Households and Housing Forecasts at State and Small Area Levels

--A New Approach and Applications to the State, Two Counties and One Town of North Carolina

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Abstract: Employing the ProFamy method/program, this study examines the methodological and empirical issues of households and housing forecasting at state and small area levels with illustrative applications to North Carolina, Orange and Chatham counties, and the town of Chapel Hill. Our analysis and forecasts demonstrate that future housing consumption is directly linked with household size/type/income, age/race of the householder, and changes in demographic rates. The results show that there will be a 16-17% increase in owned housing units and a 16-19% increase in rented housing units from 2005 to 2015. Growth in the number of owned housing units with 0-2 bedrooms is faster than that of units with 3+ bedrooms. The growth in housing consumption of smaller households, elderly households, and Hispanic households will be faster than that of other household types. The housing demand of low income households will grow slightly faster than that of households with high and medium income. Our empirical analysis shows that the headship-rate method will substantially bias the forecasts of both the owned housing market and rental housing market due to its inherent deficits of being unlinked to demographic rates and excluding household size and cohort-component effects, which will definitely alter future households structure and size distribution.

1. INTRODUCTION

Given that the changing demographic structure and magnitude of the population and households could reshape the housing market in the next few decades, it is important to forecast future households and housing demands. By using the ProFamy method/program for household forecasting developed by Zeng and colleagues (1997; 1998; 2005a; 2005b), this study aims to present a new approach to forecast households and housing consumption by type/size and income of households, and age and race/ethnicity of the householder. We will also present illustrative applications of households and housing forecasts from 2005 to 2015 for NC, two counties, and one town, based on the census and other conventional demographic data. To our knowledge, as compared to previous similar studies, this study is the first to present housing consumption forecasts by detailed household type/size/income, age, race, and gender of the reference persons at state and small area levels. We will briefly review the related literature in the remainder of this introductory section. The method discussion, data, estimates and assumptions sections follow. We then present and discuss the forecasting results.

The housing sector has been the cornerstone of economic activity over the past several decades in the U.S. (Berson et al., 2005). Housing is the first, most important possession of the great majority of American households (Medlock and Sologo, 2002). Nearly two million new homes have been built each year recently in the United States; replacement and second homes are also in demand (Berson et al., 2005; Joint Center for Housing Study of Harvard University (JCHSHU, 2005). Homeownership not only provides various benefits, including accumulation of

wealth and social status, but also is the basis for a number of positive social, economic, family and civic outcomes (Berson et al., 2005). With the historically low mortgage interest rate, strong increases in house value, and dramatic increase in the number of households due to demographic changes, the homeownership rate and number of housing units steadily increased in the 1990s in the U.S. after a decade of decline. The homeownership rate reached a new peak (69%) in 2004 (U.S. Census Bureau, 2005). There are sizable differences in homeownership rates across income levels, racial/ethnic groups, and household types/sizes, however (Berson et al., 2005; U.S. Census Bureau, 2005). For example, between 1994 and 2003, the relative increase in the number of homeowners among African-Americans, Hispanics, and Asian and Pacific Islanders reached 25.1%, 62.8%, and 103%, respectively, as compared to 7.6% for non-Hispanic Whites. But even with these gains, the homeownership rate among African-Americans and Hispanics is still less than 50%, lagging below that of non-Hispanic Whites, whose homeownership rate is higher than 75% (Berson et al., 2005).

In the rental housing market, despite the slow growth of rental demand due to the increase in homeownership, more than one million new rental housing units were built between 1992 and 2001 in the U.S., excluding those built as replacements (JCHSHU, 2004). This increase is mainly contributed by household increases in minority and immigrants. Indeed, without the rapid growth in the number of minority households, the number of rental housing units would have fallen during the 1990s (JCHSHU, 2004). The demographics of the renter population have correspondingly changed. For example, the share of minority renters climbed from 31 percent to 39 percent while the foreign-born share grew from 12 percent to 17 percent, which lowers the overall income level of renters because the incomes of minority and foreign-born renters are normally lower than those of White and native-born renters (JCHSHU, 2004).

Analyses of housing survey data in the U.S. have consistently shown the close relationship of household characteristics such as age, race/ethnicity, and household type/size/income with housing consumption (Smith, 2005; Berson and Neely, 1997). The changes in demographic characteristics have a direct impact on the composition and location of housing, as well as an area's residential needs, patterns, and preferences in addition to macroeconomic growth, and mortgage and interest rates. Demographic factors become increasingly important as the forecast horizon is extended (Berson et al., 2005). Berson and Neely (1997) report that the homeownership rate rises with age until about seventy. This is due mainly to higher mobility rates among young people that inhibit them from owning houses (Berson et al., 2005; Kan, 2000). The advent of the population bulge of the baby boom generation moving into prime home owning years will be one of the most potent forces affecting the housing market and homeownership (Berson et al., 2005). Indeed, the growth in the homeownership rate after 1990 is related to baby boomer cohorts (Berson and Neely, 1997). Because the size of the baby boomer cohort (about 77 million) is much larger than other cohorts , the overall homeownership rate is expected to increase for a couple of decades (Smith, 2005). Myers and Vidaurri (1996) show how population aging will enlarge the future housing market. Martin (2005) believes that the baby boom appears to dominate factors such as housing prices, tax changes, improvements in financial markets, and changes to monetary policy on the housing consumption market.

Household type/size is relevant to housing ownership. Empirical studies have shown that couple households tend to own homes with more rooms as compared to unmarried households (Bajari and Kahn, 2005). Census data has indicated that the proportion of married couple households with/without children has steadily declined in the recent few decades. Furthermore, married couples with children are now choosing to have fewer children. On the other hand, the number of people living alone has swelled. It is estimated that those living alone make up the second largest category of households in the United States; it appears that this group will continue to grow due to high divorce rates, postponement of marriage and longer life spans (Berson et al., 2005). According to a recent study by the Department of Housing and Urban Development (HUD, 2005), demographic changes played a critical role in the homeownership rate change from 1990 to 2000. Decomposition analyses show that, for example, population aging will contribute more owner-occupied housing unit consumption, while the increased share of minorities in the composition of the population and households lowered the homeownership rate in the period.

The 2000 census data show that the homeownership rate is less than 50 percent for households with an annual income less than ten thousand dollars, while it surpasses 90 percent for those with one hundred thousand dollars (Berson et al., 2005). The homeownership rate is also determined by housing prices and the affordability conditions. States with higher home prices typically have lower homeownership rates. Urban areas usually have higher housing costs but also offer more rental alternatives. Thus, the homeownership rate is often lower in more urbanized areas (Berson et al., 2005).

The homeownership rate of Black, Asian, and Hispanic households is much lower than that of White & Non-Hispanic households (Coulson, 1999). Poor financial skills, low incomes and little wealth, and/or other socio-demographic factors are roots of racial inequalities in housing (Berson and Neely, 1997; Kutty, 1999; Megbolugbe and Linneman, 1993; Vanderhart, 1993). Estimates by the Joint Center for Housing Studies at Harvard University show that if income, age and family type of minorities were similar to that of Whites, the homeownership gap would be reduced from roughly 25 to about 10 percentage points (JCHSHU, 2003). The racial gap is narrowing by efforts through education and information providing, building affordable housing, and governmental intervention (e.g., Delgadillo and Dorwart, 1998; Peterson, 1998; Roach, 2002; Ross and Turner, 2005; The Bipartisan Millennial Housing Commission, 2002), although some researchers argue that promotion of homeownership in low-income households will do little to narrow the racial gap (Denton, 2001; Rosenbaum and Friedman, 2004).

According to the 2000 Census, North Carolina (NC) had 3.1 million households; among them, 69.4% are homeowners and 30.6% are renters.[1] Although its homeownership rate has not changed much between 1990 and 2000, the population size and number of households in North Carolina has experienced dramatic growth, indicating that housing demand is increasing. According to census data, between 1990 and 2000, NC gained 0.46 million homeowners (an increase of 27%) and 0.15 million renters (an increase of 20%). The increases in both owned and rented housing units from 1990 to 2000 rank among the top five in the nation. This quick increase is somewhat contributed by the large increase in immigration. Because it takes time for immigrants to become homeowners, the overall homeownership rate leveled off in the 1990s, despite rapid growth in the number of households.

Although the ownership rate for Orange and Chatham (two counties as a group: 63.5% in 2000) is lower than the statewide average, the relative increase in owned-housing units was faster than that of the state by more than 4 percentage points from 1990 to 2000 due to a faster increase in the growth of the population and households. The relative increase in rental housing also had faster growth for these two counties combined than did the state. The homeownership rate in the town of Chapel Hill in 2000 was 42.9%, much lower than that of the state and the two counties combined. But owned-housing units gained more than a 36% increase from 1990 to 2000, nearly 10% more than the state average. The rental housing units in 2000 had a 24% increase over 1990, 4% more than the state average.

In summation, housing consumption is determined by demographic changes, household characteristics, economic growth, policy, and other relevant factors. Analyzing the housing market is one of the central focuses for any community, especially for those communities experiencing significant changes in the structure of the population and households.

2. METHOD

Knowledge of the future trend in housing consumption is one of the central strategic plans for both governmental developments, to improve the quality of life of its citizens, and homebuilders, to increase their sales market. In estimating the homeownership rate, some studies provide several demographic and economic scenarios (Berson et al., 2005), some use econometric modeling (Green and Hendershott, 1996; Mean, 1998), some use the cohort method (Myers, Pitkin, and Park, 2002; Pitkin and Myers, 1994), and others use linear extrapolation combined with expert opinion (Forrest and Leather, 1998). Another approach to forecast housing consumption is based on regression modeling. For example, based on a model using the individual as the analysis unit, Macpherson and Sirmans (1998) use estimated housing composition derived from multinomial logit regression to project housing demand for South Carolina and its counties by assuming that the regression estimated composition of each type of housing is constant across forecast years in the presence of some covariates (i.e., race, age, sex, education, and income). Although econometric methods and the regression approach for housing consumption forecasts have their merits by means of integrating various economic factors or even some policy factors into the model, they neglect or overlook the important impacts of the future changes in demographics and household type/size on housing consumption. Hendershott and Weicher (2002) further emphasize the extreme difficulties in forecasting economic and policy factors with reasonable accuracy.

As indicated earlier in reviewing the literature, housing consumption is determined by household type/size/income, and age/race of the householder, which depend on demographic changes to a large extent. It follows that more accurate and reasonable forecasts of housing consumption should be based on demographic household forecasting by size/type/income, and age/race of the householder. However, very few previous studies have attempted to forecast future housing consumption by detailed household characteristics. Most existing housing forecasts are based on the classic headship-rates and population projection, disaggregated by age-gender (Berson et al., 2005; Department of Housing & Community Development of California, 2000; Forrest and Leather, 1998; Green and Hendershott, 1996; Holmans, 1995).

