boundary not identical to a Census 2000 census block boundary.

Methods

To accomplish the projections for the 356 census tracts and their 3,318 block groups in Clark County, three steps were used. First a set of preliminary projections was produced using 1990–2000 CCRs, calibrated to estimates of the total population of each census tract in 2004. Second, as set of provisional projections was produced, which the preliminary projections were re-run with caps and floors. Third, the provisional projections were turned into final projections via two scenarios, which we discuss in more detail later:

(1) Hamilton–Perry Final (Provisional); and
(2) "REMI: Controlled

The Preliminary Population Projections

In early March of 2006, preliminary sub-county control projections by age were completed using the Hamilton–Perry Method. As described earlier, the projections are based on cohort change ratios between 1990 and 2000 for Clark County tracts

and tract groups that were assembled to represent the same geographic areas using the population-based tract relationships developed by the U.S. Census Bureau for this purpose. The 1990–2000 CCRs from tracts applied to all BGs within tract and projected from 2000 to 2020 after tract totals were calibrated to 2004 population estimates made by the Clark County Planning Department for census tracts. The 2004 estimate of the total population of Clark County was 1,747,025.

These preliminary projections were edited and double-checked and then used as controls for projections launched from 2000 block groups. The refined projections were informed by the actual location of these tracts and tract groups in the county (via maps) (Fig. 1).

The initial sub-county control projections are done by age (not by sex and age) because of how age data are reported for tracts in1990. As the projections were refined, sex was included.

The block group data for Clark County were assembled while the preliminary tract projections were being done. Both tasks were completed in early March and preliminary projections for were made for them using the refined tract level control projections. A subset of the preliminary projections was distributed for review

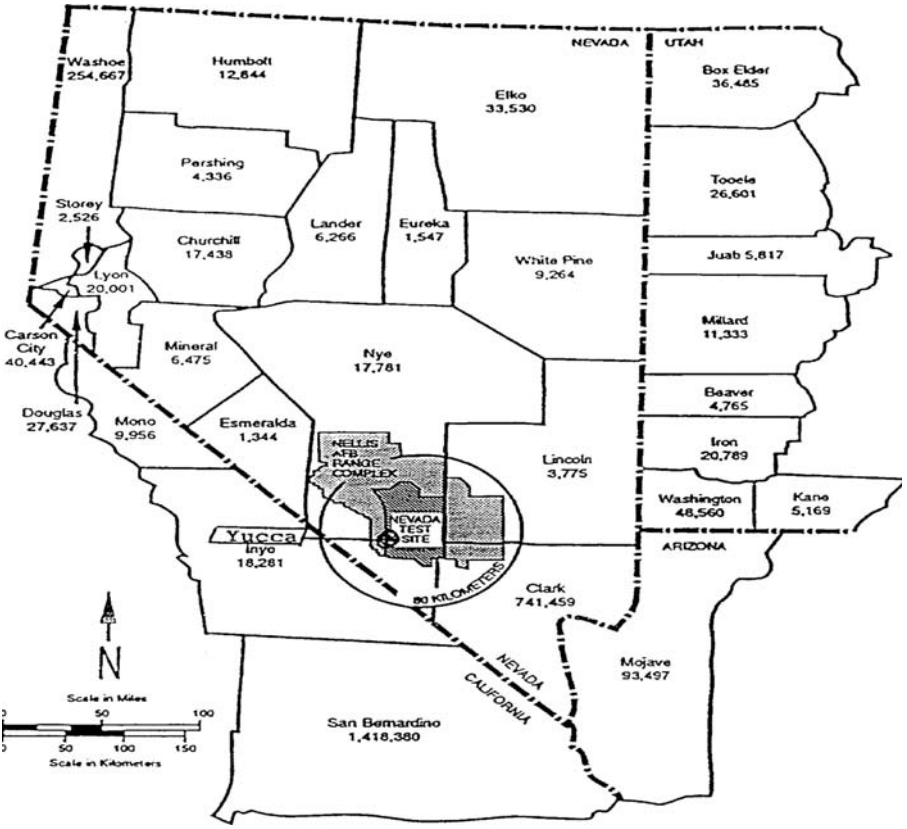

Fig. 1 Map of counties in Nevada

shortly thereafter. The excel files containing these projections were set up so that the BGs and tracts in which they are located can be easily identified and the projections easily read for purposes of review. This subset showed that the projections for all block groups could be loaded into a single file that was easier to analyze than the excel files used to generate the preliminary, revised, and final projections. This approach to organizing the projections was deemed acceptable and work proceeded accordingly.

