Evaluating the U.S. Census Bureau's 2005 State Population Projections

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Abstract

The U.S. Census Bureau's most recent set of state-level population projections was prepared in 2005. The performance of these projections has not been formally evaluated against the results of the 2010 decennial census. I compare the 2005 state-level projections for 2010 against the results of the 2010 decennial census. The results show that all states were projected within 8% of their enumerated population, while the projection for the District of Columbia was approximately 11.8% lower than the census count. I also formally evaluate the projections using the mean absolute percentage error (MAPE) and mean algebraic percentage error (MALPE). These calculations enable comparison with earlier projections series to demonstrate the 2005 projections' relative accuracy.

Introduction

The U.S. Census Bureau regularly prepares national-level population projections for the United States. Less frequently, the Census Bureau also prepares population projections at the state level. The most recent set of such projections was published in 2005 as interim projections, and covers the period 2005 to 2030 (U.S. Census Bureau 2005a). While the performance of the prior set of state-level population projections prepared by the Census Bureau in 1995 (Campbell 1996) was formally evaluated by the Census Bureau after the results of the 2000 decennial census (Campbell 2002, Wang 2002), the Census Bureau has not released such evaluations comparing the 2005 projections with the results of the 2010 decennial census. Identifying geographic trends in projection discrepancies could lead to improvements in future population projections by identifying states and regions in which the projection model does or does not perform well. Reliable projections are vital because population projections are used by government decision-makers and the private sector to anticipate service needs, funding levels, and market characteristics.

Methods

The projections use the cohort-component method to produce age- and sex-specific projections of the resident population of each state through 2030. The District of Columbia is also included; the territories are not. Fertility and mortality rates are based on data from 1999 to 2000, with small adjustments based on data from 2001 to 2003. Internal migration rates are based on IRS data from 1975 to 2000, while international migration rates are based on Census Bureau estimates for 2001 to 2003. The state population projections are adjusted to match the national population totals by age and sex from the national population projections published in 2004. Full details of the projection methodology are available on the Census Bureau website (U.S. Census Bureau 2005b).

Projections are made for July 1 of the target years, while decennial census counts are taken for April 1. Following Campbell (2002: 6), I adjust the projections for 2010 from July 1 to April 1 using Waring's linear interpolation method. I also report the results using three other

methods: (1) the geometric interpolation used by Wang (2002), (2) a simple linear extrapolation from the 2005 projections (i.e. not using the cohort-component method) also tested by Campbell (2002), and (3) a comparison of the unadjusted projections for July 1, 2010, with the Census Bureau's Vintage 2018 post-censal estimates for July 1, 2010 (U.S. Census Bureau 2018).

For each method, I calculate the percentage and absolute difference between the projection and census count (or estimate). I also calculate the mean absolute percentage error (MAPE) and mean algebraic percentage error (MALPE) for each method for the U.S., Census regions, and Census divisions (Campbell 2002, Wang 2002). The MAPE is the average of the absolute percentage difference between the projection and census count (or estimate). The MALPE is similar but does not take the absolute value of the difference, and so can give an indication of the direction of the discrepancy. I compare the MAPE and MALPE values for these projections to earlier projections releases. Earlier state projections have been evaluated by the Census Bureau to identify the sources of discrepancies in model inputs and assumptions (Wang 2002). The information released with these projections does not permit the same kinds of detailed analyses, but I provide a brief overview of trends in the components of population change during the period 2005 to 2010.

Percentage and Absolute Differences by State

Table 1 shows the percentage and absolute differences between the projections and census counts (or estimates) for each of the four methods described above for states and the U.S. The five largest over-projections for each method are shown in bold/red, and the five largest under-projections are shown in italics/green. Figure 1 shows the states with a projection discrepancy of over 2% in purple (projection under census count) and green (projection over census count) for the linearly adjusted projections.