Criticized widely by demographers for more than a decade (Bell and Cooper, 1990; Murphy, 1991; Mason and Racelis, 1992; Spicer Diamond, and Bhrolchain, 1992), the classic headship-rate method used in previous studies for households and housing consumption

forecasting is not linked to demographic rates and projects a few household types without size. It is clear that the classic headship-rate method is insufficient for sound household housing consumption forecasting because housing consumption is closely related to changes in demographic rates, household size and composition. We, thus, adopt a new demographic approach using the ProFamy method/program to forecast age-race-sex-type/size-income-specific numbers of households in the future. As compared to the classic headship-rate approach, the new ProFamy method uses demographic rates as input and projects more detailed household characteristics of type, size, age, race, etc. (Zeng, Vaupel, and Wang, 1997; 1998; Zeng, Land, Wang, and Gu, 2005a; 2005b).

The ProFamy model's methodological background, accounting equations, procedures for ensuring consistencies between the two sexes and between parents and children, assumptions, discussions, most recent extensions, and validations of the method through projecting from 1990 to 2000 and comparing the results to the 2000 census observations, etc., were presented in previous publications (Zeng et al., 1997; 1998; Zeng et al., 2005a; 2005b), and, thus, will not be repeated here. In the rest of this section, we focus on the methodological issues of applying the ProFamy method for household forecasting to the state and small area levels. One needs to prepare age-sex-specific standard schedules of demographic rates or to employ the existing age-sex-specific model standard schedules of demographic rates (see (2) in Table 3 in Zeng et al., 2005b). One then projects or assumes the demographic summary measures (see (3) in Table 3 in Zeng et al., 2005b) based on time series or expert opinion analysis. The standard schedules describe the age pattern of demographic processes. ProFamy can take into account anticipated changes in the age pattern, such as delaying or advancing marriage and fertility, by adjusting the schedules to match the projected mean ages of the demographic events in the future years. Based on the standard schedules and demographic summary measures, ProFamy generates estimates of the time-varying age-sex-specific demographic rates needed to project households and the population into future years. Projecting the future demographic summary measures can be done either by using statistical software for time series analysis or by the expert opinion approach. Users may even want to include the time series data of other related socioeconomic covariates (e.g., average income, labor force participation, education, urbanization) in demographic summary measures projection. Projections based on time series analysis or assumptions based on expert opinion are made about the components of changes in demographic factors that produce household distributions in the future years. Thus, the ProFamy approach is analogous to and a substantive extension of the classic cohort-component population projection model.

Data for preparing age-race-sex-specific standard schedules of the demographic rates for household forecasting may not be available at the state level, such as is the case for NC. However, once the age-race-sex-specific standard schedules at the national level have been prepared (and updated every a few years or so, depending on the availability of new data), as we have done, other analysts could simply employ these standard schedules as "model standard schedules" for household forecasting at the state level. Such an approach is equivalent to the widely practiced applications of model life tables (e.g., Coale, Demeny, and Vaughan, 1983). The theoretical foundation of the applications of *model standard schedules* is that demographic summary measures are crucial, but age-specific model standard schedules are not substantially sensitive to the forecasting results as long as they reveal the general age patterns of demographic processes of the population. For applications of ProFamy to household forecasting, this argument was tested and validated by us (Zeng et al., 2005a: Appendix A for detailed results) and was further illustrated in validation test of the NC state application to be presented later in this section.

In brief, using the existing model standard schedules and projected (or assumed) demographic summary measures such as TFR, life expectancy at birth, general rates of marriage, divorce, cohabitation and union dissolution, census data, as well as the ProFamy software, one can conveniently produce household forecasts at the state level. Of course, someone needs to produce the model standard schedules for those who deal with the same or similar populations to use. Following such a strategy, we use the race-age-sex-specific model standard schedules based on pooled national survey data[2] (Zeng et al., 2005a) in the application of households and housing forecasting for North Carolina in this paper.

The largest challenge faced by population and household forecasting for small areas is that it is usually impossible to have a large enough sample size to make the meaningful estimates and forecasts of demographic rates necessary to apply the cohort-component method. Indeed, even the census datasets, although valuable, cannot provide information at the small area level (e.g., county) for all the characteristics that are of interest. Therefore, in making population and household forecasting for small areas with an adequate level of precision, most researchers use indirect methods that "borrow strength" based on a projection for the parental state (the state in which a small area is located) to increase the accuracy of the projections (Rao, 2003). Practically, most current official household forecasts at the small area level in the U.S. and elsewhere follow the ratio trend extrapolation approach using the parental state's household forecasts, which are based on the headship-rate method, which has the inherent disadvantages discussed earlier. Furthermore, most of these small area level projections forecast only the number of households, with a few exceptions that forecast a few household types without size information (e.g., Crowley, 2004; Ip and McRae, 1999).

Ratio trend extrapolation methods (e.g., extrapolating county shares of the state population) are frequently used for small area forecasts because their data requirements are minimal, they are easy to apply, and their forecasts often to be reasonably accurate (Smith, 2003). In household forecasting using the ProFamy method, we employ the ratio trend extrapolation method and let the user choose either the constant-share or the shifting-share approach (Smith et al., 2001) to conduct household forecasts for small areas, in combination with the household forecasts of the parental state. The household forecasts of the parental state must be done first to serve as a basis. We then compute the race-sex-age-specific proportions of the households with various types/sizes of the small area among the corresponding households of the parental state. We assume that the proportions are constant or changing following the past trends or projected new trends, and we then multiply the existing parental state's household forecasts by the proportions to derive the household forecasts for the small area. The assumption imposed and the rationale of such constant-share or shift-share approaches in household forecasts for small areas are the same as the ones generally used for small area population forecasts, which has proven a valid method (Smith et al., 2001). The technical procedure and formulas designed for household forecasts for small areas using the ProFamy method are presented in Zeng et al. (2005b).

One useful validation exercise for a model and computer program for population projections is to project between two past dates for which the observations are known, and then compare the observed data with the projected data. We previously tested the ProFamy method/program for household forecasting at the national level by projecting U.S. households from 1990 to 2000. Comparisons between the census observed and the projected main indices of U.S. households in 2000 in that exercise show the differences are within reasonable range. It is

clear that the ProFamy method/program works well at the national level (see Section 2.3 in Zeng et al., 2005a).

Does the ProFamy method/program also work reasonably well at state and small area levels? To address this issue, we conducted household forecasts for North Carolina (NC) from 1990 to 2000. We calculated the NC starting population for the projections based on the 1990 census. We then conducted two kinds of tests. The first applies the ProFamy method/program and the national race-sex-age-specific standard schedules observed in the 1980s and the NC demographic summary measures projected through extrapolations based on time series data before or in 1990. This test assumes that we have no data after 1990 and conduct the forecast based solely on pre-1990s data and the ProFamy model. This exercise tests the accuracy of the forecasts at state and small area levels using the ProFamy model in the real world (assuming the accuracy of the 2000 census observations). The second test uses the ProFamy method/program and the national race-sex-age-specific standard schedules and NC summary measures observed in the 1990s as input to project NC households from 1990 to 2000. This test validates the simulation properties of the ProFamy model at state and small area levels based on the assumptions that the input data (observed in the 1990s) and the 2000 census observations (outcome in this exercise) are correct. We also performed the two kinds of tests of household forecasting for the Triangle Area[3] from 1990 to 2000 based on the forecasted household distributions of North Carolina in 1990-2000 and the constant-share approach. Note that the Triangle Area includes Orange and Chatham counties and a couple of other small counties that share a super PUMS code in the census micro data files. Comparisons of the total number of households, total number of group quarter residents, total population size, average household size, percent of 1, 2-3, 4-5, and 6+ person households, percents of single-parent and couple households between the forecasted and observed in 2000 census are given in Table 1a and 1b.

Among the twenty pairs (ten pairs in each test) of the main indices between the ProFamy forecasted and the 2000 census observed, seven (35 percent) of the absolute values of the relative discrepancies are less than 1%, eight (40 percent) are 1-4.9%, four (20 percent) are 5-9.5%, and the smallest group (6+ person households) has the largest discrepancy, 13.3%, in the state (Tables 1a and 1b). Similar patterns and magnitudes of the relative discrepancy rates are also found between the ProFamy forecasted and the 2000 census observed in the Triangle Area. These results show that the differences are within reasonable range. We are not sure whether the discrepancies are due mainly to the model specification, or to inaccuracies of the census and other data, or a combination of these. It is, however, clear that the ProFamy method/program for household forecasting works reasonably well not only at the national level but also at the state level using the national model standard schedules, and at the small area level, as well.

Table 1a. Comparing ProFamy-projected and census-observed U.S. households and population in 2000, employing the ProFamy method/program and the race-sex-age-specific standard schedules observed in the 1980s and the demographic summary measures projected through extrapolation based on data before 1991, North Carolina and the Triangle Area

North Carolina				Triangle Area			
	Census	ProFamy	Diff.%		Census	ProFamy	Diff.%
Total number of households	3,132,013	3,186,569	1.7	Total number of households	214,363	218,700	2.0
Average Household Size	2.48	2.47	-0.6	Average Household Size	2.42	2.42	0.0
Percent of				Percent of			
1 person households	25.39	27.18	7.0	1 person households	27.69	29.08	5.0
2 -3 person households	52.78	50.76	-3.8	2 -3 person households	52.21	49.60	-5.0
4-5 person households	19.08	19.68	3.1	4+ person households	20.10	21.32	6.1
6+ person households	2.75	2.38	-13.3				
Couple households	57.12	59.94	4.9	Couple households	52.02	51.00	-2.0
Single-parent households	17.49	15.83	-9.5	Single-parent households	20.29	19.92	-1.8
Total population size	8,049,313	8,097,882	0.6	Total population size	541,922	551,162	1.7
Group quarter residents	253,881	256,024	0.8	Group quarter residents	23,235	22,229	-4.3

Table 1b. Comparing ProFamy-projected and census-observed U.S. households and population in 2000, employing the ProFamy method/program and the race-sex-age-specific standard schedules and the demographic summary measures observed in the 1990s, North Carolina and the Triangle Area

North Carolina				Triangle Area			
	Census	ProFamy	Diff.%		Census	ProFamy	Diff.%
Total number of household	3,132,013	3,171,262	1.3	Total number of household	214,363	218,065	1.7
Average Household Size	2.48	2.47	-0.3	Average Household Size	2.42	2.43	0.4
Percent of				Percent of			
1 person households	25.39	27.08	6.6	1 person households	27.69	28.79	4.0
2 -3 person households	52.78	50.81	-3.7	2 -3 person households	52.21	49.68	-4.8
4-5 person households	19.08	19.47	2.1	4+ person households	20.10	21.52	7.1
6+ person households	2.75	2.64	-3.8				
Couple households	57.12	61.18	7.1	Couple households	52.02	49.42	-5.0
Single parent households	17.49	17.51	0.1	Single parent households	20.29	21.79	7.4
Total population size	8,049,313	8,097,882	0.6	Total population size	541,922	551,162	1.7
Group quarter residents	253,881	256,024	0.8	Group quarter residents	23,235	21,393	-7.9

Notes: Due to the sample size limitation of the census 5% micro data, we currently group households of size 4,5,6+ into one category of size 4+ for small areas.

3. DATA, ESTIMATES, AND ASSUMPTIONS

As discussed and validated earlier, we employ the national race-sex-age-specific model standard schedules, estimated by Zeng et al. (2005b) based on the pooled national survey data and other data released by the Census Bureau, for households forecasting at the state level. Data to derive the base population for household forecasts for the state of North Carolina and the two counties in this study are based on 2000 census 5% micro data. The assumed demographic summary measures in the future years for NC state household forecasting are listed and discussed in Appendix A.