The preliminary projections were distributed for review in early April. These projections were extrapolations of the 1990–2000 cohort change ratios and as such represented what the populations of the tracts (and when summed up, Clark County as a whole) would be if the 1990–2000 components of population change remain in effect to 2020. It was noted that this assumption may be reasonable in some cases, but unlikely to be reasonable in many, as revealed by the review of the preliminary projections. The reviewers were also advised to keep in mind that as control totals and other modifications were developed in the round of work in which to revise the preliminary projections were revised and became provisional projections.

The review of the preliminary projections was used to identify block groups (tracts) that: (1) have no substantial group quarters population and are "filled in," such that a continuation of 1990–2000 components of change is unrealistic given current land use and other constraints;(2) have no substantial group quarters population and had little (or even zero) population in 2000 and little, if any change from 1990 to 2000, but for which growth could be explosive as housing is built and populations move into these areas; (3) have no substantial group quarters population and have moderate growth potential—are neither filled in nor subject to potentially explosive change; and (4) have substantial group quarters populations (barracks, prisons, dorms) and, as such, have different population change dynamics than those areas without substantial group quarters populations. These identifications were used to develop "control totals" to use as a basis for the "calibration" and "adjustments" of the 1990–2000 CCRs, which, when completed, will produce the provisional projections that, in turn, will form the basis of the development of the final projections when informed judgment is applied to them. All of these features, it was noted, could be captured by using the 2004 tract level estimates for Clark County as calibration points.

The Provisional Population Projections

As soon as the preliminary projections were reviewed, work started on the provisional projections. The provisional projections were based on the calibrations of the preliminary projections to the 2004 population estimates produced by the Clark County Department of Comprehensive Planning for each of the 268 (or so) census tracts in Clark County. This means that the projection trajectory out to the horizon of 2020 conforms to the trend defined by the change between 2000 population totals and the 2004 population totals. That is, the age-sex data produced by the 1990–2000 cohort change ratios are controlled to this trend.

After, inspecting the preliminary projections and considering realistic rates of extended growth, a ceiling was placed on the annual rate of growth that a tract can

have over the 15 years from 2005 to 2020. The ceiling was established as 1.05. A floor on the annual rate of decline a tract can have over the 15 years from 2005 to 2020 also was set. The floor was established as 0.98. The preliminary BG projections of total pop are calibrated to the tract level per the ceiling and floor and the age and sex projections of each BG are calibrated to the BGs total population.

A provisional projection file for Tract 101 and its four block groups was distributed for review during the second week of April. It represented what was believed to be the most reasonable configuration for generating and reviewing the provisional projections. Basic documentation was included in the file. At the same time, the review team was informed that the remaining provisional projections will also be sent separately by tract (268 separate files) and that like the one for Tract 101, each file will provide census 2000 numbers and both the preliminary and provisional projections for 2005, 2010, 2015, and 2020 by block group and for the tract as a whole. During this same period, it was determined that including race along with age and sex was not feasible because of the way that small numbers were entwined with spatial distributions.

Starting on June 1st, the provisional projections were distributed for review. This set also served as "near-final" projections. By mid-June, the set of population projections for all census tracts and each of their constituent block groups in Clark County was delivered (as an ms-excel file). The tracts (and their constituent BGs) that comprise this file are those listed in the report titled "Clark County, Nevada 2004 Population—By Census Tract, By Housing Type, July 1 2004" (which is found at the Clark County Planning Department's website) and two tracts (and their constituent BGs) not listed in this report: Tract 500 and Tract 6102. Note that the sum of the 2000 census data by tract does not match the total shown for all of Clark County in 2000 by the U. S. Census Bureau: the sum of the tract totals is less than the total given for all of Clark County.

