VTRC
Virginia Transportation Research Council

We Bring Innovation to Transportation

Potential Socioeconomic Forecasts in Support of VTrans

http://www.virginiadot.org/vtrc/main/online_reports/pdf/20-r20.pdf

HARITHA BHAIRAVABHATLA
Research Assistant

AMY A. O'LEARY, Ph.D.
Associate Director

MADDISON A. GASSE
Research Assistant

JOHN S. MILLER, Ph.D., P.E.
Principal Research Scientist

Final Report VTRC 20-R20

VIRGINIA TRANSPORTATION RESEARCH COUNCIL
530 Edgemont Road, Charlottesville, VA 22903-2454
vtrc.virginiadot.org

Standard Title Page - Report on Federally Funded Project

1. Report No.: FHWA/VTRC 20-R20	2. Government Accession No.:	3. Recipient's Catalog No.:
4. Title and Subtitle: Potential Socioeconomic Forecasts in Support of VTrans		5. Report Date: May 2020 6. Performing Organization Code:
7. Author(s): Haritha Bhairavabhatla, Amy A. O'Leary, Ph.D., Maddison A. Gasse, and John S. Miller, Ph.D., P.E.		8. Performing Organization Report No.: VTRC 20-R20
9. Performing Organization and Address: Virginia Transportation Research Council 530 Edgemont Road Charlottesville, VA 22903		10. Work Unit No. (TRAIS): 11. Contract or Grant No.: 115949
12. Sponsoring Agencies' Name and Address: Virginia Department of Transportation 1401 E. Broad Street Richmond, VA 23219	Federal Highway Administration 400 North 8th Street, Room 750 Richmond, VA 23219-4825	13. Type of Report and Period Covered: Final 14. Sponsoring Agency Code:

15. Supplementary Notes:
This is an SPR-B report

16. Abstract:

In support of VTrans, this report summarizes potential changes in population, employment, and household income that are forecast from various sources and identifies potential transportation implications. Statewide, Virginia's population is forecast to grow 24% to 33% from 2017-2045, with four regions clustered along the I-95 corridor (roughly the planning district commissions [PDCs] of Northern Virginia, George Washington, and Richmond Regional) and the eastern portion of the I-64 corridor (Hampton Roads) accounting for 83% to 85% of this growth. Employment is also forecast to grow statewide from 18% to 44%, with the same PDCs accounting for 80% to 87% of new jobs by 2045. Household income is forecast to increase, in real dollars, by 25% to 38%. These forecasts do not account for unexpected shocks: a case study with a sudden arrival of a large employer (not anticipated in the original forecasts) suggests that the affected PDCs' 2045 forecasts for employment and population are increased by 3% and 6%, respectively.

Virginia forecasts reflect the observation that uncertainty for employment forecasts is greater than that of population forecasts. Examination of two different forecast sources for 2017-2045 shows that the difference for expected population growth (9%) is smaller than the difference for expected employment growth (27%). Virginia historical data also show employment is more volatile than population: for all nine VDOT districts, average annual employment growth rates for the period 1975-2000 exceeded those for the period 2000-2017; the same was applicable for population (except for the case of the VDOT Lynchburg District). However, the average difference in the employment growth rates for these two periods (about 2.80%) was much larger than the average difference in the population growth rates (about 0.35%).

These socioeconomic changes have the potential to affect the need for travel in Virginia. Although aggregate population and employment increases generally correspond to an increase in travel demand, the types of population and employment changes may affect how this demand is met. Virginia's population age 65+ is forecast to increase from 1.27 million to between 1.99 million and 2.26 million from 2017-2045. Although persons age 75+ are a relatively small percentage of the state's population at present (6%), this group is expected to grow by 104% to 150%, becoming 10% to 11% of the total state's population. This has implications for how travel is provided for seniors, affecting dimensions such as pedestrian facilities, support for aging in place, transit options, driving options, and demand for new technologies such as driverless vehicles. Employment growth is also uneven by sector; for instance, professional and technical services employment, which presently is associated with longer commute times than for most other employment, is expected to grow 31% to 61% from 2017-2045 (statewide), but this varies greatly by region (e.g., increases of 67% to 89% are forecast for Richmond Regional compared to increases of 27% to 34% for West Piedmont), suggesting uneven impacts in travel demand throughout Virginia.

17 Key Words: population forecasting, socioeconomic factors, uncertainty, long-range planning	18. Distribution Statement: No restrictions. This document is available to the public through NTIS, Springfield, VA 22161.

19. Security Classif. (of this report): Unclassified	20. Security Classif. (of this page): Unclassified	21. No. of Pages: 114	22. Price:

FINAL REPORT

POTENTIAL SOCIOECONOMIC FORECASTS IN SUPPORT OF VTrans

Haritha Bhairavabhatla
Research Assistant

Amy A. O'Leary, Ph.D.
Associate Director

Maddison A. Gasse
Research Assistant

John S. Miller, Ph.D., P.E.
Principal Research Scientist

In Cooperation with the U.S. Department of Transportation
Federal Highway Administration

Virginia Transportation Research Council
(A partnership of the Virginia Department of Transportation
and the University of Virginia since 1948)

Charlottesville, Virginia

May 2020
VTRC 20-R20

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the Virginia Department of Transportation, the Commonwealth Transportation Board, or the Federal Highway Administration. This report does not constitute a standard, specification, or regulation. Any inclusion of manufacturer names, trade names, or trademarks is for identification purposes only and is not to be considered an endorsement.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

Introduction

In support of Virginia's statewide multimodal transportation plan known as VTrans, this report identifies, from various sources, potential forecasts for population, employment, and household income (for year 2045 from a base year of 2017). Forecasts in general are associated with some uncertainty because they require assumptions about future trends in the economy, in- and outmigration patterns, the environment, or policies that may influence where people choose to live (Sen, 2017a). For example, the City of Williamsburg (2013) attributed a difference between the 1981 population forecast for year 2000 (11,200 people) and the observed 2000 value (11,998 people) to unanticipated population growth that followed the establishment of Anheuser-Busch Brewery, Busch Gardens, and the Kingsmill development prior to 1981.

As information about assumptions is acquired, it is not unusual for forecasts to be updated. For example, the 2040 projection for Virginia's total population dropped by about 3.2% for a forecast made in 2019 compared to a forecast made 2 years earlier (Weldon Cooper Center for Public Service [hereinafter "Weldon Cooper"], 2017a, 2019b), with Sen (2019) attributing the lower number to fewer people moving to Virginia, a reduced birth rate, and more deaths than had been observed for the period 2000-2010. Given the uncertainty inherent in such predictions, Lombard (2017a) recommends that one explicitly acknowledge that all population projections have a margin of error, with a greater margin for longer term forecasts than for shorter term forecasts. In support of VTrans, the research team sought to convey this uncertainty by obtaining two or more sources for each forecast and thus indicating a potential range of values from credible sources.

The magnitude of this uncertainty will also vary by the phenomenon being forecast (e.g., income, employment, or population) and the size of the entity for which the forecast is generated (e.g., a locality, a metropolitan area encompassing several localities, or the entire state of Virginia). As an example of the former, although unknown changes in immigration affect both population and employment forecasts (Toossi, 2015), factors such as technological innovation, changes in production methods, the replacement of one service with another, and changes to the size of business establishments also affect employment forecasts (Bureau of Labor Statistics, 2018c). For that reason, the uncertainty associated with employment forecasts for year 2045 for Virginia is more than twice as great as the uncertainty associated with population forecasts for the same year. Uncertainty is also magnified for smaller locations: for instance, for 5 of Virginia's 21 PDCs, one source (Woods & Poole Economics, Inc. [hereinafter "Woods & Poole"], 2018b) shows positive employment growth whereas another source (Jeafarqomi, 2018) shows a decrease in employment. Although part of this discrepancy may be attributed to differences in how employment is measured, an observation that forecast accuracy for larger sample sizes is greater than forecast accuracy for smaller sample sizes appears apt.

Purpose and Scope

This Executive Summary presents socioeconomic forecasts for year 2045 that will support the Office of Intermodal Planning and Investment in the creation of Virginia's Statewide Multimodal Plan, also known as VTrans. In addition, it discusses potential transportation implications of these forecasts that were identified in consultation with staff of the Office of Intermodal Planning and Investment. This Executive Summary thus answers two questions.

1. What ranges of population, employment, and income growth are forecast for 2045?
2. What are potential relationships between these forecasts and travel demand?

The findings are detailed in the body of the report, summarized in the "Conclusions" section of the report, and noted here.

Results

Population Forecasts

Virginia's population is forecast to increase between 24% and 33%, from 8.47 M in 2017 to between 10.53 M and 11.28 M in 2045. On an annual basis, this forecast growth rate of 0.78% to 1.03% is near the upper middle of the forecast growth rates of border states; surpassed by North Carolina (1.18%); inclusive of Tennessee (0.98%); and larger than the forecast rates of West Virginia (<0.01%), Kentucky (0.40%), and Maryland (0.57%).