To perform households and housing forecasting for a small area (e.g., the two counties and the town of Chapel Hill), we need its parental state's baseline data in the starting year and forecasted distributions of households in the future years (Zeng et al., 2005b). We also need the small area's baseline data of the numbers of households by type/size, race and age-group of the reference persons in the starting year. Taking into account the constraints of sample sizes for small areas, we normally group the small areas' households and persons living in group quarters into the following 11 categories: (1) single-man only; (2) single-woman only; (3) a single-man & children/other, size 2-3; (4) a single-man & children/other, size 4+; (5) a single-woman & children/other, size 2-3; (6) a single-woman & children/other, size 4+; (7) a couple only; (8) a couple and children/other, size 3-4; (9) a couple and children/other, size 5+; (10) men living in group quarters; (11) women living in group quarters. "Single-" refers to not-married and not-cohabiting persons (never-married, divorced, or widowed). "One-couple" refers to a married or cohabiting couple. We normally classify the ages of household reference persons and group quarter persons by four age groups: <35, 35-64, 65-79 and 80+. The seven combinations of legal marital status and cohabiting status, single-year ages and exact household size up to 9+ persons are distinguished in the ProFamy household projection model; they are aggregated here due to the sample size constraints in small areas. Note that a user may choose to have more detailed classifications of household type, size, age-group, and elderly living arrangement, if the sample size of the small area is large enough.

The following eight categories of households by race, income and the age groups <35, 35-64, 65-79 and 80+ are available from Census Bureau publicly available on-line census tabulations for state, county, county subdivision, town, subbarrio, census tract, and block group data: I: single-man only; II: single-woman only; III: a not-married-man & children/other, size 2+; IV: a not-married-woman & children/other, size 2+; V: a married couple only or a married couple with children/other, size 2+; VI: a cohabiting couple only or a cohabiting couple with children/other, size 2+; VII: men in group quarters; VIII: women in group quarters. Note that the on-line available categories I, II, VII, VIII are the same as the needed categories (1),(2),(10),(11); but the available categories III, IV, V, VI are not the same as the needed (3)-(9). We can use the proportional distributions of household categories (3)-(9) derived from 5% micro data of the census PUMA area (e.g., two counties in this study), which includes the smaller area (e.g., Chapel Hill in this study) to decompose the small area's on-line available categories III, IV, V, VI to reasonably approximate its needed categories (3)-(9). (Note: a PUMA area usually includes a couple of neighboring counties; the Census 5% micro data file has PUMA codes but no county, town, and other smaller unit codes).

The ACS will produce annually updated, 5-year average data sets for geographic areas down to the block group level. For example, in 2008 and 2009 there will be public-use micro-data files covering the period 2003-2007 and 2004-2008, respectively, and so forth. Each 5-year average can be thought of as replacing a hypothetical census long form in the middle year; for example, the 2003-2007 average would correspond to "2005 census long form data." The ACS will also produce 1-year averages for geographies with 65,000 persons or more and 3-year average estimates for geographies with 20,000-65,000 persons. These averages will be regularly available for the full range of tables (Alexander, 2002). Therefore, we will be able to obtain appropriate baseline household data for states and small area forecasts with a starting year in or after 2005.

We use the census (or ACS) data to estimate age-race-sex-household type/size-income specific homeownership rates in the future years. The homeownership rate is defined as the proportion of households that own a housing unit (house or apartment). Households that do not own a housing unit are noted as renters. The sum of the homeownership rate and home-renter rate is equal to one. The homeownership rates and home-renter rates are classified by income, household type/size and age/race of the householder, with exactly the same categorization as that for the households. The homeownership rates are further decomposed into three components for three types of housing units for the state and counties[4]: housing units with 0-2 bedrooms (0 bedrooms means that the bed is in the living room), housing units with 3 bedrooms, and housing units with 4+ bedrooms. We then multiply the homeownership rates and home-renter rates by the corresponding type/size/age/race/income specific numbers of households forecasted by the new ProFamy approach to yield projected future housing demands.

We use percentiles to define income categories: high income - 1st quartile; middle income - 2nd quartile and 3rd quartile; low income - 4th quartile. The primary reasons for using income category percentiles rather than absolute dollar numbers to define the income categories and why the age-race-household type/size-specific proportions of high, middle, and low income from 2000 to 2015 are assumed to be the same as those observed in the 2000 census are discussed in detail in Appendix B. The procedure to keep the consistency of the income category percentiles distribution (high income, top 25%; middle income, 25-75%; low income, bottom 25%) in the population under study (a nation, state, or a small area) in each of the forecasting years, while the population and households structure are changing, are also presented in Appendix B. Four race/ethnic groups are distinguished for NC in this study, following the latest classification by the Census Bureau: White Non-Hispanic, Black Non-Hispanic, Hispanic, and Asian & Others Non-Hispanic.[5]

Table 2 presents the estimates of the somewhat aggregated homeownership rates for NC, the two counties (Orange & Chatham) combined, and Chapel Hill in 2000. Around 71% of North Carolina households owned a house or apartment in 2000, slightly higher than the national rate derived from the 100% data released by the Census Bureau. As compared to the NC average, the homeownership rates in Orange & Chatham and Chapel Hill are lower (Table 1). The much lower homeownership rate in Chapel Hill is mainly because of the location of the University of North Carolina (UNC), which has high proportion of young people who do not own a house or apartment. The general patterns of the NC homeownership rates across ages, races, and incomes categories are similar to the national average, with some noticeable differences. For example, the homeownership rate for Hispanics in NC is lower than the national Hispanic average rate by

12 percentage points. The Non-Hispanic Black rate in NC is slightly higher than the national rate. Note that homeownership rates actually used in our housing forecasting are cross-classified by household type/size/income, age/race of the householder and number of bedrooms, which are much more detailed than the data summarized in Table 2.

Table 2. Aggregated homeownership rate by number of bedrooms and one household variable in 2000 (%)

	NC				Orange & Chatham counties				Chapel Hill
	0-2 bedrooms	3 bedrooms	4+ bedrooms	Total	0-2 bedrooms	3 bedrooms	4+ bedrooms	Total	
Total	17	41	13	71	14	36	15	64	43
Age									
<35	12	30	8	49	8	16	5	29	10
35-64	15	46	16	78	14	44	21	79	69
65+	27	42	11	80	24	42	13	79	71
Race									
Non-Hispanic White	18	44	14	76	NA	NA	NA	NA	NA
Non-Hispanic Black	12	34	9	55	NA	NA	NA	NA	NA
Hispanic	13	17	5	34	NA	NA	NA	NA	NA
Non-Hispanic Others	14	33	13	60	NA	NA	NA	NA	NA
Income									
Low	21	26	5	52	18	19	3	40	12
Middle	18	44	9	71	15	40	10	64	38
High	9	51	28	88	9	44	37	89	84
Household type/size									
One person	24	30	5	59	21	23	5	49	27
Single/2-3	14	32	7	53	9	28	4	40	20
Single/4+	8	31	15	53	5	14	15	34	18
Couple only	20	51	14	84	16	45	17	78	73
Couple/3-4	11	51	19	80	10	48	25	82	69
Couple/5+	6	34	31	71	7	31	38	77	69

Note: (1) Rates for NC and the two counties are obtained from the 2000 census 5% micro data files. Rates for Chapel Hill are estimated from combined data sources of the 2000 census 5% micro data files and the online 100% tabulations. (2) "Single" includes not-married and not-cohabiting men and women; "Couple" includes married and cohabiting couples. (3) NA indicates that data are not available.

To illustrate the application of households and housing forecasting with detailed household characteristics of type/size/age/race/income, we adopt the medium assumptions of the changes in demographic parameters (see Appendix A) and simply keep the race-sex-age-household type/size-income-specific homeownership rates constant. We call the forecasts

presented in this report "medium forecasts." One common approach in forecasting is to hold some of the current age-attribute-specific rates constant throughout the relatively short forecasting horizon (e.g., Day, 1996; Treadway, 1997). Smith, Tayman and Swanson (2001: 83-84) argue that holding some of the rates and proportions constant when forecasting can be justified on either of two grounds. The first is that future rates and proportions are unlikely to differ much from the current level. The second is the belief that neither the direction nor the magnitude of future changes can be predicted accurately. The argument here is not so much that the current rates will remain constant, but rather that scientific theories and past history do not provide reliable bases for predicting how those rates will change. If upward or downward movements are equally likely, the current rates provide a reasonable forecast of future rates. The analysis of a forecasting interval formulated by high and low bounds on future housing consumption with scenarios of changes in demographic parameters and homeownership rates will be conducted in our further studies.

4. RESULTS OF THE HOUSING FORECASTS

In this section, we will integrate the discussions on household forecasts with housing forecasts, which are the focus of this paper. Due to space limitations, we will summarize the main results here and provide some detailed forecast outcomes as illustrative examples in Appendix C. We emphasize that these results are "medium forecasts" (or educated forecasts). The interval forecasts with high and low bounds to reveal the uncertainties will be done in our further study, as we did for U.S. national households and vehicle consumption forecasting (Zeng et al., 2005a; Zeng, Wang, and Gu, 2005).

4.1. General trends in future housing demands

Table 3 shows that the total number of owned-housing units is around 2.35 million in 2005 in NC, while the 0-2 bedroom units, 3 bedroom units, and 4+ bedroom units consist of 23.7%, 57.7%, and 18.6% of the total; this composition will remain rather stable over the period 2005-2015. The total forecasted number of owned-housing units in NC in 2015 will reach 2.73 million, 0.38 million more than that in 2005, representing a 16.4% relative increase in 10 years. The relative increase in 0-2-bedroom owned-housing units in the next decade is around 19%, which is higher than those for 3-bedroom and 4+-bedroom units by nearly 4 percentage points. Out of the 0.38 million increase in owned-housing units, 0.11 million (28.0%), 0.21 million (54.2%), and 0.07 million (17.8%) will have 0-2 bedrooms, 3 bedrooms, and 4+ bedrooms, respectively. These figures suggest that, although the relative increase in 0-2 bedroom units is higher, the future demand in owned-housing units will be relatively dominated by 3-bedroom units in NC.

The percent of household-owned 4+ bedroom units in Orange & Chatham counties is substantially higher than and the smaller housing units' shares are lower than that of the NC average over the period 2005-2015 (Table 3). The relative increase in owned-housing units over the period 2005-2015 in Orange & Chatham counties (17%) and Chapel Hill (17.2%) are slightly larger than that of the NC average (16.4%). From 2005 to 2015, about 7,300 and 1,400 owned-housing units will be added in Orange & Chatham counties and Chapel Hill, respectively. Similar to the NC average, the household-owned 0-2 bedroom housing unit demand in Orange & Chatham counties will grow relatively faster than those of the 3 bedroom and 4+ bedroom units. 3 bedroom units, however, will continue to relatively dominate the housing market in the next ten years.