We checked and double-checked the 2000 data by tract and found that they were the same as provided for these same tracts by the U. S. Census Bureau and the tracts in the file match those shown in the county's list for the 2004 estimates (plus two tracts that were found and not in the list, namely census tracts 500 and 6102). Further checking of the census tract listings in different sources did not reveal the reason for this discrepancy (e.g., we took the census tract data directly from American Factfinder on the Census Bureau's webpage and it could be the case that they omitted some of Clark County's tracts in this source) as well as "corrections" that may have been issued by the U.S. Census Bureau that entered one set of data but not another.

The Final Population Projections and the Two Scenarios: REMI and Constrained

As described earlier, the final projections we generated via two scenarios:

(1) The Provisional Scenario as described earlier, now referred to as the "Hamilton–Perry Final Scenario;" and (2) the "REMI" Scenario.

The reason for having two scenarios stemmed from a discussion that took place during the later part of June among reviewers, which led to the idea to "control" the population projections to independent total population forecasts for Clark County done by the Center for Business and Economic Research at UNLV.

Because these forecasts are made using the REMI model (Treyz 1993; Treyz et al. 1993), they are labeled the "REMI" forecasts. What are the REMI forecasts? Each year, the Regional Transportation Commission, the Southern Nevada Water Authority, Clark County Comprehensive Planning, and the Center for Business and Economic Research at the University of Nevada, Las Vegas, work together to provide a long-term forecast of economic and demographic variables influencing Clark County. The primary goal is to develop a long-term forecast of Clark County population that is consistent with the structural economic characteristics of the county. Toward this end, a general – equilibrium demographic and economic model developed by Regional Economic Models, Inc. (REMI) specifically for Clark County is employed. The model is annually recalibrated to reflect the most current information available about the local economy, to include the most recent information about employment growth, expected hotel construction, transit investment, and an amenity variable representing negative externalities from a larger population. The version used in conjunction with the census tract/block group projections predicts positive economic growth throughout the range of the forecast, with a population forecast of 2,999,953 in 2020 and 3,580,908 at the end of the REMI horizon in 2035.

The total population figures for 2005, 2010, 2015, and 2020 were compared against the forecasted "REMI" totals for the county for these same years and the REMI numbers were found to be consistently higher. These comparisons are summarized in Table 1. The suggestion was made to use both REMI controlled population projections and the "final "projections we had already developed and issue them as two projection scenarios (1) the REMI scenario; and (2) the CONSTRAINED scenario.

The REMI scenario required special handling because population change is not uniformly distributed over Clark County, which meant that all tract (and block group) population projections should not be controlled to REMI. Instead, the census tracts that had already experienced "fill-in" had to be distinguished from those that could accommodate the growth implied by the REMI forecast. The summaries shown in Tables 1, 2, and 3 resulting from this process were distributed for review in late June.

It made no sense to allocate the preceding differences into all/most tracts/BGs by using a proportional share or anything similar because many of the tracts/BGs cannot accommodate more growth given current levels of "in-fill" and existing land-use regulations and related issues. The differences shown above were allocated

Table 1 Difference between the "Constrained V3a" and "REMI" population projections

Year	V3a	REMI	Difference
2005	1,833,500	1,757,507	75,933
2010	2,281,340	1,991,655	289,685
2015	2,687,055	2,217,045	470,010
2020	2,999,953	2,471,533	528,420