Four regions clustered along the I-95 corridor (roughly the planning district commissions [PDCs] of Northern Virginia, George Washington, and Richmond Regional) and the eastern portion of the I-64 corridor (Hampton Roads) account for 83% to 85% of Virginia's forecast growth from 2017-2045. For the three most populous PDCs combined (Northern Virginia, Richmond Regional, and Hampton Roads), population is expected to grow by 30% (Weldon Cooper, 2017a) or 39% (Woods & Poole, 2018b).

Compared to a statewide forecast increase of 24% to 33%, there is greater uncertainty for the growth rates of some particular PDCs; for example, the corresponding differences between the minimum and maximum values for Accomack-Northampton, George Washington, and Cumberland Plateau are 25%, 21%, and 18%, respectively. Declines in population are forecast for between 1 and 6 of Virginia's 21 PDCs from 2017-2045, depending on which source (Woods & Poole, [2018b] or Weldon Cooper [2017a]) is used.

Figure ES1 presents the population growth forecasts for 2045 by modified PDC, where the PDCs therein are similar to existing PDCs except that each Virginia city or county appears in exactly 1 PDC, where the low and high forecasts are based on Woods & Poole (2018b) and Weldon Cooper (2017a). The black bars show these forecasts as a range. For example, relative to a 2017 population of 182,993, the modified PDC of New River Valley is forecast to grow in 2045 to a population of 202,913 or 208,993 based on the research team's tabulations of local forecasts from these two sources, which is a percent change of 11% to 14%, as reflected in

Figure ES1. These forecasts are presented in the body of the report (Table 39) as a range, where in order to avoid conveying a false sense of accuracy, the lower and upper bounds were rounded to the nearest thousand such that they exceeded the exact mathematical forecast. (For instance, the population forecast for New River Valley is between 202,000 and 209,000.)

From 2017-2045, the proportion of Virginians statewide under age 20 is forecast to remain relatively constant at about 24% to 25%. However, a shift is forecast for Virginians from those age 20-64 to those age 65+: the younger group may decrease from 60% of the total population (2017) to 56% of the population (2045), accompanied by an increase in the proportion of persons age 65+ from 15% of the population (2017) to 19% to 20% of the population (2045). The population age 65+ throughout Virginia is expected to increase between 56% and 78% from 2017-2045 (Weldon Cooper, 2017a, 2017b, 2018; Woods & Poole, 2018b). Further, these two sources suggest that the population of Virginians age 75+ (0.512 million in 2017) is forecast to more than double from 2017-2045, increasing between 104% and 150%. Of interest is that some PDCs with a relatively low proportion of persons age 65+ at present are forecast to see the greatest relative increases by 2045. For example, the number of persons age 65+ is forecast to roughly double in George Washington (an increase of 111% to 168%) and Northern Virginia (92% to 132%).

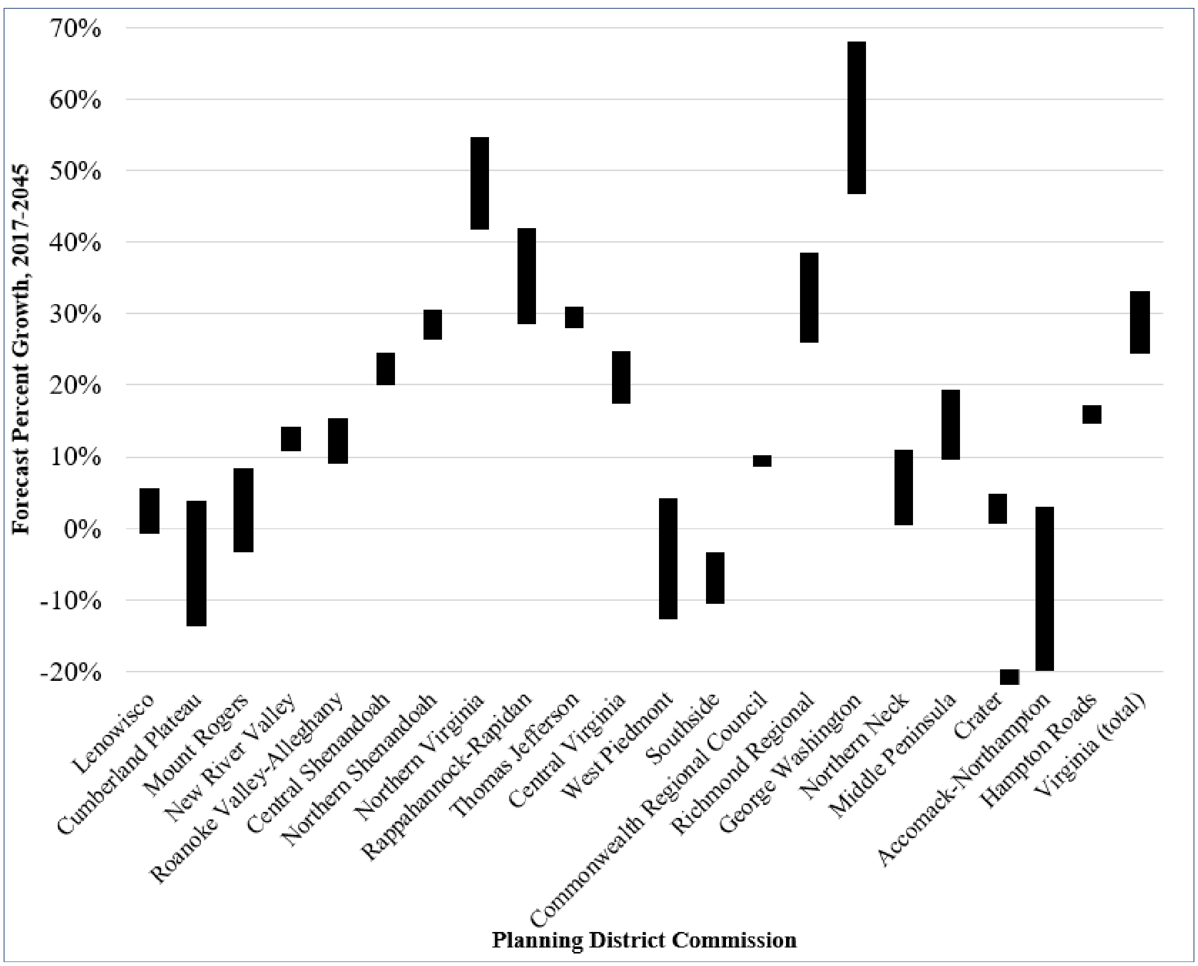


Figure ES1. Forecast Growth in Virginia Population (2017-2045). Drawn based on data from Woods & Poole (2018b) and Weldon Cooper Center for Public Service (2017a).

Employment Forecasts

Employment is forecast to grow statewide between 18% and 44% from 2017-2045 based on two respective sources: IHS Markit (Jeafarqomi, 2018), and Woods & Poole (2018b). Virginia's 2017 employment is concentrated in the three most populous PDCs: Northern Virginia, Hampton Roads, and Richmond Regional. One source suggests that by 2045, these three PDCs will account for 70% of Virginia's jobs and they will also account for three-fourths of the growth in jobs during the intervening years (Woods & Poole, 2018b). Another source, IHS Markit (Jeafarqomi, 2018), shows similar quantities: by 2045, these three PDCs will account for 69% of all jobs in Virginia and they will also account for slightly more than four-fifths of new jobs created from 2017-2045. With the addition of George Washington Regional to this list, the four PDCs will account for 80% to 87% of new jobs by 2045.

A complication with employment is that jobs are defined in a different manner by each source. For instance, IHS Markit (Jeafarqomi, 2018) reported Northern Neck's 2017 employment as 15,975 whereas Woods & Poole (2018b) reported the 2017 employment as 22,331. Woods & Poole (2018b) reported that its employment values may be larger than those of other sources because proprietors and military workers as well as full-time and part-time jobs are included. Differences in definitions are not unusual, with the Bureau of Economic Analysis and the Bureau of Labor Statistics having a difference of about 6% for total U.S. jobs (Bureau of Economic Analysis, 2017). Thus, this study compares changes in employment percentages, for instance, for the IHS Markit 2045 forecast of 14,726 (represents a drop in Northern Neck employment relative to a 2017 value of 15,975 of 8%) (Jeafarqomi, 2018). By contrast, the Woods & Poole (2018b) 2045 forecast of 27,988 is an increase of 25% relative to the 2017 value of 22,231. Figure ES2 presents the employment growth forecasts for 2045 by PDC, where the low and high forecasts are based on Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018). As with Figure ES1, the black bars show these forecasts as a range, indicated by the vertical black bars. Table 40 in the body of the report presents these forecasts numerically as a range, such that a smaller bar indicates a smaller difference between the estimates from two data sources.

Employment and employment growth are uneven by industry. More than one-half of Virginia's jobs in 2017 are in five categories: accommodation and food services, health care and social assistance, retail trade, professional and technical services, and government. Although both Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018) forecast these sectors to grow by 2045, the forecast growth rates differ, as shown in Figure ES3; for instance, the former source expects health care and social assistance to grow by 90% whereas the latter source forecasts growth of 33%. The industries in Figure ES3 are listed in decreasing size of employment by industry (Woods & Poole, 2018b) from top to bottom. (For instance, the government sector is the largest industry based on Woods & Poole, so it is listed first.) IHS Markit data would give a similar ordered list with one notable exception: whereas "real estate and rental and leasing" is the 11th largest industry based on Woods & Poole, it is the 3rd largest industry based on IHS Markit.