Table 3. Forecasted numbers of owned-housing units by the number of bedrooms in 2015, and the increases in 2015 as compared to 2005

	All		0-2 bedrooms		3 bedrooms		4+ bedrooms	
	Number	%	Number	%	Number	%	Number	%
NC								
2005	2,349,556	100.0	557,089	23.7	1,355,798	57.7	436,670	18.6
2015	2,734,112	100.0	664,810	24.3	1,564,289	57.2	505,013	18.5
# Inc.	384,556	100.0	107,721	28.0	208,491	54.2	68,343	17.8
% Inc.	16.4		19.3		15.4		15.7	
Orange & Chatham Counties								
2005	43,233	100.0	9,354	21.6	23,684	54.8	10,195	23.6
2015	50,583	100.0	11,161	22.1	27,462	54.3	11,957	23.6
# Inc.	7,347	100.0	1,807	24.6	3,778	51.4	1,762	24.0
% Inc.	17.0		19.3		16.0		17.3	
Chapel Hill								
2005	8,246	100.0	NA	NA	NA	NA	NA	NA
2015	9,662	100.0	NA	NA	NA	NA	NA	NA
# Inc.	1,416	100.0	NA	NA	NA	NA	NA	NA
% Inc.	17.2							

Note: (1) # Inc. and % Inc. refers to the number and % of increase in owned-housing units in 2015 as compared to 2005. (2) Forecasted numbers of owned-housing units are also available for each of the years between 2005 and 2015, but they are not presented in the tables due to space limitations. (3) NA: baseline data are not available.

Table 4 presents the total number of forecasted rental housing units in NC, Orange & Chatham counties, and Chapel Hill. The total number of rental housing units in NC will hit 1.23 million in 2015, 0.20 million more than that in 2005, representing a 19.3% increase as compared to 2005. It is expected that there will be about 5,600 and 2,000 more rental housing units in Orange & Chatham counties and Chapel Hill in 2015 as compared to 2005, respectively. The relative increase in rental housing units from 2005 to 2015 in Orange & Chatham counties is almost the same as that of NC. The cumulative increase in rental housing units in each year 2006-2015 as compared to 2005 in Chapel Hill is substantially lower than those in NC and Orange & Chatham counties.

Table 4. Forecasted total numbers of rental housing units in each year 2005-2015 and the percent of cumulative increase as compared to 2005

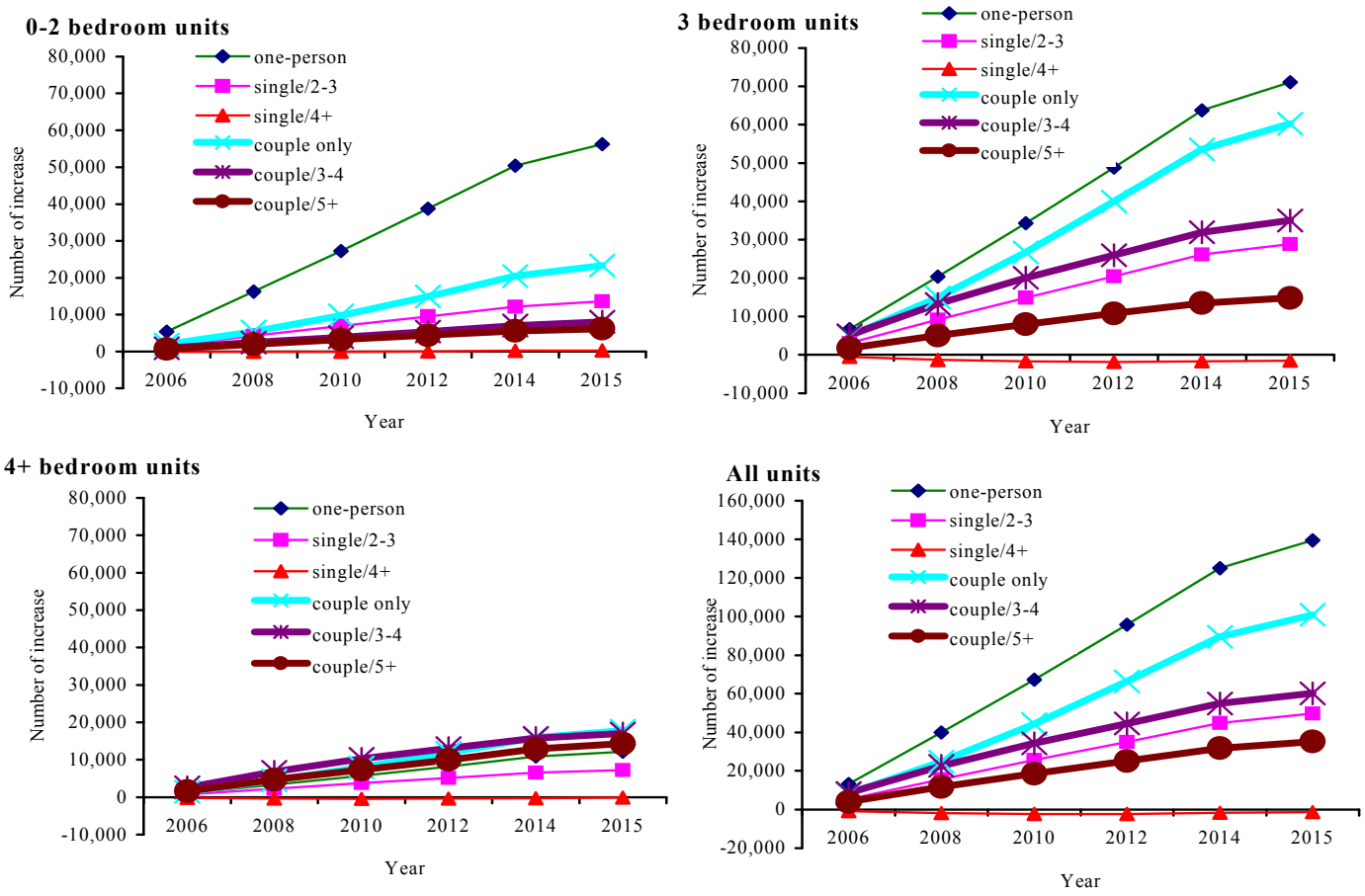
	NC		Orange & Chatham Counties		Chapel Hill	
Year	Number	% Inc.	Number	% Inc.	Number	% Inc.
2005	1,031,567	--	29,226	--	12,176	--
2006	1,050,522	1.8	29,683	1.6	12,299	1.0
2008	1,088,436	5.5	30,755	5.2	12,650	3.9
2010	1,129,870	9.5	31,993	9.5	13,109	7.7
2012	1,171,921	13.6	33,226	13.7	13,595	11.7
2014	1,211,131	17.4	34,311	17.4	13,995	14.9
2015	1,231,127	19.3	34,822	19.1	14,176	16.4

Note: % Inc.: % of cumulative increase as compared to 2005.

4.2. Forecasts of the number of housing units by household type/size and age of the reference persons

Figure 1 demonstrates that the differences in the increase in housing units owned by households with different types/sizes are substantial. The increase in 0-2 and 3 bedroom housing units owned by single-person-only households is projected to be the largest as compared to the increase in 0-2 and 3 bedroom housing units owned by any other kind of household. The increase in housing units with 0-2, 3, and 4+ bedroom housing units owned by couple-only households rank the second largest, and rank the first largest in units with 4+ bedrooms after 2012. It is interesting to note that the number of all three types of housing units owned by single-parents with a household size of 4+ will decline. These trends are induced by demographic change, namely, the increase in smaller households, especially one-person-only households, will be substantially larger than that of larger households in the next decade.

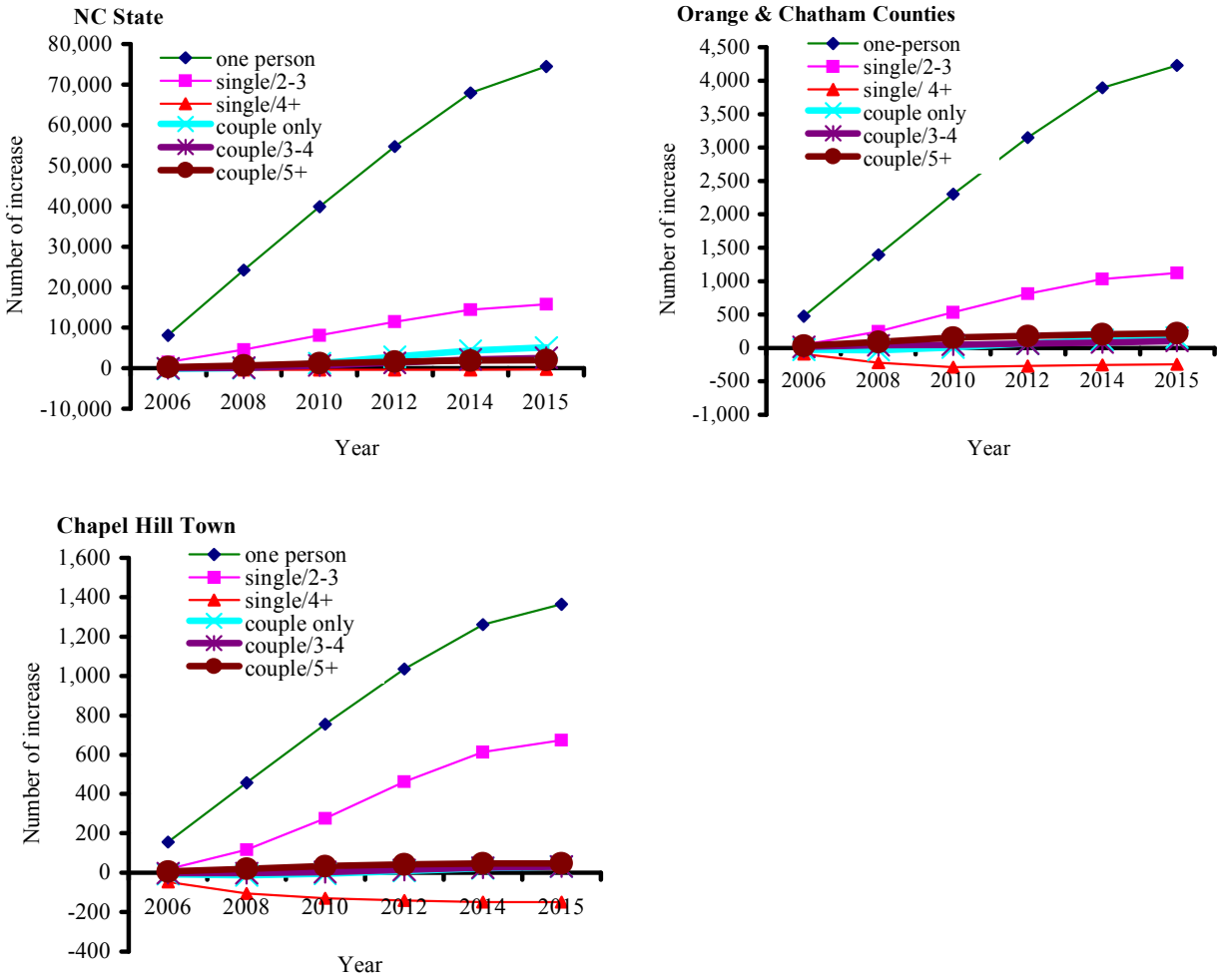
Figure 1. Forecasted cumulative increase of housing units as compared to 2005 by household type/size, NC



Note: Single/2-3 and single/4+ refer to single-parent households of size 2-3 and 4+; couple/3-4 and couple/5+ refer to couple-households of size 2-3 and 5+.