Table 2 Clark County summary, REMI control scenario

Summary Tracts 101-9405	Census 2000 Tract summary	Final projection 2005	Final projection 2010	Final projection 2015	Final projection 2020
Total	1,367,649	1,835,156	2,284,392	2,689,263	3,002,616
Males (years)	696,367	954,488	1,208,098	1,419,615	1,581,968
Under 5	52,967	70,298	85,762	100,694	113,890
5–9	53,096	63,810	73,844	87,651	98,886
10–14	47,668	62,918	76,693	87,027	96,205
15–19	43,491	58,601	73,576	75,638	76,937
20–24	48,578	64,263	80,702	90,746	100,677
25–29	56,213	75,405	84,011	110,083	124,767
30–34	59,617	75,933	88,556	108,178	123,803
35–39	60,344	74,151	83,646	89,804	112,500
40–44	53,888	89,157	81,828	88,443	33,172
45–49	46,431	63,683	86,030	87,701	88,325
50–54	42,033	61,913	81,716	88,263	82,838
55–59	34,808	54,575	73,850	90,464	102,372
SO and 64	28,887	48,723	68,555	87,632	100,348
65 and 69	24,408	40,618	60,872	77,834	88,570
70–74	19,814	29,600	42,569	59,368	70,232
75–79	13,555	18,827	25,780	38,371	47,838
80–84	6,841	11,061	16,475	22,888	27,433
85 and over	3,611	7,882	12,271	18,008	22,801
Female (years)	671,232	880,672	1,078,252	1,272 382	1/123,525
Under 5	50,043	44,678	38,410	78,342	108,515
5–8	50,456	43,238	35,745	70,028	34,604
10–14	44,867	59,402	71,348	53,211	41,652
15–19	40,589	55,745	70,070	50,546	36,760
20–24	44,183	60,331	77,575	86,003	84,486
25–29	52,458	70,742	88,836	104,410	118,424
30–34	53,614	71,617	85,077	103,511	118,881
35–39	54,272	69,627	80,738	34,532	106,627
40–44	48,752	65,178	75,884	83,484	89,731
45–48	45,214	61,882	76,585	81,254	84,671
50–54	42,842	61,194	77,268	82,235	85,711
55–59	35,553	53,508	70,287	82,107	80,478
60 and 64	28,784	48,828	73,877	86,887	84,586
65 and 68	24,475	40,338	58,748	74,464	83,508
70–74	21,166	29,215	38,363	61,224	76,383
75–79	16,036	19,845	24,887	37,828	47,458
80–84	9,635	12,732	16,572	21,632	25,486
85 and over	6,880	10,810	15,785	20,273	24,184

Table 3 Clark County summary, Hamilton Perry scenario (Not controlled to REMI)

Summary Tracts 101-9405	Census 2000 Tract summary	Final projection 2005	Final projection 2010	Final projection 2015	Final projection 2020
Total	1,367,649	1,757,507	1,991,655	2,217,045	2,471,533
Male (years)	693,367	912,739	1,048,823	1,163,639	1,294,616
Under 5	52,967	68,147	77,416	86,995	98,344
5–9	53,096	61,712	66,361	74,419	83,448
10–14	47,668	60,817	69,038	74,321	81,709
15–19	43,491	56,651	66,292	65,232	65,833
20–24	48,578	62,533	73,492	80,113	89,137
25–29	56,213	72,960	83,965	94,670	107,847
30–34	59,617	73,800	81,047	93,584	106,129
35–39	60,344	71,557	75,323	84,062	93,706
40–44	53,898	66,401	72,592	75,710	80,416
45–49	46,431	63,582	74,416	73,039	74,296
50–54	42,038	58,653	69,122	71,236	75,560
55–59	34,809	51,155	61,343	70,392	79,855
60 and 64	28,987	45,357	56,440	65,824	75,272
65 and 69	24,409	37,283	46,540	55,869	64,471
70–74	19,814	27,162	32,354	42,022	50,230
75–79	13,555	17,388	20,205	26,768	32,266
80–84	6,841	10,237	13,082	16,017	18,911
85 and over	3,611	7,343	9,794	13,317	17,176
Female (years)	671,282	844,773	945,790	1,056,147	1,179,794
Under 5	50,048	43,599	36,122	68,182	93,495
5–9	50,456	42,105	33,253	59,691	79,396
10–14	44,887	57,296	64,549	46,769	37,576
15–19	40,599	53,950	63,717	44,911	33,034
20–24	44,183	58,549	69,895	75,335	83,316
25–29	52,459	68,421	78,670	90,159	103,468
30–34	53,614	69,668	78,042	88,550	101,061
35–39	54,272	67,768	74,193	79,811	87,820
40–44	49,752	62M879	68,387	72,397	78,027
45–49	45,214	59,414	67,357	69,807	73,027
50–54	42,842	58,136	66,494	68,367	72,030
55–59	35,553	50,646	60,172	66,330	73,104
60 and 64	28,794	46,596	59,600	66,587	73,757
65 and 69	24,475	37,368	46,834	55,975	64,243
70–74	21,186	27,282	31,388	43,966	54,219
75–79	16,036	18,636	20,116	27,091	33,386
80–84	9,685	12,015	12,785	16,267	18,852
85 and over	6,980	10,230	13,000	15,714	18,998