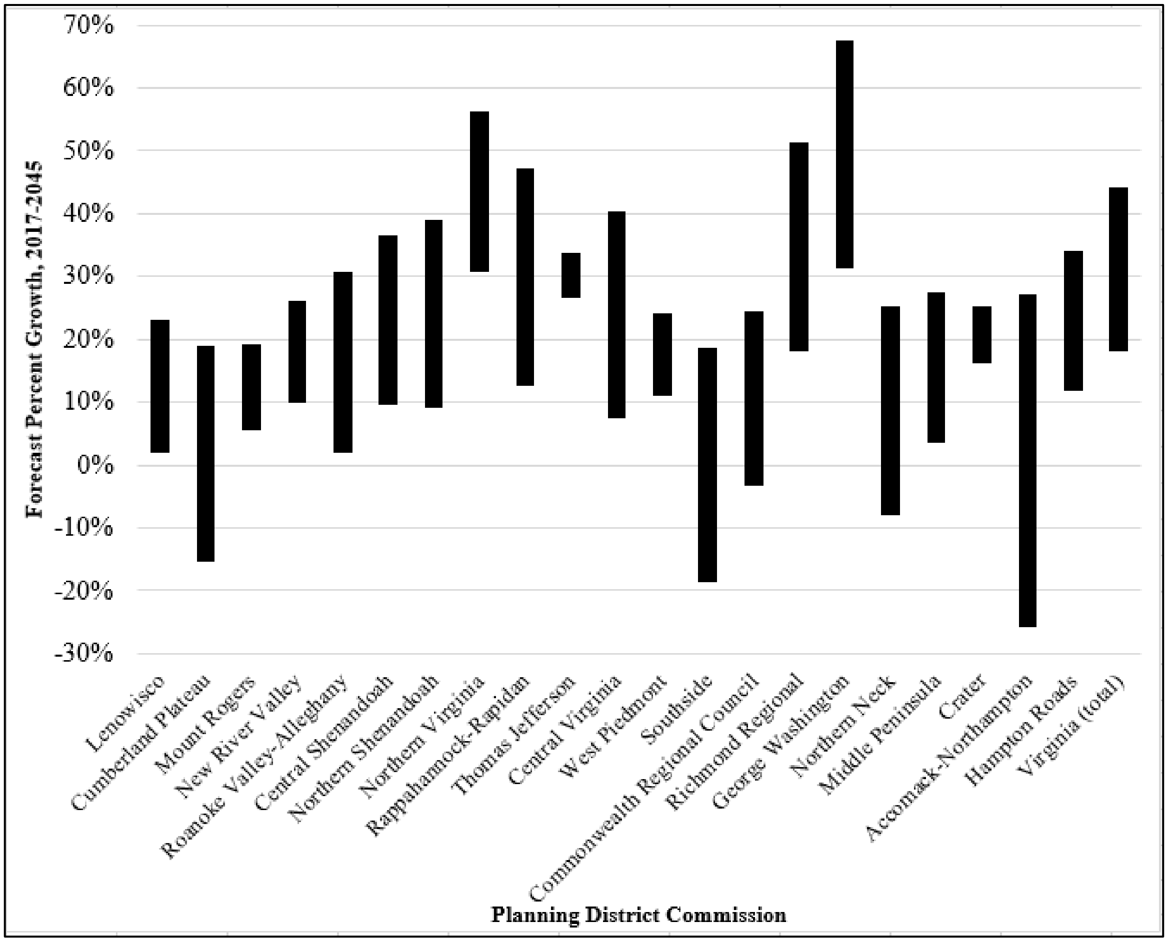


Figure ES2. Forecast Growth in Virginia Employment (2017-2045). Drawn based on data from Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018).

Household income is forecast to increase, in real dollars, by 25% to 38% based on two distinct sources, which measure income in two fundamentally different ways. Woods & Poole (2018a) reports the mean household income, whereas Moody's Analytics (hereinafter "Moody's") (2019) reports the median household income. In locations where there were some households with very large or very small household incomes, there could be a difference between the mean and the median incomes. Further, Moody's (2019) and Woods & Poole (2018a, b) do not define income in the same manner.

Although both sources include wages and salaries, Woods & Poole also includes "proprietors' income, rental income of persons, dividend income, personal interest income, and transfer payments less personal contributions for social insurance." Although Moody's income includes transfer payments (e.g., social security income and public assistance income [Moody's, 2019; U.S. Census Bureau, 2018c]), Woods & Poole (2018b) notes that income as reported by the U.S. Census Bureau excludes certain items such as the value of food stamps, medical payments, and the rental value of one's residence. Thus, for year 2017, household income as reported by Woods & Poole ranged from about 1.5 to 2.2 times the household income reported by Moody's. For instance, the latter source reports a 2017 household income, in 2009 dollars, of $48,139 for the Roanoke Valley-Alleghany Regional Commission and the former source reports a 2017 household income, also in 2009 dollars, of $90,024.

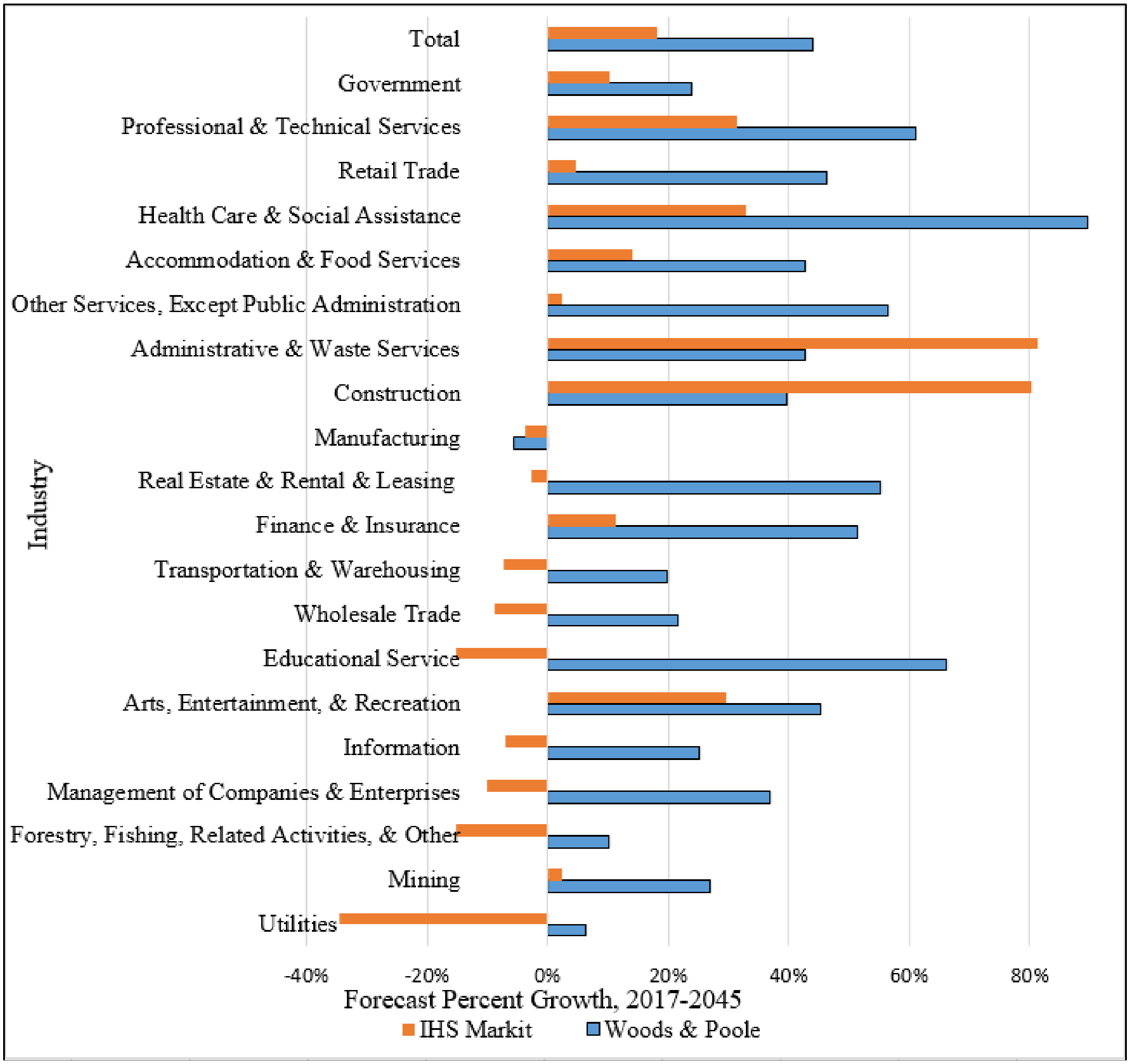


Figure ES3. Forecast Growth in Virginia Employment by Industry (2017-2045). Drawn based on data from Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018). Industries are sorted based on total employment in 2017 (Woods & Poole, 2018b).