Figure 2 shows that the forecasted increase in rental housing units is almost exclusively consumed by one-person-only households and non-couple households of size 2-3; one-person-only households particularly dominate. The increase in rental housing units for households of other types/sizes is minor. The demand for rental housing units by non-couple households of size 4+ will decrease.

Figure 2. Forecasts of cumulative increase in rental housing units by household type/size, as compared to 2005



The forecasting results presented in Figure 3 are striking. In the NC, about 55% and 36% of the total increase in owned-housing units in 2015 as compared to 2005 are consumed by households with a reference person aged 35-64 and 65+, respectively; the younger households with a reference person aged less than 35 share a very small portion of the market. The pattern in Orange & Chatham counties is rather similar to that of the state. But the "aging of owned-housing market" in Chapel Hill is even more striking: elderly households aged 65+ will occupy the largest share (49%) of the increase in owned-housing units after 2012 (see Figure 3). As the baby-boomers age, the housing market will also age; governmental agencies and the business

community will need to take this trend into account seriously. Figure 4 shows that the majority of the cumulative increase in rental housing units will be consumed by younger households aged less than 35, especially in Chapel Hill.

Figure 3. Forecasts of the cumulative increase in owned-housing units by the age of the reference person, as compared to 2005

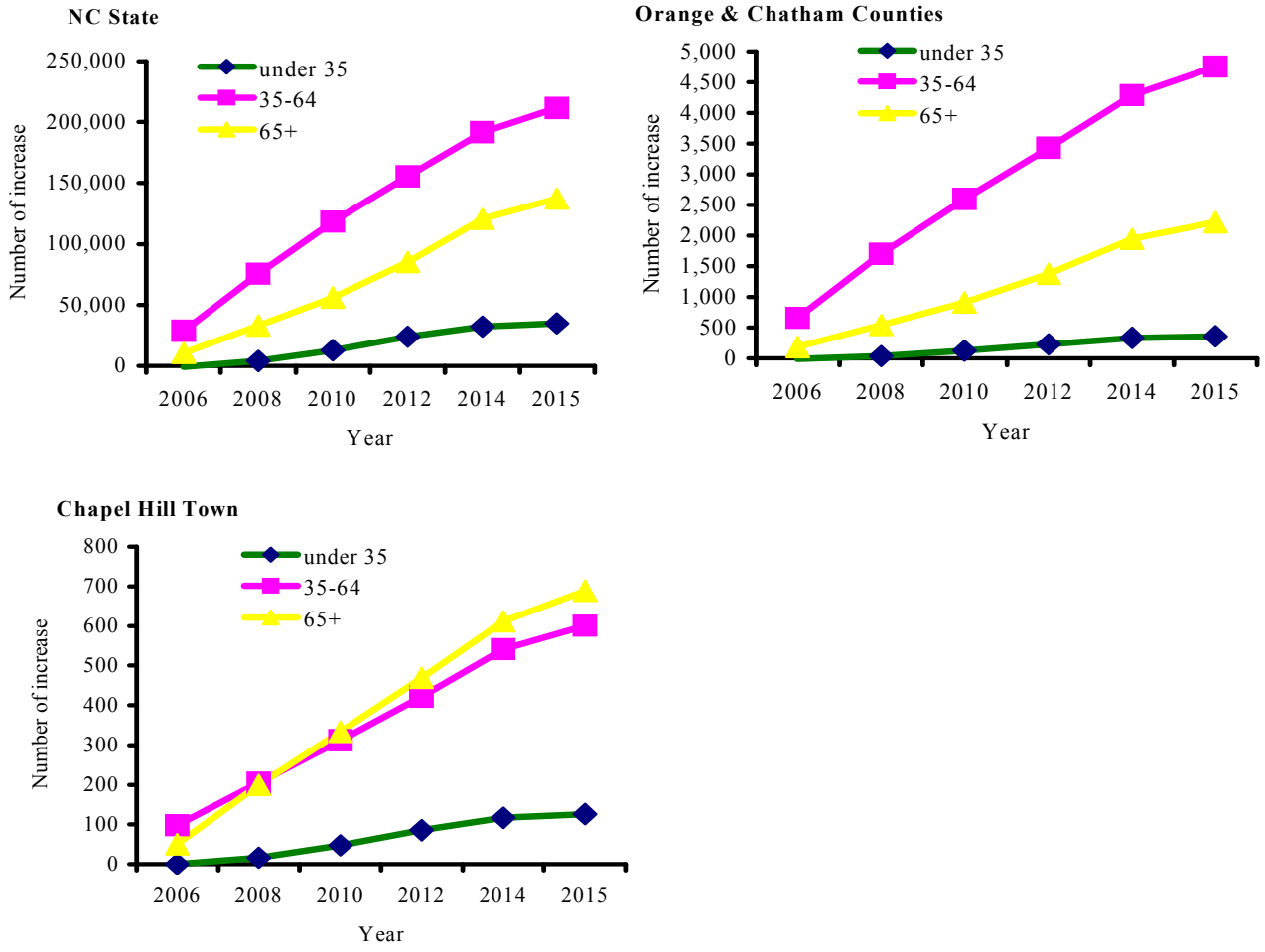
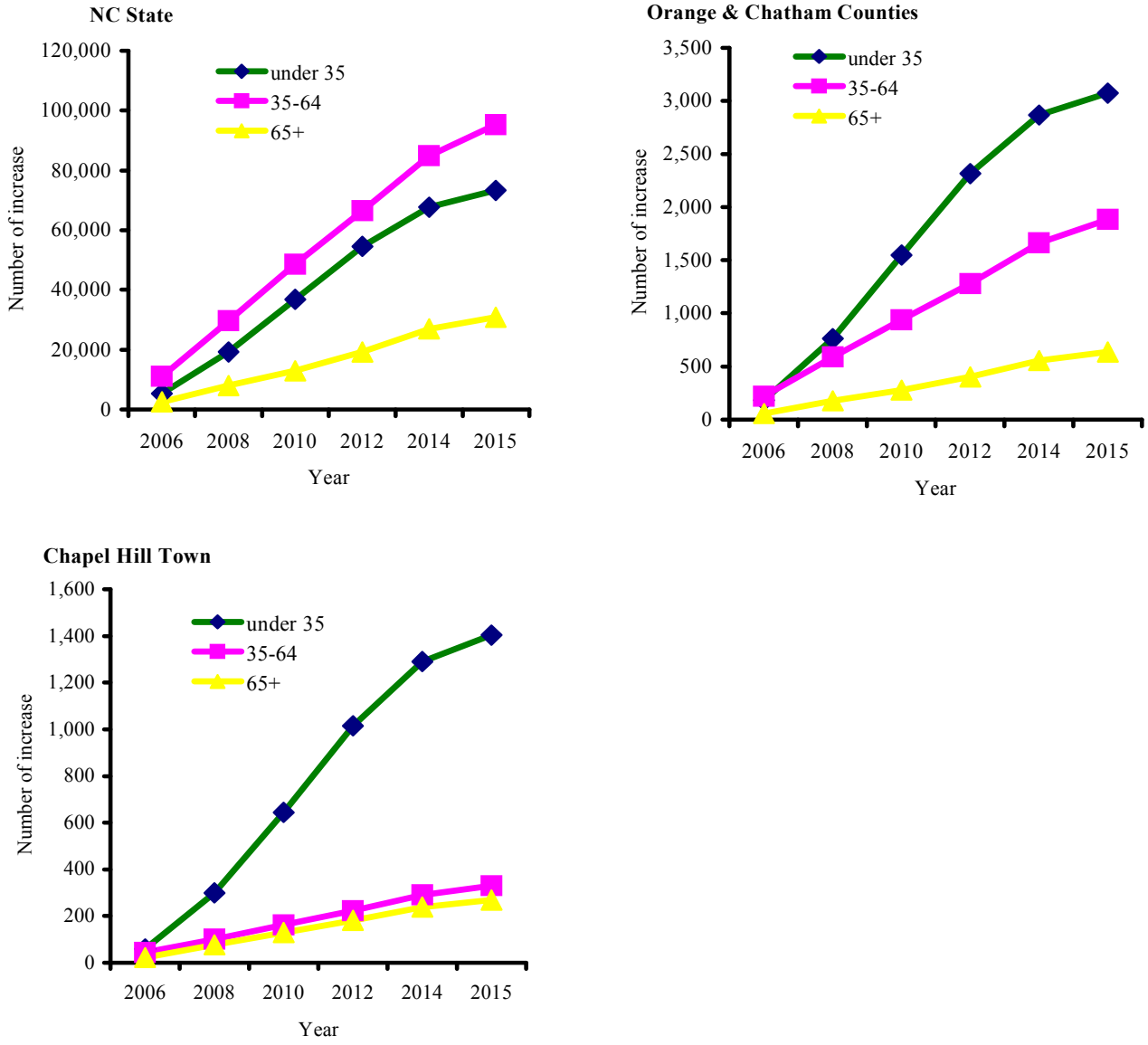


Figure 4. Forecasts of the cumulative increases in rental housing units by the age of the household reference person, as compared to 2005