into the tracts that are most likely to bear the brunt of growth generated by the REMI forecasts. These are census tracts that tend to be at the fringe of current high growth areas that are now "filling in," given certain restrictions (e.g., no growth was allocated into Red Rock Canyon National Conservation Area). With this in mind, eight census tracts were identified as those most likely to bear the brunt of the growth under the REMI scenario and put all of the differences into these eight tracts. Thus, the differences noted above were allocated into eight census tracts (and the BGs that comprise them) as follows.

Tract 5501 (south of US 93, west side of Boulder City area)	
Year	Revised total population to accommodate REMI forecast
2005	13,277
2010	35,738
2015	54,485
2020	60,451

Tract 5502 (south of US 93, east side of Boulder City area)	
Year	Revised total population to accommodate REMI forecast
2005	10,382
2010	27,323
2015	41,655
2020	46,671

Tract 5703 (East of I-15, area from Jean to Stateline and to Searchlight)	
Year	Revised total population to accommodate REMI forecast
2005	9,456
2010	30,029
2015	47,273
2020	52,965

Tract 5705 (Laughlin area)	
Year	Revised total population to accommodate REMI forecast
2005	2,806
2010	5,522
2015	7,744
2020	8,467

Tract 5710 (East of I-15, south of Las Vegas and Henderson)	
Year	Revised total population to accommodate REMI forecast
2005	39,974
2010	103,682
2015	155,903
2020	173,144

Tract 5816 (West of I-15, South of Blue Diamond Road)	
Year	Revised total population to accommodate REMI forecast
2005	40,581
2010	96,841
2015	143,149
2020	158,825

Tract 5901 (Mesquite, NV area	
Year	Revised total population to accommodate REMI forecast
2005	7,220
2010	13,184
2015	17,895
2020	19,564

Tract 5902 (east of US 95, north of Las Vegas and north of North Las Vegas)	
Year	Revised total population to accommodate REMI forecast
2005	16,519
2010	58,328
2015	93,512
2020	106,317

It was noted that in order to adjust everything to the REMI totals, there are/will be inconsistencies between the 2004 (and 2005) estimates for the preceding tracts, but these inconsistencies are part of the price for using the REMI controls and implementing them in such away as to avoid stuffing people into tracts where they literally cannot fit.

The preceding population projections were reviewed during July of 2006 and deemed final in August.

Results

Space prohibits us form providing the details for each census tract, much less the block groups (the detailed results are available from the authors in the form of excel spreadsheets) However, as an example, we display results for census tract 5703. Table 4 shows the results for this tract under the "REMI" scenario. Table 5 shows the "Hamilton–Perry Scenario (not controlled to REMI) for this same tract.

Discussion

The standard Cohort-Component Method was not feasible for this project because of lack of birth, death, and migration data at sub-county level. The Hamilton–Perry Method was selected instead because it is a type of cohort-component method and, as such, can generate age and sex data, which were required for this project.