Income Forecasts

Both sources forecast that real household incomes will increase from 2017-2045 for all PDCs, as shown in Figure ES4. Virginia's statewide household income is forecast to grow by between 25% and 38%, with PDC increases ranging from 9% to 50%.

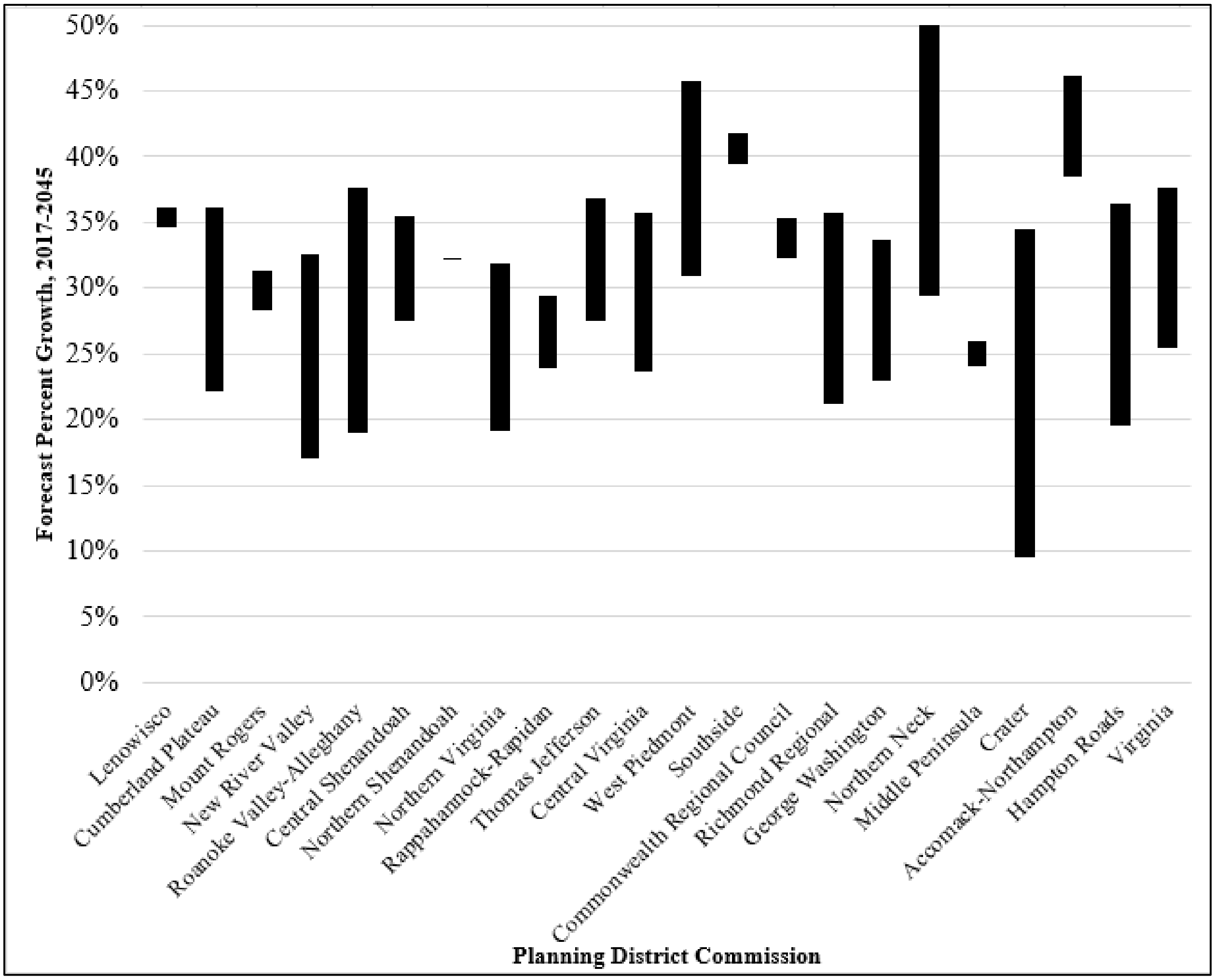


Figure ES4. Forecast Growth in Real Household Income. Drawn based on data from Woods & Poole (2018b) and Moody's Analytics (2019).

A caution for interpreting Figure ES4 is that 2017 incomes vary widely by PDC: for 2017, the highest income (Northern Virginia) is between 2.8 and 3.4 times higher than the value of the lowest income PDC (Lenowisco). As is the case with Figure ES2, the percentage increases are relative to their respective data sets. For instance, Woods & Poole forecasts that Middle Peninsula's mean household income will increase from $95,167 to $118,114 (all in 2009 dollars) for an increase of 24%. Moody's (2019) forecasts that this PDC's median household income will increase from $53,696 to $67,646 (all in 2009 dollars) for an increase of 26%. Thus a vertical bar showing an increase of 24% to 26% is given in Figure ES4 for the Middle Peninsula PDC.

Potential Relationships Between Forecasts and Travel Demand

Traditionally, a key reason for forecasting population, employment, and income is to understand future travel demand. However, the causal relationship can vary: although a change in a forecast can portend a change in travel demand, there can be cases where better transportation infrastructure attracts additional land use. Further, the degree of causality can also differ by local context: a change in transportation infrastructure might greatly affect land development or affect it relatively little. Four potential relationships between socioeconomic forecasts and transportation demand were of interest to VTrans stakeholders:

1. Forecasts generate an expectation of additional travel demand.
2. A change in forecasts alters expected travel demand.
3. Additional transportation infrastructure affects socioeconomic forecasts.
4. Factors other than transportation affect socioeconomic forecasts.

Case 1. Forecasts Generate an Expectation of Additional Travel Demand

The expected 56% to 78% increase in persons age 65+ from 2017-2045, compared to a 24% to 33% increase in the overall population, suggests a greater emphasis on transportation needs for that particular age group. With regard to only the anticipated change from 2020-2040, the change in this older cohort is not monolithic: the population of adults age 75+ is projected to increase by 82.0%, but the population of adults age 65-74 is projected to increase by only 9.1% in that period. By 2040, the population of older seniors (75+) is forecast to surpass that of youthful seniors (65-74) (Weldon Cooper, 2017b).

The change in age distribution may have impacts on how Virginia improves safety for motorists. For example, Getzmann et al. (2018) suggest that a reduction in distracted driving has greater benefit for younger drivers whereas older drivers benefit more from steps that prepare them for the cognitive workload of driving, such as getting more rest. Although public transit may be a viable option for seniors in many urban areas, this may not necessarily be the case in the rural and suburban communities where older people are most likely to live (National Aging and Disability Transportation Center, 2019). A majority of Americans are "aging in place," with only 5% changing their community of residence after the age of 55, a trend that leads to "naturally occurring retirement communities," which were not necessarily built or designed with services for older people in mind (DeGood, 2011). As a consequence, older residents of these communities may lack the services they need, including transportation options.

Employment forecasts also have implications for travel demand. A review of Crane and Chatman (2003) and Kopf (2016) illustrates why employees in some technical services jobs might have longer commutes than those in other types of jobs: some individuals must work at employment centers in "remote locations." The category of professional and technical services is forecast to grow between 31% and 61% statewide. An implication for Virginia is that the impact of these jobs on commute times will depend to some extent on whether the jobs are located near population centers and whether there is a supply of housing that these workers can afford. Generally, this particular category of employment is forecast to grow in some urban or urbanizing areas (e.g., George Washington) and also in some more rural locations (e.g., West Piedmont).

Case 2. A Change in Forecasts Alters Expected Travel Demand

The arrival of a large employer (Amazon) to National Landing in Northern Virginia suggests how these forecasts might be altered by an unexpected event, as this event was not known and thus not explicitly incorporated into population and employment forecasts for 2045 such as those of Woods & Poole (2018b) and Weldon Cooper (2017a). For the Northern Virginia PDC, the forecast population for 2045 increases by about 6.3% based on a 2040 build-out analysis (Fuller and Chapman, 2018) that is applied to the 2045 forecast (Weldon Cooper, 2017a) and that presumes these individuals live in Northern Virginia. Similar calculations based on employment (Woods & Poole, 2018b) show an increase in employment of 3.4%.

The effects are of course magnified at the local level. With Amazon's potential addition of 50,000 direct jobs plus another 2,310 induced jobs, Arlington County's employment base by 2039 would increase by 44.4% rather than the original estimate of 17.6% (Fuller and Chapman, 2018). It is important to note that Fuller and Chapman (2018) also indicate that the 2,310 ripple effect jobs in Arlington County are only a portion of induced and indirect jobs; another 42,011 indirect jobs are forecast for the remainder of Virginia.

In this particular case, the increase in population and employment (beyond what was originally forecast) may increase demand for travel and, as a consequence, needed infrastructure. Existing heavy traffic congestion in the I-395 corridor may worsen and render access to Reagan National Airport even more difficult during rush hours (Shaban, 2018). In response, Virginia plans an investment of $195 million for transportation improvements to Metro stations and Reagan National Airport and for the construction of a pedestrian bridge connecting Amazon's new hub in National Landing to Reagan National Airport; Arlington County and Alexandria City have also pledged to invest $570 million in transportation projects (Woolsey, 2018).