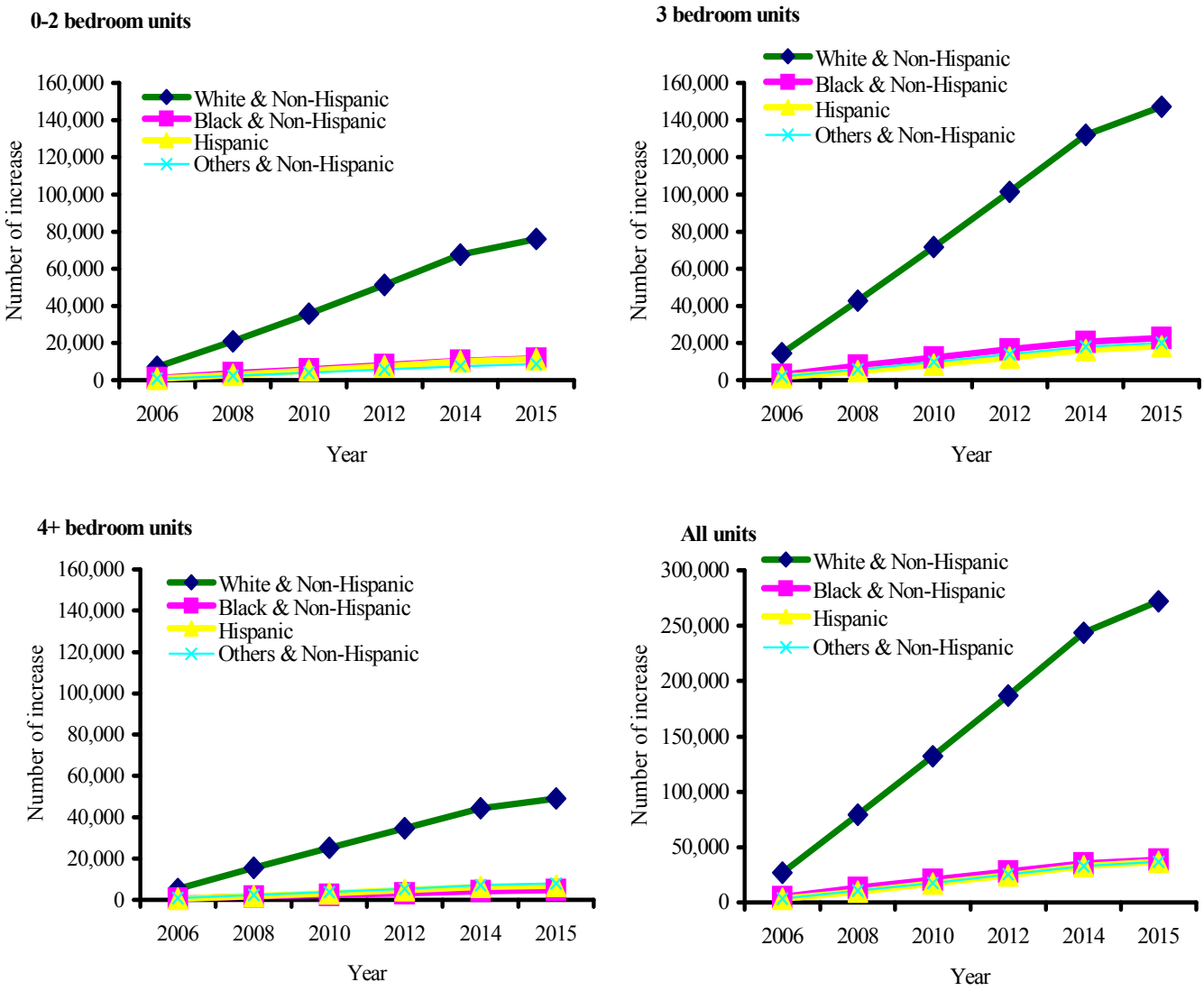
4.3. Racial differentials

Figure 5 shows the racial differentials of the increase in owned-housing units in the next ten years in NC. Obviously, the increase in owned-housing units with different numbers of bedrooms during the period 2005-2015 in NC will be dominated by the White & Non-Hispanic, which accounts for about 70% of the total increase. However, Hispanics will have the largest relative increase (80%) in owned-housing units, followed by Others & Non-Hispanic (51%). The relative increases for White & Non-Hispanic and Black & Non-Hispanic are 14% and 11%, respectively. The much larger relative increase in owned-housing units consumed by Hispanic

households is linked to the much faster growth of their population size and much lower homeownership rates at baseline.

The racial gap between minorities and White & Non-Hispanics in the future increase of rental housing consumption is much smaller as compared to that of owned-housing units (Figure is not shown here). White & Non-Hispanics will contribute 50% of the total absolute increase in the rental housing market in the next 10 years, followed by Hispanics (24%), Black & Non-Hispanics (16%) and Other & Non-Hispanics (10%). But the highest relative increase in rental housing from 2005 to 2015 is in Hispanics (53%), followed by Other & Non-Hispanics (43%), Black & Non-Hispanics (17%), and White & Non-Hispanics (11%).

Figure 5. Forecasts of the cumulative increase in owned-housing units by race as compared to 2005, NC State



4.4. Forecasts of housing demands by household income

Table 5 lists the forecasted cumulative increase in owned-housing units over 2005-2015 by household income categories**.** In NC and Orange & Chatham counties, the increase in owned-housing units with 0-2 bedrooms will be consumed mainly by middle and low income households, while the increase in housing units with 3 or 4+ bedrooms will be mainly by high and middle income households. In Chapel Hill, about 45% and 48% of the total increase in the owned-housing market will be consumed by high and medium income households (Table 5). Table 6 shows that future increases in rental housing units will be consumed mainly by medium and low income households.

Table 5. Forecasts of the cumulative increases in owned-housing units by household income in 2015, as compared to 2005

	Total		0-2 bedrooms		3 bedrooms		4+ bedrooms	
	# Cum. Inc.	%	# Cum. Inc.	%	# Cum. Inc.	%	# Cum. Inc.	%
NC								
High income	118,171	30.7	14,540	13.5	63,767	30.6	39,864	58.3
Medium income	192,402	50.0	59,695	55.4	109,694	52.6	23,013	33.7
Low income	73,983	19.3	33,486	31.1	35,031	16.8	5,466	8.0
Total	384,556	100.0	107,721	100.0	208,492	100.0	68,343	100.0
Orange & Chatham Counties								
High income	2,584	35.2	240	13.3	1,168	30.9	1,176	66.7
Medium income	3,952	53.8	1,186	65.6	2,207	58.4	559	31.7
Low income	811	11.0	381	21.1	402	10.7	28	1.6
Total	7,347	100.0	1,807	100.0	3,777	100.0	1,763	100.0
Chapel Hill								
High income	637	45.0	NA	NA	NA	NA	NA	NA
Medium income	684	48.3	NA	NA	NA	NA	NA	NA
Low income	95	6.7	NA	NA	NA	NA	NA	NA
Total	1,416	100.0	NA	NA	NA	NA	NA	NA

Note: (1) # Cum. Inc.: cumulative increases in housing units in 2015 as compared to 2005. (2) NA: baseline data for the forecasting are not available.

Table 6. Forecasts of the cumulative increases in rental housing units by household income in 2015, as compared to 2005

	NC		Orange & Chatham Counties		Chapel Hill	
	# Cum. Inc.	%	# Cum. Inc.	%	# Cum. Inc.	%
High income	23,047	11.5	280	5.0	174	8.7
Medium income	100,152	50.2	2,639	47.2	1,035	51.7
Low income	76,361	38.3	2,677	47.8	791	39.6
Total	199,560	100.0	5,597	100.0	2,000	100.0

4.5. Likely biases in households and housing forecasts if they were produced by the headship-rate method

In most previous studies of households and housing forecasting, the number of households was forecasted using the headship-rate method. As discussed earlier in the method section, the ProFamy approach is theoretically sounder than the classic headship-rate method since ProFamy overcomes the major limitations of the headship-rate method, which does not link to demographic rates and forecasts limited household types without household size information. The results of the validation tests listed in Tables 1a and 1b provide empirical evidence showing that ProFamy can produce household forecasts with reasonable accuracy. Thus, we are confident that short-term housing forecasting based on the households forecasts by type/size/age/race/income produced following the ProFamy approach is of reasonable quality, as long as the homeownership rates are reasonably projected. We also fully recognize that we do not know the actual degree of accuracy of our forecasts; many uncertainties have not been estimated or measured at the current stage of this study. On the other hand, the headship-rate method, which has been used in most other studies, needs much less data than does the ProFamy approach. Therefore, one may ask: Does the new ProFamy approach more accurately forecast housing consumption than the headship-rate method, making ProFamy's heavier data demand worthwhile? We have performed the following specific empirical analyses/exercises to answer this question.

The first exercise is to multiply the age-race-specific headship rates by the age-race-specific number of persons forecasted by ProFamy, assuming that the age-race-specific headship rates remain constant, as did those observed in the 2000 census. This simplest exercise indicates that the forecasted total number of NC households in 2015 is smaller than that forecasted by the ProFamy approach by 92,970 (15.9%). Although there is no way to verify the actual observation since we are still 10 years from 2015, we believe that the number of NC households in 2015 as forecasted by the constant headship-rate method is downwardly biased based on theoretical and empirical considerations. Theoretically speaking, demographers believe that American households will become smaller due to higher divorce rates, lower and later marriage rates, as well as later and lower fertility. Thus, the number of households and the age-race-specific headship rates may increase. Even if the age-specific divorce, marriage, and fertility rates remain constant, the fact that the older cohorts, who experience more traditional family patterns (lower divorce rate and higher marriage rate), are being replaced by younger cohorts, who experience the modern family patterns (higher divorce rate and lower marriage rate), will result in more small households. This trend can be explained by the theory "family household momentum," which was empirically proven using U.S. data (Zeng et al., 2005a). For the empirical test, we use the 1990 census data as the base population and project NC households from 1990 to 2000 through the headship-rate method, using the constant age-race-specific headship rates derived from the 1990 census data. As compared to the 2000 census observation, the headship-rate method under-forecasts the total number of households in 2000 by 7.8% (245,105 households), which are mostly small households. As shown in Tables 1a and 1b, the difference between the number of NC households in 2000 forecasted by the ProFamy approach (using the 1990 census and other data observed in or before 1990) and the 2000 census observed number of households is 1.7%. Therefore, our forecasted number of NC households in 2015 following the ProFamy cohort-component approach, which captures the changes in demographic rates and the cohort-

renewing effects, is more reasonable than that produced by following the headship-rate method: constant headship-rates may produce a significant bias in housing demand.

The left panel of Table 7 shows the likely substantial biases in the forecasts produced by constant headship rates as compared to forecasts using the new ProFamy approach. In total, the classic approach, with constant age-race-specific headship rates, would under-forecast the cumulative increase of all types of owned-housing by nearly 23,000 units and more than 57,000 units in 2010 and 2015 in NC, 12% and 15% downward forecasting, respectively. The likely under-forecasting rates of the owned-housing units with 0-2, 3, and 4+ bedrooms in 2015 in NC will be 23.8%, 14.4%, and 18.4%, respectively. The classic approach, with constant age-race-specific headship rates, would likely under-forecast the cumulative increase in rental housing units by 21.1% and 21.5% in 2010 and 2015.

One may argue that it is theoretically and empirically true that the constant headship rates approach produces an under-forecasting bias, but that the headship rates may be made variable through regression or other trend extrapolation based on past census data[6]. We, however, believe that even if one is lucky enough to produce correct age-race-specific numbers of households using the correct changing headship rates based on regression or past trend extrapolation, the headship rates may still likely result in biased household consumption forecasts due to the inherent limitation caused by excluding household size because household size is an important determining factor in household consumption. To verify this speculation, we perform another exercise in which we assume that the changing headship rates approach will produce exactly the same age-race-specific numbers of households as those forecasted by the ProFamy approach. The comparisons listed in the right panel of Table 7 show that changing headship rates likely over-forecast the cumulative increase in owned-housing units by 5.1% (9,532 units) and 4.2% (16,200 units) in 2010 and 2015, respectively (see Table 7); it over-forecasts the increase in 3 and 4+ bedroom owned-housing units by 7% and 4%, and under-forecasts the increase in 0-2 bedroom owned-housing units by 3% in 2015 (not listed in Table 7); it also under-forecasts the increase in rental housing units by 9.7% (9,532 units) and 8.1% (16,200 units) in 2010 and 2015, as compared to 2005. These likely biases are due to the mixture of households of different sizes using the headship-rate method. Although the forecasted total number of households is assumed to be correct, household size composition is changing towards smaller & non-couple households, which are less likely to own a housing unit. Indeed, the effect of household size changes on housing consumption is well-recognized in the literature (e.g., Myers et al., 2002).

The headship-rate method's producing biased household consumption forecasts due to its inherent drawback of being unable to project household size, even if its forecasted total number of households were correct, has also been demonstrated by other studies. Prskawetz et al. (2004) and Wang et al. (2005) found that the headship-rate method yields serious misleading forecasts of the increase in automobile use in Austria and the U.S. through multiplying the forecasted number of households without size information by the average number of automobiles per household derived from a recent survey. This is because the future Austrian and American households will comprise many more one- and two-person households (which mostly need only one car) than do today's average households, but the headship-rate method cannot forecast households by size. Prskawetz et al. (2004) and Wang et al. (2005) applied the ProFamy

method/program and produced much more realistic and detailed forecasts of future households (by size, types, and age of the reference persons) and automobile use.