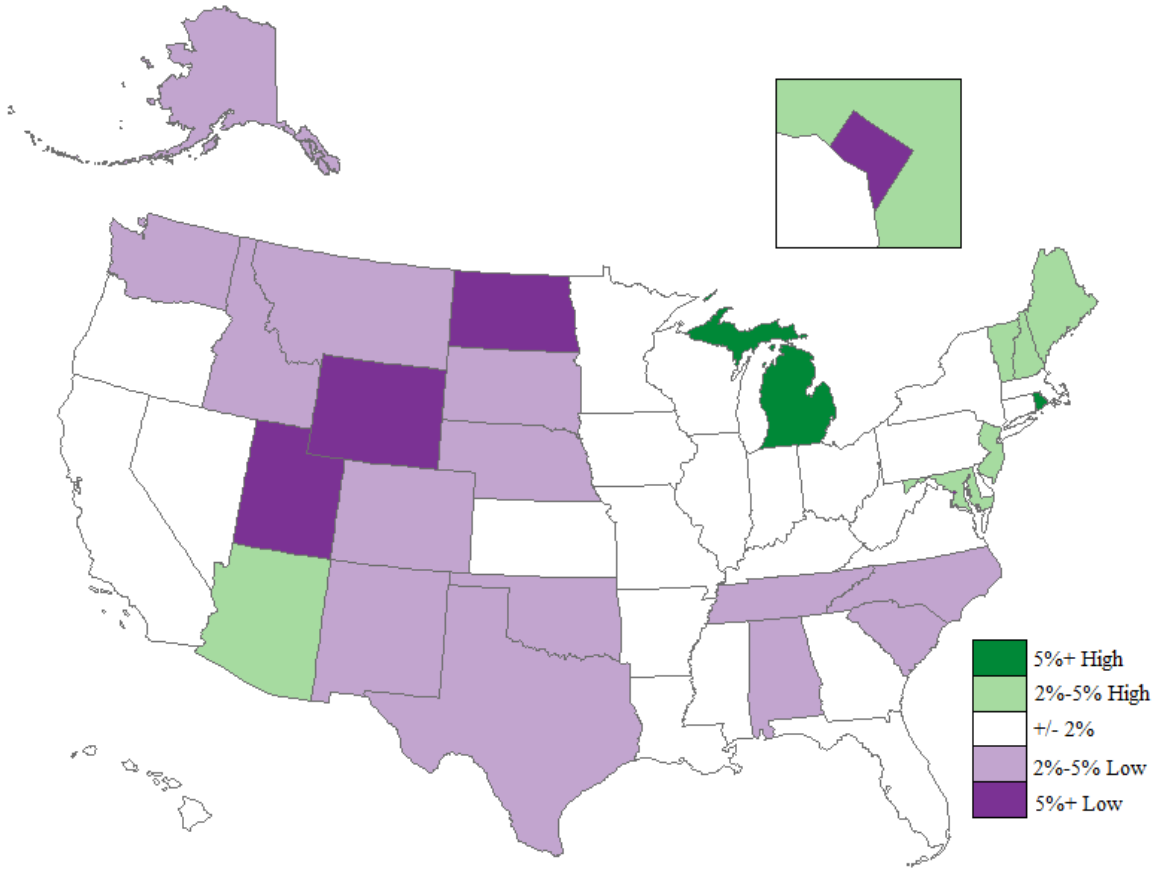
Table 1. Percentage and absolute differences between 2005 projections for 2010 and 2010 decennial census counts (or population estimates) for the U.S. and states.