Case 3. Additional Transportation Infrastructure Affects Socioeconomic Forecasts

In the past, transportation investments have led to an increase in population with supporting conditions. Arlington County's population had been declining for a decade when, in 1982, John (1982) reported that an increase in population was expected because of the rezoning of land near heavy rail stations that would allow condominiums and commercial construction. A 12% increase was realized for Arlington. In this particular case, the presence of a transportation investment (heavy rail) coupled with a supporting land use policy (allowing for intense development near stations) appears to have contributed to a population increase. Wilbur Smith Associates (2010) reported that several companies moved to Front Royal, Virginia, specifically to take advantage of Virginia's inland port. Meyer and Miller (2013) point out that although initial transportation investments have greatly influenced land development and hence population or employment growth (a Virginia-specific example is the Monitor-Merrimac Bridge Tunnel's impact on land development in Suffolk [Pascale, 2017]), later investments that incrementally improve transportation access may not "significantly affect metropolitan patterns of urban development," leading the authors to conclude that without other factors that encourage employment or population growth, later investments in transportation may not have a substantial impact.

However, the magnitude of the effect of transportation investments on a region's ability to attract population or jobs also requires careful interpretation. Zhao and Leung (2018) report that in Minnesota counties, a 1% increase in transportation investments was "associated" with a county employment rate increase of 0.007% if the investments were in local streets and a county employment rate increase of 0.008% if the investments were in what appear to be facilities comparable to Virginia's primary system (Minnesota Department of Transportation, 2019) and employment rate is defined as "number of employed divided by the number in the labor force." However, although road investments did "contribute significantly to employment in Minnesota counties," Zhao and Leung (2018) also note that they did not find a relationship between such investments and total employment by county. They do not state why employment rate but not aggregate employment increased; potential reasons could be a change in the labor force or a change in the ability of existing employers to fill jobs.

Case 4. Factors Other Than Transportation Affect Socioeconomic Forecasts

Although population and employment can be affected by transportation investments, they can also be affected by other factors. For example, 10 of 21 PDCs in Virginia had negative employment growth rates during 2000-2017. National recessions appear to have at least partly explained these drops in employment. Lacey et al. (2017) point out that the "labor force participation rate" started to fall after the 2001 recession and then decreased radically after the 2007-2009 economic recession. Of the 10 Virginia PDCs whose employment growth rate dropped during 2000-2017, 6 also had a negative average annual population growth rate during this period. An association between population and employment at the regional level is observable: at the VDOT district level, for example, population and employment had correlations of 0.97 in 1975 and above 0.99 in 2017. Thus, this association should be expected to the extent that people will tend to move to areas with more job opportunities or that employers will tend to locate where there are more potential workers.

Another factor that affects socioeconomic forecasts is migration between Virginia and other states. Based on 2017 year data (U.S. Census Bureau, 2018g) about a quarter million individuals 1 year or older—2.96% of Virginia's 2017 population—moved to Virginia from another U.S. state (including the District of Columbia) 1 year prior to the 2017 American Community Survey data being collected. A slightly greater portion of Virginia's 2017 population—about 3.10%—moved from Virginia to another state over the same time period. Although this net loss of about 12,000 people is based on gains and losses from all 50 states plus the District of Columbia, three states in particular—Florida, Tennessee, and California—were the largest contributors to this number, taking 24,000 more Virginians than they donated to Virginia (U.S. Census Bureau, 2018g). Excluding any two of these three states would have given Virginia a net gain, rather than a net loss, attributed to migration patterns between Virginia and other states plus the District of Columbia. Further, state borders are porous: as 75% of persons who work in Washington, D.C., live elsewhere, the availability of jobs or residences in bordering jurisdictions will also affect forecasts.

Summary

- *Virginia's population is forecast to grow between 24% and 33% from 2017-2045.* Four of Virginia's 21 PDCs, clustered along the I-95 corridor (Northern Virginia, George Washington, and Richmond Regional) and the eastern portion of the I-64 corridor (Hampton Roads), are expected to account for 83% to 85% of this growth.

- *Virginia's population age 65+ is forecast to increase from 1.27 million to between 1.99 million and 2.26 million from 2017-2045*. Although persons age 75+ are a relatively small percentage of the state's population at present (6%), this group is expected to grow between 104% and 150%, becoming between 10% and 11% of the state's total population in 2045.

- *Employment is forecast to grow statewide between 18% and 44% from 2017-2045*. Four PDCs—Northern Virginia, Hampton Roads, Richmond Regional, and George Washington—account for between 80% and 87% of new jobs created from 2017-2045.

- *More than one-half (54% to 58%) of Virginia's jobs in 2017 are in five categories:* accommodation and food services, health care and social assistance, retail trade, professional and technical services, and government. Further, these five sectors account for between 57% and 61% of Virginia's forecast employment growth from 2017-2045.

- *Virginia household incomes, in real terms, are forecast to increase between 25% and 38% by 2045,* with individual PDCs forecast to see increases ranging from 9% to 50%.

- *One potential implication of these forecasts is that transportation investments to support persons age 65+ may be of interest;* these include pedestrian facilities (DeGood, 2011); assistance for persons who have trouble driving (National Aging and Disability Transportation Center, 2019); fare policies for public transportation (Loukaitou-Sideris and Wachs, 2018); and safety measures that specifically target older drivers (Getzmann et al., 2018).

- *A change in these forecasts may portend a change in travel demand.* The arrival of a large employer, for example, in Arlington County, may not only increase population and employment by an estimated 6% and 3% (relative to forecasts made prior to knowledge of this employer arriving) but may also increase demand for transit or vehicle trips, which could be exacerbated by a shortage of affordable housing (Jan and Orton, 2018; Sullivan, 2018).

- *The literature suggests that transportation investments have the potential to support population growth, but only if other conditions that also support such growth are present*. Investments in a heavy rail system along with appropriate zoning policies supported an increase in population (John, 1982); investments in roadways supported an increase in employment rate (but not total employment) (Zhao and Leung, 2018). The likelihood of an investment having an impact on growth decreases if the proposed investment only marginally improves travel conditions, as opposed to an investment that renders a formerly inaccessible area accessible (Meyer and Miller, 2013).

- *Other factors besides transportation investments can affect socioeconomic forecasts.* One such factor is changes in the national economy, where the recessions of 2001 and 2007-2008 appear to have contributed to changes in employment and population growth at the regional level. Another factor is migration between Virginia and other U.S. states plus the District of Columbia. As an example of this second factor, based on the most recent year of data available (U.S. Census Bureau, 2018g), the equivalent of 2.96% of Virginia's 2017 population migrated to Virginia from another state during a 1-year period. Further, the equivalent of 3.10% of Virginia’s population moved from Virginia to another state during the same period. A third factor is the relative attractiveness of neighboring jurisdictions, where individuals might work in one and reside in another.

FINAL REPORT

POTENTIAL SOCIOECONOMIC FORECASTS IN SUPPORT OF VTrans

Haritha Bhairavabhatla
Research Assistant

Amy A. O'Leary, Ph.D.
Associate Director

Maddison A. Gasse
Research Assistant

John S. Miller, Ph.D., P.E.
Principal Research Scientist

INTRODUCTION

Section 5.2.1: Demographic and Land Development Trends, Drivers, and Opportunities of a request for proposals from the Office of Intermodal Policy and Investment (OIPI) (2018) requires demographic information regarding potential transportation system users in Virginia. Two sources of population data are the publicly available data from the Weldon Cooper Center for Public Service (hereinafter "Weldon Cooper") (2017a, 2017b, 2018) and the proprietary data from Woods & Poole Economics, Inc. [hereinafter "Woods & Poole] (2018a, b). Other sources of proprietary socioeconomic data include employment data that may be purchased from Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018) and household income data that may be purchased from Woods & Poole (2018b) and Moody's Analytics (hereinafter "Moody's) (2019). These data sets generally include estimates of current or historical conditions and forecasts, also known as projections, of future conditions.

Although uncertainty is associated with all data sets presented herein, the degree of uncertainty varies between estimates (e.g., present-day values) and projections (e.g., forecasts). The uncertainty associated with estimates can be viewed as an interpolation exercise, where one links a known value (the decennial census) to an estimate of the population in a recent year. Population estimates are based on observed administrative records, such as births, deaths, school enrollment, and residential housing construction, to detect population changes since the most recent decennial census (Weldon Cooper, 2015). Although there is some uncertainty in this process (e.g., perhaps not all births will be recorded), the estimates can be viewed as relatively stable.

By contrast, population projections—e.g., forecasts—have higher levels of uncertainty than estimates because such forecasts require assumptions about future changes in the economy, in- and outmigration patterns, the environment, or policies that may influence where people choose to live (Sen, 2017a). For example, a 30-year forecast made in 1990 might not have anticipated the increases in home values in some central cities that would be expected to affect population growth there. Accordingly, Lombard (2017a) suggests a few rules for evaluating population projections, and these rules have implications for VTrans forecasts.

- All population projections have a margin of error (implying that forecasts should be presented as a range rather than only as a point value).

- Longer term forecasts have a greater margin of error than shorter term forecasts (implying that the margin of error should be greater for a 2050 forecast than for a 2040 forecast).