As can be gleaned from this presentation, the Hamilton–Perry Method was not, however, a "quick and easy" method to implement. It required calibrations and adjustments, especially for certain tracts (and their constituent BGs) to include identifying those tracts that: (1) grew rapidly between 1990 and 2000, but for which "in-fill" had largely occurred by 2005; (2) had little, if any, population in 2000, but were starting to grow rapidly by 2005; (3) had little, if any, population in 2005, but which were going to start growing rapidly by 2010; and (4) were declining between 1990 and 2000, but which would not decline at the same rate to 2020. Thus, specific knowledge of these areas was required to generate plausible forecasts—ones that were not unreasonably high in rapidly growing places and unreasonably low projections in places experiencing population losses. This specific knowledge was gained via a "local expert review process" similar to one used by Swanson et al. (1998) in the development of enrollment forecasts for a school district in Oregon.

We conclude by observing that the Hamilton–Perry Method is an important tool in that it can generate valid sub-county population projections, but it requires informed judgment. In areas that have been subjected to rapid population changes, informed judgment is critical. However, the combination of data assembly and expert judgment can mean that a deal of work is required to implement the method. You can get a sense of this effort by following the timeline described in the paper in which we provide approximate dates (e.g., late June) by which certain milestones were met and products were delivered, with work having commenced in February, 2006 and completed in October, 2006. We believe that it is well worth the effort because the resulting projections not only have internal validity but, also, "face validity" (Smith et al. 2001, pp. 282–285). The Hamilton–Perry is very useful in this regard because it is transparent and easy to explain to a wide range of audiences.

Table 4 Census Tract 5703, Clark County, the "REMI Controlled" scenario

File = Final projections summary V4.xls using REMI control per SNRP	Tract 5703 Tract summary			
	Census 2000	Final projection 2005	Final projection 2010	Final projection 2015
Total	2,702	9,456	30,029	47,273
Male (years)	1,975	7,071	22,729	35,921
Under 5	7	140	645	515
5–9	12	228	1,047	828
10–14	10	28	79	758
15–19	22	50	113	1,032
20–24	92	133	96	131
25–29	148	250	334	366
30–34	203	553	1,483	1,031
35–39	258	685	1,802	1,467
40–44	244	743	2,170	2,842
45–49	208	801	2672	3,417
50–54	189	793	2,744	4023
55–59	184	730	2,468	4,577
60 and 64	131	636	2,325	4,694
65 and 69	98	564	2,170	4145
70–74	95	368	1,231	2,875
75–79	41	182	647	1,790
80–84	23	126	480	896
85 and over	10	58	223	533
Female (years)	727	2,385	7,300	11,352
Under 5	12	28	65	266
05–09	25	49	91	302
10–14	13	43	135	151
15–19	17	69	235	223
20–24	9	37	125	202
25–29	14	70	258	503
30–34	25	60	145	284
35–39	39	83	170	410
40–44	64	133	267	311
45–49	72	171	404	413
50–54	109	281	720	722
55–59	87	281	854	977
60 and 64	65	354	1,341	1,664
65 and 69	61	285	1,026	1,598
70–74	51	187	611	1,600
75–79	27	115	402	903
80–84	27	86	258	456
85 and over	10	52	193	368

Table 5 Census Tract 5703, Clark County, the Hamilton–Perry scenario (Not controlled)

File = Final projections summary V3a.xls Produced by D. Swanson	Tratc 5703 tract summary				
	Census 2000	Final projection 2005	Final projection 2010	Final projection 2015	Final projection 2020
Total	2,702	2,106	1,866	1,670	1,644
Male (years)	1,975	1,575	1,412	1,269	1,252
Under 5	7	31	40	18	7
5–9	12	51	65	29	12
10–14	10	6	5	27	40
15–19	22	11	7	36	54
20–24	92	30	6	5	4
25–29	148	56	21	13	9
30–34	203	123	92	36	9
35–39	258	153	112	52	22
40–44	244	166	135	100	87
45–49	208	179	166	121	102
50–54	189	177	170	142	134
55–59	184	163	153	162	174
60 and 64	131	142	144	166	185
65 and 69	98	126	135	146	159
70–74	95	82	76	102	120
75–79	41	41	40	63	78
80–84	23	28	30	32	34
85 and over	10	13	14	19	22
Female (years)	727	531	454	401	392
Under 5	12	6	4	9	13
05–09	25	11	6	11	14
10–14	13	10	8	5	4
15–19	17	15	15	8	5
20–24	9	8	8	7	7
25–29	14	16	16	18	20
30–34	25	13	9	10	11
35–39	39	18	11	14	17
40–44	64	30	17	11	8
45–49	72	38	25	15	10
50–54	109	63	45	25	16
55–59	87	63	53	35	26
60 and 64	65	79	83	59	49
65 and 69	61	63	64	56	55
70–74	51	42	38	57	69
75–79	27	26	25	32	37
80–84	27	19	16	16	17
85 and over	10	12	12	13	14