	Adjusted Projections (Linear) and Census		**Adjusted Projections (Geometric) and Census**		**Extrapolated Projections and Census**		**Projections and Estimates**	
	Percentage	**Absolute**	**Percentage**	**Absolute**	**Percentage**	**Absolute**	**Percentage**	**Absolute**
United States	-0.15%	-473,929	-0.15%	-477,917	0.75%	2,329,480	-0.13%	-390,504
NORTHEAST								
New England								
Maine	2.03%	26,941	2.03%	26,932	2.89%	38,423	2.89%	29,502
New Hampshire	**4.98%**	65,556	**4.98%**	65,533	**6.51%**	85,705	**6.51%**	68,783
Vermont	**4.11%**	25,701	**4.11%**	25,696	**4.75%**	29,722	**4.75%**	26,632
Massachusetts	1.47%	95,945	1.46%	95,921	2.43%	158,881	2.43%	83,010
Rhode Island	**5.96%**	62,739	**5.96%**	62,733	**7.25%**	76,291	**7.25%**	62,714
Connecticut	0.00%	128	0.00%	114	1.03%	36,984	1.03%	-1,635
Middle Atlantic								
New York	0.30%	58,543	0.30%	58,519	0.99%	191,250	0.99%	43,592
New Jersey	2.43%	**213,781**	2.43%	**213,720**	3.63%	**319,149**	3.63%	**218,607**

Pennsylvania	-0.99%	-125,127	-0.99%	-125,153	-0.90%	-114,906	-0.90%	-126,671
MIDWEST								
East North Central								
Ohio	0.31%	35,519	0.31%	35,505	0.68%	78,567	0.68%	36,854
Indiana	-1.52%	-98,390	-1.52%	-98,419	-0.73%	-47,250	-0.73%	-98,297
Illinois	0.60%	76,421	0.60%	76,382	1.39%	178,225	1.39%	76,132
Michigan	**5.41%**	**534,831**	**5.41%**	**534,788**	**6.28%**	**621,071**	**6.28%**	**551,148**
Wisconsin	0.56%	32,064	0.56%	32,022	1.37%	78,095	1.37%	36,947
West North Central								
Minnesota	1.97%	104,345	1.97%	104,268	2.88%	152,952	2.88%	109,793
Iowa	-1.24%	-37,880	-1.24%	-37,885	-0.67%	-20,292	-0.67%	-40,860
Missouri	-1.24%	-74,492	-1.24%	-74,528	-0.60%	-35,916	-0.60%	-73,898
North Dakota	*-5.35%*	-35,971	*-5.35%*	-35,971	*-6.63%*	-44,564	*-6.63%*	-38,087
South Dakota	-3.49%	-28,440	-3.49%	-28,443	-2.90%	-23,633	-2.90%	-29,766
Nebraska	-3.20%	-58,457	-3.20%	-58,461	-2.48%	-45,379	-2.48%	-60,539
Kansas	-1.76%	-50,193	-1.76%	-50,204	-1.12%	-31,877	-1.12%	-52,743
SOUTH								
South Atlantic								
Delaware	-1.77%	-15,892	-1.77%	-15,907	-0.29%	-2,572	-0.29%	-15,253
Maryland	2.01%	116,261	2.01%	116,160	2.82%	163,096	2.82%	116,328
District of Columbia	*-11.77%*	-70,837	*-11.77%*	-70,837	*-12.25%*	-73,712	*-12.25%*	-75,300
Virginia	-0.17%	-13,523	-0.17%	-13,683	0.94%	75,525	0.94%	-13,435
West Virginia	-1.30%	-24,003	-1.30%	-24,004	-1.21%	-22,454	-1.21%	-25,073
North Carolina	-2.33%	*-222,062*	-2.33%	*-222,322*	-1.17%	-111,229	-1.17%	*-228,470*
South Carolina	-4.08%	*-188,772*	-4.08%	*-188,835*	-2.92%	-134,830	-2.92%	-188,952
Georgia	-1.36%	-131,289	-1.36%	-131,548	0.57%	55,312	0.57%	-122,730
Florida	1.91%	**360,003**	1.91%	**359,108**	2.11%	**396,750**	2.11%	**405,906**
East South Central								
Kentucky	-1.82%	-78,951	-1.82%	-78,971	-0.96%	-41,617	-0.96%	-83,083
Tennessee	-2.03%	-128,538	-2.03%	-128,617	-1.19%	-75,698	-1.19%	-124,449
Alabama	-3.91%	-186,805	-3.91%	-186,818	-3.43%	*-164,076*	-3.43%	*-189,118*
Mississippi	0.05%	1,597	0.05%	1,587	0.91%	26,915	0.91%	876
West South Central								
Arkansas	-1.57%	-45,636	-1.57%	-45,661	-0.84%	-24,398	-0.84%	-46,939
Louisiana	1.67%	75,806	1.67%	75,792	1.61%	73,149	1.61%	68,147
Oklahoma	*-4.35%*	-163,263	*-4.35%*	-163,277	*-4.05%*	*-151,802*	*-4.05%*	-168,116
Texas	-2.35%	*-590,184*	-2.35%	*-590,981*	-0.97%	*-244,848*	-0.97%	*-593,791*