- Projection accuracy for larger populations is greater than for smaller populations (implying that the margin of error associated with a regional forecast should be smaller than the error associated with a locality forecast).

Population projections are of interest because they affect other key socioeconomic factors. One example is labor force: Lacey et al. (2017) note that forecasts of change in the labor force are significantly affected by forecasts of change in the population, such that labor force forecast accuracy is largely dependent on population forecast accuracy. Labor force projections by the Bureau of Labor Statistics (BLS) are performed using a methodology of multiplying the projected participation rates of various demographic groups by their corresponding estimate of the civilian non-institutionalized population (BLS, 2018c). Although forecasting is not limited to simple trend extrapolation (i.e., forecasters may use scholarly articles and expert interviews in addition to quantitative historical data [BLS, 2018c]), the accuracy of population and labor force forecasts done by the same source for the same time period might be affected by unforeseen changes.

This report also presents employment and income forecasts. As is the case with population, these are affected by uncertainty—but to a greater degree. Unknown changes in immigration affect both population and employment forecasts (Toossi, 2015), but factors such as technological innovation, changes in production methods, the replacement of one service with another, and changes in the size of business establishments also affect employment forecasts (BLS, 2018c). A review of Henderson (2015) shows that unexpected changes in the overall economy, such as recessions, will naturally affect the accuracy of forecasts, although this may be mitigated to some extent if one examines changes in the distribution of jobs; however, the role technology plays, especially as it makes certain occupations more productive with fewer employees, naturally makes employment forecasting relatively challenging compared to population forecasting.

PURPOSE AND SCOPE

The purpose of this study was to develop socioeconomic forecasts for year 2045 that would support OIPI in the creation of Virginia's Statewide Multimodal Plan, also known as VTrans. In addition to the numerical values for the forecasts themselves, the study was to determine (1) relevant historical trends in these forecasts, (2) the accuracy of previous forecasts based on a comparison of observed and forecast values, and (3) the implications for transportation with regard to these forecasts. The scope of the first was limited to population and employment trends, and the scope of the second was limited to population forecasts.

METHODS

Five main steps comprised the methods: collect estimates and projections for population, employment, and household income; establish modified planning district commission (PDC) boundaries; develop population, employment, and income estimates and projections for the modified PDCs; report error from previous population forecasts; and address questions from stakeholders and reviewers.

Collect Population, Employment, and Household Income Estimates and Projections

Population estimates for all counties and independent cities of Virginia for the years 2000 and 2017 were acquired from Weldon Cooper (2018) and Woods & Poole (2018b); these were also obtained by age group from the U.S. Census Bureau (2018a). Total population projections for year 2045 and population projections by age for year 2040 (the latest year for which such information is currently available from Weldon Cooper [2017a, b)]) or year 2045 (Woods & Poole, 2018b) were also obtained.

Employment estimates for years 2000 and 2017 and the forecasts for year 2045 were obtained from Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018). Household income forecasts and estimates were obtained from Woods & Poole (2018b) and Moody's (2019). In some of these data sets, estimates and forecasts for some adjacent cities and counties had been combined in the original data set. For instance, Woods & Poole (2018b) provides a single population and employment value for Fairfax City, Fairfax County, and Falls Church. Because these three jurisdictions are in the same region, whether that region is a modified PDC (i.e., Northern Virginia) or a VDOT district (also Northern Virginia), regional totals should not be affected by this aggregation in the original data set.

In addition, historical population estimates and employment estimates for years 1975-2017 were obtained for both PDCs and, as requested by OIPI, VDOT districts. Because of the manner in which these historical data sets are organized and because some data were missing from the employment data sets, the research team took some steps to aggregate these by district and modified PDC.

Aggregation of Historical Population Estimates

Historical population data for individual jurisdictions were obtained from Weldon Cooper (undated, 1993, 2003, 2011, 2019a), where each publication reflects a 10-year period. Weldon Cooper staff took the populations for the starting and ending years of each 10-year period from decennial census values reported by the U.S. Census Bureau, and the populations for the years in between were estimated by staff based on these census values. In the publications by Weldon

Cooper (undated, 1993, 2003, 2011, 2019a), the intercensal estimates were taken on July 1 of each year and the census data were collected on April 1 of each year.

The population data were then aggregated by the research team by jurisdiction for the years 1975, 1980, 1985, 1990, 1995, 2000, 2005, 2010, 2015, and 2017. The jurisdictions were then grouped into their corresponding VDOT districts, and then a second time into PDCs. For the most part, the jurisdiction groupings remained the same from the 1975 data to the 2017 data, with a few exceptions. The cities of Bedford City, Clifton Forge City, and South Boston City reverted to town status and were thus absorbed by Bedford County, Alleghany County, and Halifax County, respectively. The jurisdiction groupings for each PDC are shown in Table 1, and the corresponding groupings by VDOT district are shown in Table 2.

Table 1. Independent Cities and Counties Associated With Each Modified Planning District Commission

No.	Modified Planning District Commission	Jurisdictions[a]
1	Lenowisco	Lee, Norton, Scott, Wise
2	Cumberland Plateau	Buchanan, Dickenson, Russell, Tazewell
3	Mount Rogers	Bland, Bristol, Carroll, Galax, Grayson, Smyth, Washington, Wythe
4	New River Valley	Floyd, Giles, Montgomery, Pulaski, Radford
5	Roanoke Valley-Alleghany	Alleghany, Botetourt, Covington, Craig, Franklin County[a], Roanoke City[a], Roanoke County[a], Salem
6	Central Shenandoah	Augusta, Bath, Buena Vista, Harrisonburg, Highland, Lexington, Rockbridge, Rockingham, Staunton, Waynesboro
7	Northern Shenandoah	Clarke, Frederick, Page, Shenandoah, Warren, Winchester
8	Northern Virginia	Alexandria, Arlington, Fairfax City[a], Fairfax County[a], Falls Church, Loudoun, Manassas, Manassas Park, Prince William
9	Rappahannock-Rapidan	Culpeper, Fauquier, Madison, Orange, Rappahannock
10	Thomas Jefferson	Albemarle, Charlottesville, Fluvanna, Greene, Louisa, Nelson
11	Central Virginia (formerly known as Region 2000 Local Government Council)	Amherst, Appomattox, Bedford, Campbell, Lynchburg
12	West Piedmont	Danville, Henry, Martinsville, Patrick, Pittsylvania
13	Southside	Brunswick, Halifax, Mecklenburg
14	Commonwealth Regional Council	Amelia, Buckingham, Charlotte, Cumberland, Lunenburg, Nottoway, Prince Edward
15	Richmond Regional	Charles City[b], Chesterfield, Goochland, Hanover, Henrico, New Kent, Powhatan, Richmond City[a]
16	George Washington	Caroline, Fredericksburg, King George, Spotsylvania, Stafford
17	Northern Neck	Lancaster, Northumberland, Richmond County[a], Westmoreland
18	Middle Peninsula	Essex, Gloucester, King and Queen, King William, Mathews, Middlesex
19	Crater	Colonial Heights, Dinwiddie, Emporia, Greensville, Hopewell, Petersburg, Prince George, Surry, Sussex
22	Accomack-Northampton	Accomack, Northampton
23	Hampton Roads	Chesapeake, Franklin City[a], Hampton, Isle of Wight, James City[b], Newport News, Norfolk, Poquoson, Portsmouth, Southampton, Suffolk, Virginia Beach, Williamsburg, York

[a] The suffix "City" and "County" are not listed in the table except in the cases where there is a city and county with the same name (e.g., Franklin City and Franklin County).
[b] The proper names of these jurisdictions, which are both counties, are "Charles City" and "James City."

Table 2. Jurisdictions Associated With Each VDOT District

District	Jurisdictions
Bristol	Bland, Buchanan, Dickenson, Grayson, Lee, Russell, Scott, Smyth, Tazewell, Washington, Wise, Wythe, Bristol, Norton
Salem	Bedford, Botetourt, Carroll, Craig, Floyd, Franklin, Giles, Henry, Montgomery, Patrick, Pulaski, Roanoke County, Galax, Martinsville, Radford, Roanoke City, Salem City
Lynchburg	Amherst, Appomattox, Buckingham, Campbell, Charlotte, Cumberland, Halifax, Nelson, Pittsylvania, Prince Edward, Danville, Lynchburg
Richmond	Amelia, Brunswick, Charles City, Chesterfield, Dinwiddie, Goochland, Hanover, Henrico, Lunenburg, Mecklenburg, New Kent, Nottoway, Powhatan, Prince George, Colonial Heights, Hopewell, Petersburg, Richmond City
Hampton Roads	Accomack, Isle of Wright, James City, Northampton, Southampton, Surry, Sussex, York, Greensville, Chesapeake, Emporia, Franklin, Hampton, Newport News, Norfolk, Poquoson, Portsmouth, Suffolk, Virginia Beach, Williamsburg
Fredericksburg	Caroline, Essex, Gloucester, King and Queen, King George, King William, Lancaster, Mathews, Middlesex, Northumberland, Richmond County, Spotsylvania, Stafford, Westmoreland, Fredericksburg
Culpeper	Albemarle, Culpeper, Fauquier, Fluvanna, Greene, Louisa, Madison, Orange, Rappahannock, Charlottesville
Staunton	Alleghany, Augusta, Bath, Clarke, Frederick, Highland, Page, Rockbridge, Rockingham, Shenandoah, Warren, Buena Vista, Covington, Harrisonburg, Lexington, Staunton, Waynesboro, Winchester
Northern Virginia	Arlington, Fairfax County, Loudoun County, Prince William, Alexandria, Fairfax City, Falls Church, Manassas, Manassas Park