A simplified numerical example may illustrate and validate the results listed in the right panel of Table 7. Let's assume that the homeownership rate for smaller & non-couple households and larger & couple-households are 0.56 and 0.76; the home-renter rate for smaller & non-couple households and larger & couple-households are 0.44 and 0.24, respectively; smaller & non-couple households and larger & couple-households consist of 30% and 70% and, thus, the average ownership rate of all households combined is 0.7; these assumed, simplified data approximately reflect the real situation in NC in 2000, as based on the census data (see Table 2). Let's also assume that these homeownership rates and home-renter rates remain unchanged until 2015, but the shares of smaller & non-couple households and larger & couple-households become 45% and 55% percent and the true number of households is H in 2015; the actual numbers of household-owned and rental housing units are 0.45*H*0.56 + 0.55*H*0.76 and 0.45*H*0.44 + 0.55*H*0.24. Suppose that one is lucky and gets a correct forecasted total number of households (H) through changing the headship rates. However, the headship rate method cannot forecast household size and must use the overall homeownership rate (0.7) and home-renter rate (0.3). Therefore, the numbers of owned-housing and rental housing units in 2015 are forecasted as 0.7*H and 0.3*H, and, thus, are over-forecasted by 4.5% and under-forecasted by 9.1%, respectively.

Table 7. Likely biases in cumulative increases (as compared to 2005) in forecasts of owned-housing units and rental housing units produced by the headship-rate method

	Likely biases produced by headship-rate method with constant age-race-specific headship rates				Likely biases produced by changing headship rates, assuming forecasted age-race-specific number of households is correct			
	Owned-housing units		Rental housing units		Owned-housing units		Rental housing units	
Year	# Inc. bias	Rel. % bias	# Inc. bias	Rel. % bias	# Inc. bias	Rel. % bias	# Inc. bias	Rel. % bias
2006	-2,330	-6.1	-2,795	-17.3	2,744	7.2	-2,744	-14.5
2008	-10,921	-9.7	-8,399	-17.3	5,977	5.3	-5,977	-10.5
2010	-22,847	-12.2	-17,135	-21.1	9,532	5.1	-9,532	-9.7
2012	-38,090	-14.4	-26,225	-23.0	12,337	4.7	-12,337	-8.8
2014	-52,249	-15.2	-32,174	-21.8	14,279	4.1	-14,279	-8.0
2015	-57,637	-15.0	-35,333	-21.5	16,200	4.2	-16,200	-8.1

Note: (1) Relative % bias=100* (cumulative increase produced by the headship rate method-cumulative increase produced by the ProFamy method)/cumulative increase produced by the ProFamy method.

5. SUMMARY AND CONCLUDING REMARKS

Employing the most recent census and other relevant data and the ProFamy method/program, this study forecasts households and the consumption of owned and rental housing having different bedrooms in the state of North Carolina, Orange and Chatham counties, and the town of Chapel Hill. The results show that there will be a 16-17% increase in owned-housing units and a 16-19% increase in rented housing units from 2005 to 2015. The growth of owned housing units with 0-2 bedrooms is faster than that of units with 3+ bedrooms. The number of low income households will grow slightly faster than those of high and medium income households. The increase in owned-housing units during the period 2005-2015 in NC will be dominated by White & Non-Hispanics, which account for about 70% of the total increase. However, as compared with its own baseline, Hispanics will have the largest relative increase (80%) of owned-housing units, followed by Others & Non-Hispanic (51%). The relative increases for White & Non-Hispanics and Black & Non-Hispanics are 14% and 11%, respectively. The much larger relative increase in owned-housing units consumed by Hispanic households is linked to the much faster growth of their population size and much lower homeownership rates at baseline.

The results demonstrate that the differences in the increase in housing units owned by households of different types/sizes are substantial. The increase in 0-2 and 3 bedroom housing units owned by single-person-only households is projected to be the largest as compared to the increase in any other kind of household. The increase in housing units with 0-2, 3, and 4+ bedrooms owned by couple-only households rank the second largest. The number of housing units owned by single-parents with a household size of 4+ will decline. These trends are induced by demographic change, namely, the increase in smaller households, especially one-person-only households, will be substantially larger than that of larger households in the next decade. The forecasted increase in rental housing units is almost exclusively consumed by one-person-only households and non-couple households of size 2-3, and is especially dominated by one-person-only households. The increase in rental housing units for households of other types/sizes is minor. The demand for rental housing units for non-couple households of size 4+ will decrease.

In NC, about 55% and 36% of the total increases in owned-housing units in 2015 as compared to 2005 will be consumed by households with a reference person aged 35-64 and 65+, respectively. Younger households with a reference person aged less than 35 share a very small portion of the market. The pattern in Orange & Chatham counties is similar to that of the state. But the "aging of owned-housing market" in Chapel Hill is even more striking: elderly households aged 65+ will occupy the largest share (49%) of the increase in owned-housing units after 2012. With the aging of the baby-boomers, the housing market will age. Governmental agencies and the business community will need to take this trend into account.

Our empirical analysis shows that the headship-rate method will substantially bias the forecasts of both the owned-housing market and rental housing market due to its inherent deficits of being unlinked to demographic rates and excluding household size and cohort-component effects, which will definitely alter future household structure and size distributions.

While we have made remarkable progress in providing unique forecasts of owned and rental housing by household type/size/age/race/income and by the number of bedrooms, we are aware that there are important limitations to this study. First, the results are our "medium forecasts" (or educated forecasts); the interval forecasts with high and low bounds to reveal the uncertainties are not yet included. They will be done in further study, however, as we did for U.S. national households and vehicle consumption forecasting (Zeng et al., 2005a; Zeng, Wang and Gu, 2005). Second, our forecasts do not include vacant housing units. The forecasted vacant housing units could be obtained by using the number of bedroom specific ratios of the number of vacant housing units to the number of occupied housing units. Unlike the national vacancy ratio, which has been very stable in recent years (Berson et al., 2005), the vacancy ratio in NC is unstable, and, therefore needs substantial further research to ensure reasonable forecasting. Third, the replacement rate (i.e., net removal) of housing units was not considered in this study. Fourth, we could not consider the impact of illegal immigrants, who are not counted in the census data on housing consumption. Illegal immigrant housing consumption was indirectly estimated to be around 25% of the total immigrant housing demand in the U.S. in 2000 (Deardorf and Blumerman, 2001). Fifth, this study did not include factors relevant to housing prices, economic growth, government policy, land-use, co-ownership, manufactured homes, and changes in personal preference that may affect homeownership. Instead, given the stability of the overall homeownership rate over the past decade in NC, this study simply assumes that the homeownership rate by household type/size/age/race/income will remain at the current level. In sum, the present study mainly examines and provides the basic bricks of demographic forecasts of the changes in housing demand by household type/size/income, and age/race of householders for further housing market planning analysis, which needs to include more business factors.

Appendix A: The Estimated and Projected Demographic Summary Measures for Household Forecasts in North Carolina

Table A1. The Assumed Demographic Summary Measures, North Carolina

	White & Non-Hispanic			Black & Non-Hispanic		
	2000	2010	2015	2000	2010	2015
Mortality						
Male e_0	74.2	75.0	75.4	66.4	68.3	69.2
Female e_0	79.6	80.5	81.0	74.4	76.4	77.4
Fertility						
TFR-all births	1.9132	1.9696	1.9978	2.0829	2.0989	2.1069
TFR(1)-1st birth	0.8358	0.8605	0.8728	0.8166	0.8229	0.8260
TFR(2)-2nd birth	0.6817	0.7018	0.7119	0.6746	0.6798	0.6824
TFR(3)-3rd birth	0.2715	0.2795	0.2835	0.3772	0.3801	0.3816
TFR(4)-4th birth	0.0918	0.0945	0.0959	0.1423	0.1434	0.1439
TFR(5)-5+ birth	0.0325	0.0334	0.0339	0.0723	0.0728	0.0731
Marriage/union formation & dissolution						
General marriage rate	0.0589	0.0589	0.0589	0.0310	0.0310	0.0310
General divorce rate	0.0227	0.0227	0.0227	0.0236	0.0236	0.0236
General cohabiting rate	0.0965	0.0965	0.0965	0.0630	0.0630	0.0630
General union break rate	0.2439	0.2439	0.2439	0.2922	0.2922	0.2922
Male mean age 1st mar.	25.7	26.3	26.6	27.5	28.5	28.9
Female mean age 1st mar.	23.6	24.2	24.5	26.1	27.1	27.5
Mean age at births	27.4	27.5	27.5	25.3	25.5	25.5

	Hispanic			Asian & Others Non-Hispanic		
	2000	2010	2015	2000	2010	2015
Mortality						
Male e_0	74.4	75.1	75.5	76.7	77.5	78.0
Female e_0	83.2	83.9	84.2	85.1	85.8	86.1
Fertility						
TFR-all births	2.8597	2.7799	2.7400	2.1016	2.0718	2.0570
TFR(1)-1st birth	0.9500	0.9235	0.9102	0.8909	0.8783	0.8720
TFR(2)-2nd birth	0.9444	0.9181	0.9049	0.6794	0.6698	0.6649
TFR(3)-3rd birth	0.5449	0.5297	0.5221	0.3444	0.3396	0.3371
TFR(4)-4th birth	0.2770	0.2693	0.2654	0.1158	0.1142	0.1133
TFR(5)-5+ birth	0.1434	0.1394	0.1374	0.0711	0.0701	0.0696
Marriage/union formation & dissolution						
General marriage rate	0.0483	0.0483	0.0483	0.0534	0.0534	0.0534
General divorce rate	0.0143	0.0143	0.0143	0.0187	0.0187	0.0187
General cohabiting rate	0.0838	0.0838	0.0838	0.1249	0.1249	0.1249
General union break rate	0.1823	0.1823	0.1823	0.2797	0.2797	0.2797
Male mean age 1st mar.	24.6	25.0	25.2	27.1	27.7	28.1
Female mean age 1st mar.	23.0	23.4	23.6	24.9	25.5	25.9
Mean age at births	25.7	25.6	25.6	27.1	27.0	27.0

The race-sex-specific life expectancies at birth in NC are estimated based on available data released by the Census Bureau. The NC race-specific TFRs are derived from National Vital Statistics Reports (Sutton and Mathews 2004). The TFRs for 2003-2015 were estimated based on the medium assumptions of the Census Bureau population projection (Hollmann, Mulder, and Kallan 2000). More specifically, we first calculated the race-specific relative change of the TFRs from 2000 to 2015 based on the Census Bureau medium projection. We then used this race-specific rate of change and the observed race-specific TFR in 2000 for NC to get the race-specific-TFR in the years 2010 and 2015.

The NC race-specific mean ages at birth for all birth orders combined were calculated based on the fertility rate reported in National Vital Statistics Reports (Sutton and Mathews, 2004). Because the data on first marriage rates at the state level are not available, the race-specific mean age at first marriage was estimated by multiplying the NC estimated race-specific mean age at the first birth by the NC ratio of race-specific mean age at first marriage to the race-specific mean age at birth implied by the model standard schedules and the NC base population in 2000.