WEST								
Mountain								
Montana	-2.28%	-22,539	-2.28%	-22,548	-2.26%	-22,357	-2.26%	-22,124
Idaho	-3.56%	-55,883	-3.57%	-55,930	-2.27%	-35,509	-2.27%	-53,482
Wyoming	*-7.85%*	-44,268	*-7.85%*	-44,271	*-7.35%*	-41,452	*-7.35%*	-44,597
Colorado	-4.14%	*-208,236*	-4.14%	*-208,301*	-1.22%	-61,196	-1.22%	*-216,727*
New Mexico	-4.00%	-82,462	-4.01%	-82,481	-3.17%	-65,373	-3.17%	-84,363
Arizona	**3.22%**	**205,550**	**3.21%**	**205,075**	**4.55%**	**290,977**	**4.55%**	**229,607**
Utah	*-6.43%*	-177,836	*-6.44%*	-177,908	*-5.12%*	*-141,602*	*-5.12%*	-180,321
Nevada	-1.02%	-27,433	-1.02%	-27,653	1.58%	42,609	1.58%	-11,933
Pacific								
Washington	-2.99%	*-200,736*	-2.99%	*-200,863*	-2.63%	*-176,712*	-2.63%	*-200,939*
Oregon	-1.31%	-50,336	-1.32%	-50,406	-1.09%	-41,919	-1.09%	-46,536
California	1.91%	**713,095**	1.91%	**712,421**	3.17%	**1,180,241**	3.17%	**746,231**
Alaska	-2.52%	-17,903	-2.52%	-17,915	-1.60%	-11,345	-1.60%	-19,797
Hawaii	-1.65%	-22,418	-1.65%	-22,435	-0.87%	-11,890	-0.87%	-23,289

Figure 1. Projection discrepancy percentages by state (linearly adjusted 2005 projections for 2010 compared to 2010 decennial census counts)



MAPE and MALPE

Table 2 shows the MAPE and MALPE values for the United States, Census-defined regions, and Census-defined divisions for each of the four methods. MAPE values are similar across the four methods. At the national level, the MALPE value for the extrapolated projections is somewhat lower, though there is more variation at the region and division levels.

Table 2. MAPE and MALPE values for the United States, regions, and divisions (2005 projections for 2010 compared to 2010 decennial census counts or population estimates)

		Adjusted Projections (Linear) and Census		Adjusted Projections (Geometric) and Census		Extrapolated Projections and Census		Projections and Estimates	
Region and Division	**Number of States**	**MAPE**	**MALPE**	**MAPE**	**MALPE**	**MAPE**	**MALPE**	**MAPE**	**MALPE**
US	51	2.67	-1.07	2.67	-1.07	2.61	-0.25	2.72	-1.07
Northeast	9	2.47	2.25	2.47	2.25	3.38	3.17	2.52	2.29
New England	6	3.09	3.09	3.09	3.09	4.14	4.14	3.16	3.14
Middle Atlantic	3	1.24	0.58	1.24	0.58	1.84	1.24	1.24	0.57
Midwest	12	2.22	-0.75	2.22	-0.75	2.31	-0.21	2.31	-0.78
East North Central	5	1.68	1.07	1.68	1.07	2.09	1.80	1.73	1.13
West North Central	7	2.61	-2.05	2.61	-2.05	2.47	-1.64	2.73	-2.14
South	17	2.61	-1.95	2.61	-1.95	2.25	-1.19	2.67	-2.00
South Atlantic	9	2.97	-2.09	2.97	-2.10	2.70	-1.26	3.06	-2.14
East South Central	4	1.95	-1.92	1.95	-1.93	1.62	-1.17	1.96	-1.95
West South Central	4	2.48	-1.65	2.49	-1.65	1.87	-1.06	2.48	-1.73
West	13	3.30	-2.51	3.30	-2.51	2.84	-1.41	3.32	-2.46
Mountain	8	4.06	-3.26	4.06	-3.26	3.44	-1.91	4.05	-3.16
Pacific	5	2.08	-1.31	2.08	-1.31	1.87	-0.61	2.13	-1.33