Aggregation of Historical Employment Estimates

Historical employment data for Virginia were obtained from the Quarterly Census of Employment and Wages (QCEW) maintained by the BLS (2018a). This data set is not necessarily directly comparable to employment data obtained from other sources; thus, any comparisons between PDCs or districts are best interpreted relative to each other rather than in tandem with the employment forecasts from other sources, such as Woods & Poole (2018b) or Moody's (2019). BLS (undated) reports that the QCEW data are based on employment as "reported by employers" and cover more than 95% of jobs in the United States. Examples of jobs that are not included are proprietors, the "unincorporated self-employed," and some domestic workers. For example, BLS (2018b) notes that although 0.3 million domestic workers are included in the 2017 QCEW, another 0.4 million domestic workers are not included; similarly, 9.5 million self-employed workers (about 8% of whom work in the agriculture industry) are also excluded from the QCEW.

Employment data were aggregated by Virginia jurisdiction for the years 1975, 1980, 1985, 1990, 1995, 2000, 2005, 2010, 2015, and 2017. Although 1975 was the earliest year available from this data set (BLS, 2018a), an advantage was that this should have minimized differences with annexations of land from counties by independent cities. As with the population data, employment aggregation is affected by the three independent cities that reverted to town status since 1975 (Bedford, Clifton Forge, and South Boston), but otherwise the jurisdictions did not change. In checking the tabulations of the data, the research team noticed discrepancies that accounted for between 0.11% and 2.89% of the statewide employment total. These discrepancies can be categorized as follows:

- *Locations where the database shows employment was deliberately not disclosed (1975-1985).* For 1975, 1980, and 1985, employment was not disclosed for certain jurisdictions: the counties of Charles City, King and Queen, King George, Spotsylvania, and Westmoreland and the cities of Bedford and Fairfax (1975); the counties of Poquoson and Craig (1980); and Poquoson (1985). Further, in 1975 only, the cities of Manassas and Manassas Park and Westmoreland County were not listed in the database.

- *Discrepancies between the reported statewide total and the total given by summing all jurisdictions plus employment in "unknown" locations if applicable (1975-2000).* For 1980, the sum of employment from all jurisdictions plus the employment from "unknown" Virginia locations was 2.074 million whereas the statewide total was reported as 2.076 million—a difference of about 2,000 jobs or roughly 0.11% of the total. The corresponding discrepancy was 1.6% (1975) and 0.7% (1985), where both data sets included employment values from "unknown" Virginia locations. For years 1990-2000, although there were no "unknown" Virginia locations or locations where employment was not disclosed, there continued to be a difference between the reported statewide total and the total obtained by summing the individual jurisdictions: discrepancies were 2.44% (1990), 2.29% (1995), and 2.13% (2000).

- *Discrepancies possibly attributable to employment in unknown locations (1975-1985 and 2005-2017).* For years 1975-1985, jobs were listed as being in an "unknown" location in Virginia, and such jobs were 2.6% (1975), 2.15% (1980), and 0.23% (1985) of the reported statewide total. It should be noted that for the years 1975-1985, the jobs in unknown locations did not account for the difference between the reported statewide total and the total obtained by summing Virginia jurisdictions. For years 2005-2017, however, the difference between the reported statewide total and the total obtained by summing employment in Virginia jurisdictions appeared to match the employment reported in unknown Virginia locations, where the percentage of statewide employment in unknown Virginia locations was 1.70% (2005), 1.88% (2010), 2.42% (2015), and 2.89% (2017).

Establish Modified Planning District Commission (PDC) Boundaries

Population and employment estimates (e.g., data for year 2017) and projections (e.g., forecasts for year 2045) for each independent city and county in Virginia were aggregated by modified PDC. Most of Virginia's 133 independent cities and counties are in exactly 1 of Virginia's 21 PDCs, with 7 exceptions (Virginia Association of Planning District Commissions, 2018): Cumberland County and Nottoway County are not in any PDC; Chesterfield County and Charles City County are in 2 PDCs (Crater and Richmond Regional); Gloucester County is in 2 PDCs (Hampton Roads and Middle Peninsula); Surry County is in 2 PDCs (Crater and Hampton Roads); and Franklin County is in 2 PDCs (Roanoke Valley-Alleghany Regional Commission and West Piedmont). Accordingly, to avoid double counting estimates and to include every jurisdiction within exactly 1 PDC, the following changes were made when aggregating results by PDC.

- Cumberland County and Nottoway County were placed in the Commonwealth Regional Council PDC.

- Chesterfield and Charles City County were kept in only the Richmond Regional PDC.

- Gloucester County was kept in only the Middle Peninsula PDC.

- Surry County was kept in only the Crater PDC.

- Franklin County was kept in only the Roanoke Valley-Alleghany Regional Commission.

Figure 1 shows the resultant boundaries of the modified PDCs, and Table 1 lists the jurisdictions associated with each. In the remainder of this report, the term "PDC" means the modified PDCs created so that no county or jurisdiction was split between multiple PDCs.

The data provided by IHS Markit (Jeafarqomi, 2018) lists two jurisdictions named "Bedford." Because these two jurisdictions have different FIPS codes (Bedford County has FIPS Code 019, and Bedford City has FIPS Code 515), the research team inferred that IHS Markit had categorized the employment values in these two jurisdictions independently of each other. FIPS is an acronym for what used to be termed "Federal Information Processing Standards" and what is now termed "Federal Information Processing Series," where these are, for the cases of independent cities and counties in Virginia, three digit numbers signifying a particular city or county (U.S. Census Bureau, undated). Therefore, the research team combined Bedford County and Bedford City and placed them in the jurisdiction of Bedford County since Bedford City no longer existed (as it reverted to town status in 2013).

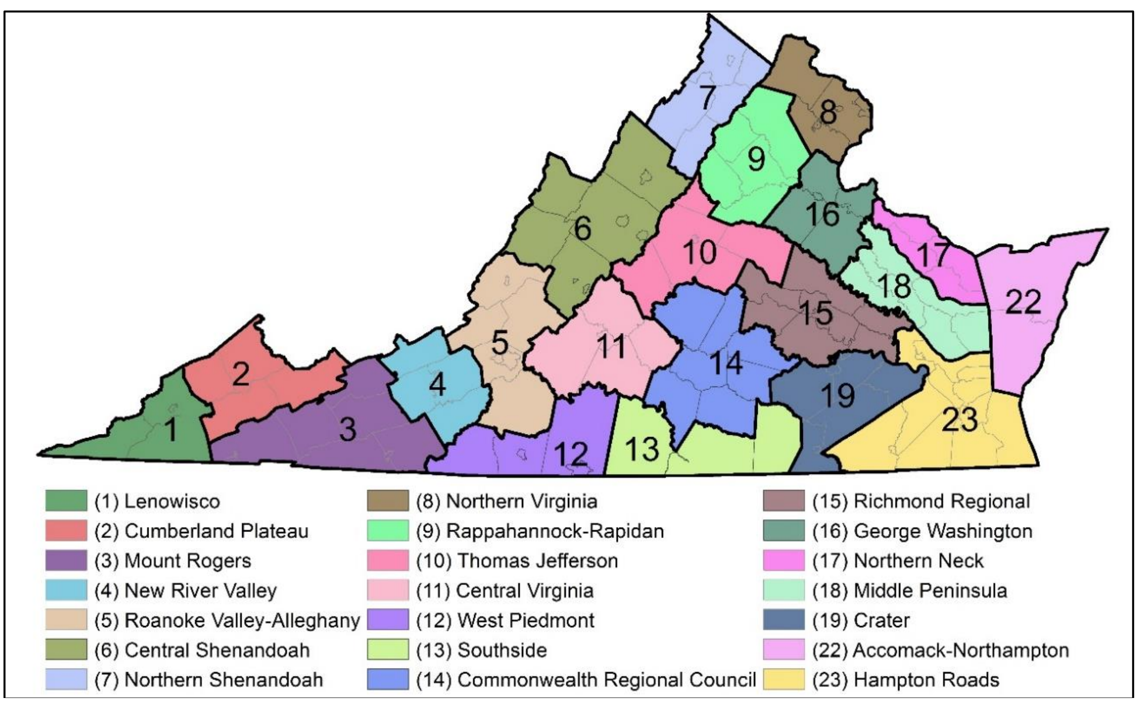


Figure 1. Modified Virginia Planning District Commissions

A graph of the employment in Bedford County and Bedford City based on IHS Markit data (Jeafarqomi, 2018) also supports this view: the conversion of Bedford City to the Town of Bedford (where the town is then defined as a part of Bedford County) did not alter the manner in which the data were characterized by IHS Markit. In short, Figure 2 suggests that in 1990, if one wanted to know the total employment in Bedford City and Bedford County, one would sum both values for a total of approximately 16,000. Figure 2 also suggests that in 2045, if one wants to know the total employment in Bedford County (which after 2013 included the Town of Bedford, where the town was formerly Bedford City), one must again sum both values (for a total of approximately 23,000).