The all-races combined general marriage rate and general divorce rate in 2000 for NC were calculated based on the total number of marriages and the total number of divorces published by vital statistic (NCHS 2004) and the population by marital status from the 2000 census data. We then used the ratios of race-specific general marriage and divorce rates to the corresponding rates of all-races combined at the national level to estimate the NC race-specific general marriage and divorce rates. The race-specific general rates of cohabitation and union dissolution for NC were estimated by multiplying the occurrence/exposure (o/e) rates of cohabitation and union dissolution of the national standard schedules (Zeng et al., 2005a) by the race-specific corresponding risk populations in 2000 in NC derived from the census. The general rates for marriage, divorce, cohabitation and union dissolution from 2001 to 2050 were assumed to be the same as in 2000.

The numbers of domestic immigrants and emigrants as well as the international net migrants in 2000, 2001 and 2002 are derived from the published Census Bureau data.[7] The net domestic migration from other states for 2003-2050 was assumed equal to the net domestic migration average in 2000-2002, while the total number of net international migrants from abroad to NC is the same as the number of net international migrants determined from the medium assumption made by the Census Bureau's population projection (Hollmann, Mulder, and Kallan, 2000). Based on the 2000 census 5% micro data set, we estimated race-sex-age-specific probabilities of domestic emigration from NC to the rest of the country and race-sex-age-specific frequencies of immigration from the rest of the country to NC.

Appendix B

B-1. Primary reasons for using percentiles to define income categories

Using percentiles to define income categories makes more sense than using absolute dollar numbers for household income and housing forecasts because of the following factors:

(1) Absolute dollars change over time even after dollar values have been standardized; e.g., $78,000 was high income in 2000, but may not be considered high in future years;

(2) It is very hard to predict future years' households income distributions as measured by absolute dollars; e.g., predicting the future % of households of certain types/sizes that will have income >$78,000 would be very hard, since economic growth, changes in income diversity, inflation or deflation of dollars, and households composition & age distribution must be taken into account but are very hard to separate;

(3) It is relatively easy to predict future years' income distributions using percentiles to define income categories. It is also relatively easy to forecast the average housing consumption of different household income categories (defined by percentiles), type/size and age through time series analysis with expert opinions of economic growth, income diversity, and consumer behavior changes. For example, one may forecast that low-income homeowners (the lowest 25% income households) may increase by 10% in 10 years because of the improvement of the living standard of society as a whole, as well as other related factors (e.g., a decrease in housing prices). However, it would be very hard to predict the changes in housing demand of a household group with an annual income of less than $30,000 in 10 years because we do not know the value of $30,000 10 years from now. $30,000 may presently indicate an extremely poor or not so poor household, depending on inflation, deflation, or changes in wage levels.

The age-race-specific proportions of high, middle, and low incomes for each household category from 2001 to 2015 are assumed to be the same as those obtained from the 2000 census 5% sample micro-data set. One common approach in short-run demographic and market projections is to hold some of the current age-specific proportions constant throughout the projection horizon (e.g., Day, 1996; Treadway, 1997). Smith, Tayman and Swanson (2001: 83-84) argue that holding some of the rates and proportions constant in the demographic projections could be justified on either of two grounds. One is that in the short-run (e.g., 10-15 years) future rates and proportions (i.e., the first, second, third, and fourth quartile in this case) are not likely to differ much from the current level. Another justification for holding the rates and proportions constant is the belief that neither the direction nor the magnitude of future changes can be predicted accurately. The argument here is not so much that the current proportions of low, middle, and high incomes will remain constant, but rather that scientific theories and past history do not provide a reliable basis for predicting how those proportions will change. If upward or downward movements are equally likely, the current proportions provide a reasonable forecast of the future proportions.

Moreover, if we do not impose the assumption of a constant proportion distribution of four income category quartiles, we would have to extrapolate a total number of 3,584 cells (i.e., [4 income categories] x [16 household categories] x [14 age groups] x 4 [races] = 3,584 cells); the sum of the extrapolated proportions of high, middle I, middle II, and low incomes for each race-age-specific household category must be equal to one. Such work involving 3,584 cells' separate extrapolation forecasts would be methodologically un-adjustable because each cell has

only two observations. Thus, keeping the race-age-household category-specific proportions of four income distribution quartiles constant is, perhaps, the only practical solution.

But the aggregated race-specific proportions of the four income categories for each household type of all-ages-combined (labeled 'total' in each table) are not constant over time because they are the weighted averages of the proportions across ages, and the age structure of the reference persons (i.e., the weights of the aggregate proportions) change over time. The procedure to keep the consistency of the percentile distribution of income categories in the future projection years is, as follows:

$$\overline{I^t_{r,h}}(i) = \frac{\sum_x I^t_{r,h}(i,x) \times N^t_{r,h}(x)}{\sum_x N^t_{r,h}(x)}, \qquad \text{(B-1)}$$

where $\overline{I^t_{r,h}}(i)$ is the aggregated proportion of the income category i for household type h with race r in forecasting year t; $I^t_{r,h}(i,x)$ is the age-specific proportion of the income category i for household type h with race r, and household type h in age group x in forecasting year t; $N^t_{r,h}(x)$ is the number of households with type h for race r in age group x in forecasting year t.

Similarly, the age-specific proportions of each income category of all-races-combined for each household category are not constant over time because they are the weighted average of the proportions across races, and the race compositions of households change over time. The formula is

$$\overline{I^t_h}(i,x) = \frac{\sum_r I^t_{r,h}(i,x) \times N^t_{r,h}(x)}{\sum_r N^t_{r,h}(x)}, \qquad \text{(B-2)}$$

where $\overline{I^t_h}(i,x)$ is the all-race-combined proportion of the income category i and household type h in age group x in forecasting year t.

In sum, the overall proportions of each income category for each race and all-ages-combined, and the age-specific proportions of each income category for all-race-combined, and the overall all-age-race-combined proportion of the income category are dynamic from 2000 to 2015 due to changes in the households distributions and age structure of the reference persons. At the same time, the census-based (or ACS-based) age-race-household category-specific proportions of each income category, which measure the race-age-sex differentials of income distributions, are basically kept constant.

B-2. Procedure to ensure the consistency of the percentile distribution of income categories in the projection years

Let $I_k(t)$ denote the percent of income category k, e.g., four categories of $I_k(t)$ =0.25 (high income: the first quartile; middle I income: the second quartile; middle II income: the third quartile; low income: the forth quartile). We derive the cutting point of the income (in dollars) of each of the income categories based on the most recent census or ACS.

$P_k(i,x,t,r,j)$, proportion of households of k^{th} income category among households of type/size i with reference person of age group x in year t, race group r, and region j; one may assume that $P_k(i,x,t,r,j)$ in the projection year are the same as the observed ones in the most

recent year or assume some systematic changes, e.g., that the % in the low income category among the elderly may increase/decrease due to weakening/strengthening social security and retirement pension programs. In any case, $\sum_k P_k(i,x,t,r,j) = 1.0$.

H(i,x,t,rj), number of projected households of type/size i with reference person of age group x in year t, race group r, and region j;

H(i,x,t,r,j) P_k(i,x,t,r,j) is the first estimate of the number of households with income category k, household type/size i, and reference person of age x, race group r, and region j. Because of the changes in composition of households of different types/size and age structure of reference persons in projection year t, $\sum_i \sum_x \sum_r \sum_j H(i,x,t,r,j)P_k(i,x,t,r,j) / \sum_i \sum_x \sum_r \sum_j H(i,x,t,r,j)$ may not be exactly equal to I_k(t) although the discrepancy is usually not large. Thus, some adjustments are needed.

$$\frac{C_k(t)\sum_i \sum_x \sum_r \sum_j H(i,x,t,r,j)P_k(i,x,t,r,j)}{\sum_i \sum_x \sum_r \sum_j H(i,x,t,r,j)} = 0.25$$

$$C_k(t) = \frac{0.25\sum_i \sum_x \sum_r \sum_j H(i,x,t,r,j)}{\sum_i \sum_x \sum_r \sum_j H(i,x,t,r,j)P_k(i,x,t,r,j)} \qquad \text{(B-3)}$$

$$P'_k(i,x,t,r,j) = C_k(t)\, P_k(i,x,t\, r,j) \qquad \text{(B-4)}$$

$$P''_k(i,x,t,r,j) = P'_k(i,x,t,r,j)\frac{1.0}{\sum_k P'_k(i,x,t,r,j)} \qquad \text{(B-5)}$$

We then compute the quartiles of high, middle I, middle II, and low income again. If their relative differences from 0.25 are all less than 0.01 (say, or another criterion), we accept the P''_k(i,x,t,r,j).

More specifically, if $\{[\frac{\sum_i \sum_x \sum_r \sum_j H(i,x,t,r,j)P''_k(i,x,t,r,j)}{\sum_i \sum_x \sum_r \sum_j H(i,x,t,r,j)} - 0.25]/0.25\} < 0.01$ for all income categories (e.g., k=1,2,3,4), we accept the P''_k(i,x,t,r,j). Otherwise, we repeat the adjustment procedure expressed in formulas (B-3), (B-4), and (B-5) until the criterion is met.

Appendix C

Output Tables of Housing Forecasts in North Carolina, Orange and Chatham counties, and the town of Chapel Hill

(omitted)

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[1] The latest data show the homeownership rate is 69.8 in 2004 for NC statewide. See http://www.infoplease.com/ipa/A0780145.html

[2] The marriage/union history data from the following four national surveys are pooled to estimate the model standard schedules: (a) the 1990 and 1995 Current Population Surveys (CPS); (b) the 1992-94 National Survey on Family Households (NSFH); (c) the 1995 National Survey on Family Growth (NSFG); (d) the 1996 Survey on Income and Program Participation (SIPP).

[3] We could not perform the testing projection from 1990 to 2000 for Orange and Chatham counties since the 1990 baseline data at county level are unavailable.

[4] Information on the number of bedrooms are available in the census 5% micro data but are not available in the 2000 census online 100% tabulations. Therefore, we are able to forecast housing consumption only by the number of bedrooms at state and PUMA (e.g., two neighboring counties) levels. In the future, we will be able to forecast for geographic units below PUMA level (e.g., a single county or town) using the services provided by Census Bureau special tabulation program.

[5] Given the small sample size for minorities in 5% PUMA, we do not include the race classification at county and town levels, but do include it at the state level.

[6] The extrapolation of age-sex-specific headship rates using regression or other approach is problematic and troublesome. For example, the Census Bureau performed 100 sets of time series regression models to project age-sex specific headship rates in the future years (the 100 sets = (10 age groups) x (2 marital statuses) x (5 household types)). The trends of the headship-rates (with no connection to demographic rates) could be unreasonably extrapolated into the future years. Therefore, the projection was arbitrarily judged using slopes of the regression line that were less extreme than those obtained from the 100 regression models. For example, slopes indicating changes in the percent of those never married for ages <35 were reduced by two-thirds; slopes indicating changes in the percent of married couple households for all ages were reduced by one third. The mechanisms behind these adjustments appear arbitrary (Bureau of the Census, 1996).

[7] Migration data is available at http://www.census.gov/population/www/socdemo/migrate.html