Components of Change

Wang's (2002) evaluation of the 1995 state population projections for 2000 includes an analysis of births, deaths, domestic migration, international migration, errors in state estimates, census undercounts, and the size of population change as possible contributors to discrepancies between the projections and the census counts. Wang (2002: 13) finds that census undercounts and errors in state estimates had a particularly strong effect on discrepancies in the 1995 state projections for 2000. A comparable analysis for the 2005 projections for 2010 is not feasible using the publicly-released projections data. Broadly, for the United States during the period 2005 to 2010, birth rates and counts rose until 2007 and then declined (Martin et al. 2012), age-adjusted death rates declined (Murphy et al. 2013), domestic migration declined (Ihrke et al.

2011, Ihrke and Faber 2012), and net international migration declined slightly (United Nations 2017). The undercount in the 1990 decennial census was a source of discrepancies in the 1995 projections for 2000 (Wang 2002). The 2000 decennial census had an overcount (0.49%), but it was of a smaller magnitude than the 1990 decennial census's undercount (1.61%) (U.S. Census Bureau 2012).

Comparisons with Previous State Projections

As shown in Table 1, the projection model was approximately 0.15% below the 2010 decennial census count (the simpler extrapolation model was approximately 0.75% above the 2010 decennial census count). At the national level, the prior set of state population projections (Campbell 1996) for 2000 was approximately 2.6% below the 2000 decennial census count (Campbell 2002). The District of Columbia also had the largest discrepancy in those earlier state projections, at 8.38% below the 2000 decennial census count using both the linear (Campbell 2002) and geometric (Wang 2002) adjustment methods and the "Series A" projections from 1995 (the comparable percentage for "Series B" is 7.33% under for both adjustment methods). The comparable value for the District of Columbia in the later projections (2005 projections for 2010) is 11.77% for both adjustment methods.

MAPE values are similar across the two sets of projections (1995 for 2000 and 2005 for 2010). Using the linear adjustment, MAPE for the 1995 "Series A" projections for 2000 was 2.63 (Campbell 2002), compared with 2.67 for the 2005 projections for 2010. The comparable values for the geometric adjustment are 2.64 (Wang 2002) and 2.67, respectively. The MAPE for the 1995 "Series B" projections was somewhat lower at 2.44 for both adjustment methods (Campbell 2002, Wang 2002). An alternate series is not available for the 2005 projections for 2010. Compared to the earlier projections (Campbell 2002, Wang 2002), MAPE values are similar for the Northeast and South, somewhat higher in the Midwest, and somewhat lower in the West. The MALPE value for the 1995 "Series A" geometrically adjusted projections for 2000 was -1.40 (Wang 2002), compared to -1.07 for the comparable 2005 projections for 2010.

Summary

The performance of the 2005 projections for 2010 compares favorably with the performance of earlier sets of state-level projections produced by the U.S. Census Bureau. The largest under-projections generally occurred in the western half of the country, parts of the South, and the District of Columbia, with over-projections in Michigan, Arizona, and the northeastern part of the U.S. Future research should examine the sources of discrepancies in more detail, which may require access to data resources not publicly available from the Census Bureau at this time.

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