References

Ambrose, D., & Pol, L. (1994). Motel 48: Evaluating the profitability of a proposed business. In H. Kintner, T. Merrick, P. Morrison, & P. Voss (Eds.), *Demographics: A casebook for business and government* (pp. 144–154). Boulder: CO. Westview Press.

Billings, G., & Pol, L. (1994). Improving cellular market area valuation with demographic data. In H. Kintner, T. Merrick, P. Morrison, & P. Voss (Eds.), *Demographics: A casebook for business and government* (pp. 93–108). Boulder: CO. Westview Press.

George, M. V., Smith, S., Swanson, D., & Tayman, J. (2004). Population projections. In J. Siegel & D. Swanson (Eds.), *The methods and materials of demography* (2nd ed., pp. 561–601). New York, NY: Elsevier Academic Press.

Hamilton, C., & Perry, J. (1962). A short method for projecting population by age from one decennial census to another. *Social Forces, 41*(December), 163–170. doi:10.2307/2573607.

Johnson, K. (1994). Selecting markets for corporate expansion: A case study in applied demography. In H. Kintner, T. Merrick, P. Morrison, & P. Voss (Eds.), *Demographics: A casebook for business and government* (pp. 129–143). Boulder: CO. Westview Press.

Mason, A. (1996). Population and housing. *Population Research and Policy Review, 15*(5–6), 419–435.

Morrison, P., & Abrahamse, A. (1996). Applying demographic analysis to store site selection. *Population Research and Policy Review, 15*(5–6), 479–489.

Murdock, S., & Hamm, R. (1994). A demographic analysis of the market for a long-term care facility: A case study in applied demography. In H. Kintner, T. Merrick, P. Morrison, & P. Voss (Eds.), *Demographics: A casebook for business and government* (pp. 218–246). Boulder: CO. Westview Press.

Siegel, J. (2002). *Applied demography: Applications in business, government, law, and public policy*. San Diego, CA: Academic Press.

Smith, S., Tayman, J., & Swanson, D. (2001). *State and local population projections: Methodology and analysis*. New York, NY: Kluwer Academic/Plenum Press.

Swanson, D., & Pol, L. (2008). Applied demography: Its business and public sector components. In Yi Zeng (ed.) *The Encyclopedia of Life Support Systems, Demography Volume*. UNESCO-EOLSS Publishers. Oxford, England. (with L. Pol).(Online at http://www.eolss.net/).

Swanson, D., Hough, G., Clemans, C., & Rodriguez, J. (1998). Merging methods and judgment for K-12 enrollment forecasting. *Educational Research Service Spectrum, 16*(Fall), 24–31.

Thomas, R. (1994). Using demographic analysis in health services planning: A case study in obstetrical services. In H. Kintner, T. Merrick, P. Morrison, & P. Voss (Eds.), *Demographics: A casebook for business and government* (pp. 159–179). Boulder: CO. Westview Press.

Treyz, G. (1993). *Regional econometric modeling: A systematic approach to economic forecasting and policy analysis*. Boston, MA: Kluwer Academic Publishers.

Treyz, G., Rickman, D., Hunt, D., & Greenwood, M. (1993). The dynamics of U.S. internal migration. *The Review of Economics and Statistics, 75*, 221–253. doi:10.2307/2109425.

U.S. Census Bureau. (2001). Census Tract Relationship Files, US Census Bureau. (online at http://www.census.gov/geo/www/relate/rel_tract.html, last accessed January, 2007).