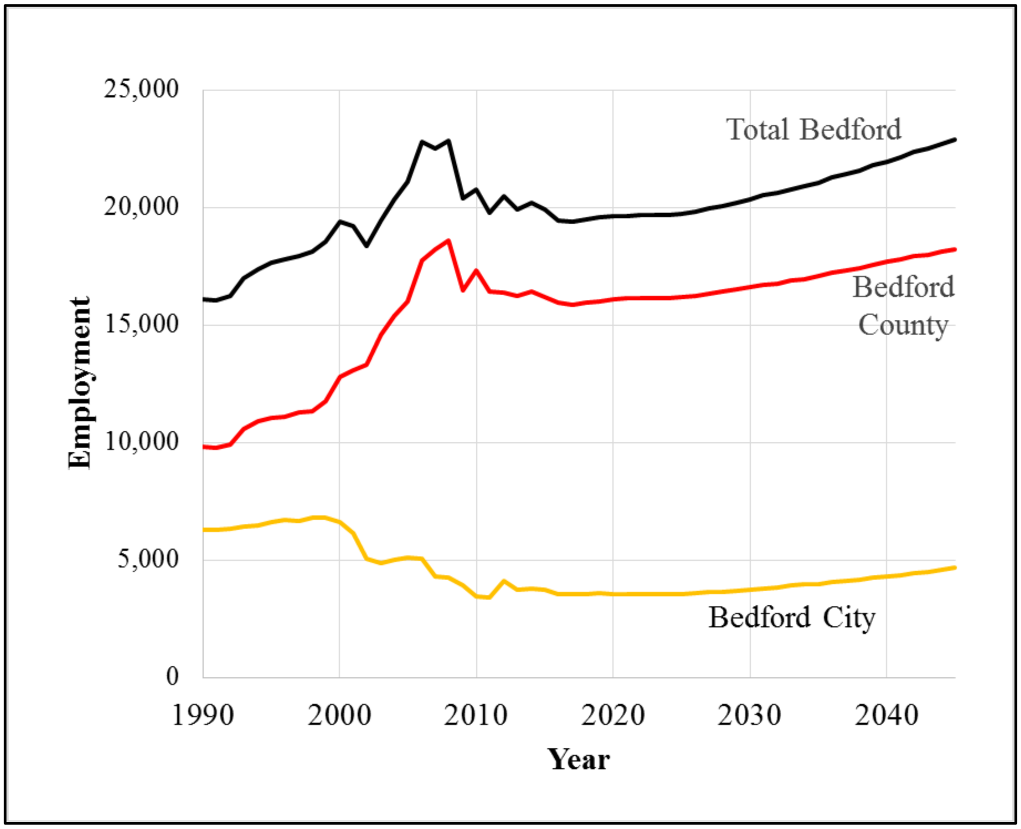


Figure 2. Derivation of Total Employment for Bedford County. Based on data From IHS Markit (Jeafarqomi, 2018).

Develop Population, Employment, and Household Income Estimates and Projections

After population, employment, household income estimates and projections by locality were obtained, the data were arranged by modified PDC (as described previously) and by VDOT district (VDOT, 2018). Then, for each such PDC or district, the current population (for year 2017); the forecast population (for year 2045); and the change in population by age group on both a nominal and a percentage basis were calculated. Because of how these data sets are organized, adjustments were needed for the population and income forecasts. No adjustments were needed for the employment forecasts; however, the fact that employment forecasts from different sources are not necessarily directly comparable needed to be kept in mind.

Adjustments for Population Forecasts

It is important to note that Weldon Cooper (2017b) provides age-based forecasts for year 2040 rather than year 2045. The provider of these forecasts suggested that to obtain 2045 values for individual units (e.g., PDCs or districts), one could multiply the 2040 distribution by age by the 2045 values in order to obtain "quick but still o.k." values (Cai, 2018). Accordingly, for each district and PDC, the age distributions for under age 20, age 20-64, and age 65+ that had been developed for year 2040 (Weldon Cooper, 2017b) were multiplied by the 2045 total population values (Weldon Cooper, 2017a). For example, for year 2040, the percentage of persons age 65+ in the Bristol District was forecast to be 21.1%, and the total population of the Bristol District for year 2045 is forecast to be 325,987. The product of these two values yields a 2045 forecast of 80,910 persons age 65+ for the Bristol District.

This method will provide interpolated values for districts or PDCs. However, because the individual VDOT districts (or individual Virginia PDCs) are growing at different rates, if one desires a statewide total for persons by age in 2045 (that follows the same percentages for year 2040), one should not simply sum the columns in Table 3. Rather, one would apply the statewide percentages from year 2040 to year 2045. For example, for year 2040, the percentage of persons in Virginia under age 20 is forecast to be 24.6%. To estimate the number of persons statewide in Virginia under age 20 in year 2045, one multiplies this percentage by the total 2045 forecast (10,528,817) to obtain an estimate of 2,594,493. This total is slightly different from the value of 2,596,387 that would be obtained by simply summing the population for each district under age 20 in the second column of Table 3. That said, the discrepancy of slightly less than 1,900 people reflects a difference of 0.02% between these two values.

Table 3. Example of Interpolated Age Forecasts for Year 2045 by VDOT District[a]

District	Under 20	20-64	65+
Bristol	68,931	176,146	80,910
Salem	171,928	406,607	174,397
Lynchburg	99,985	229,885	93,552
Richmond	390,890	895,031	311,055
Hampton Roads	479,434	1,117,088	383,636
Fredericksburg	177,954	373,128	134,529
Culpeper	131,454	296,097	116,113
Staunton	165,833	361,225	146,755
Northern Virginia	909,978	2,094,567	541,710
Statewide	2,594,493	5,947,411	1,986,913

[a] Based on data from the Weldon Cooper Center for Public Service (2017a).

Adjustments for Income Forecasts

It should also be noted that as is the case with employment, the household income reported by Woods & Poole (2018b) is typically higher than that of other sources such as the U.S. Census Bureau. Formally, the Woods & Poole income includes not only wages and salaries but also "proprietors' income, rental income of persons, dividend income, personal interest income, and transfer payments less personal contributions for social insurance." Woods & Poole (2018b) reports that income as reported by the U.S. Census Bureau excludes certain items such as the value of food stamps, the value of medical payments, and the "imputed rental value of owner-occupied housing." Another factor is that whereas Woods & Poole (2018b) reports the mean household income, other sources may report the median household income. For these reasons, it is not surprising that the mean household income in Virginia for 2017 ($120,910) is considerably higher than the median household income reported by the U.S. Census Bureau ($68,766)—even though the former is in 2009 dollars and the latter is in 2017 dollars (U.S. Census Bureau, 2018b).

For household incomes reported by Moody's (2019), there are four methodological differences that affect how these data are interpreted with respect to incomes reported by Woods & Poole (2018a). First, although Virginia has 133 independent cities and counties in total, Moody's reports data for only 105 geographical areas in Virginia, which in total represent the entire state. Most (82) of Moody's areas correspond directly with a Virginia jurisdiction; for example, Moody's provides an income for the independent city of Virginia Beach. However, about one-fifth (23) of Moody's 105 areas are an aggregation of two or more Virginia jurisdictions. For example, Moody's provides a single income for the combined area of Roanoke County plus the City of Salem (but the City of Roanoke is reported separately); another example is that the cities of Colonial Heights and Petersburg, along with Dinwiddie County, are reported as a single area. As shown in Table 4, the county that represented these combined areas was used to assign the area to the appropriate VDOT district or modified PDC. For instance, because Prince George County is in the Crater PDC and VDOT's Richmond District, Table 4 shows that the City of Hopewell is also placed in this same PDC and district.

Table 4. Correspondence Between Moody's Areas and the Assigned Jurisdiction

Moody's Combined Area	Assigned Jurisdiction
Albemarle + Charlottesville (VA)	Albemarle County, Va.
Alleghany, Clifton Forge + Covington (VA)	Alleghany County, Va.
Augusta, Staunton + Waynesboro (VA)	Augusta County, Va.
Campbell + Lynchburg (VA)	Campbell County, Va.
Carroll + Galax (VA)	Carroll County, Va.
Dinwiddie + Colonial Heights + Petersburg (VA)	Dinwiddie County, Va.
Fairfax County, Fairfax City + Falls Church (VA)	Fairfax County, Va.
Frederick + Winchester (VA)	Frederick County, Va.
Greensville + Emporia (VA)	Greensville County, Va.
Henry + Martinsville (VA)	Henry County, Va.
James City + Williamsburg (VA)	James City County, Va.
Montgomery + Radford (VA)	Montgomery County, Va.
Pittsylvania + Danville (VA)	Pittsylvania County, Va.
Prince George + Hopewell (VA)	Prince George County, Va.
Prince William, Manassas + Manassas Park (VA)	Prince William County, Va.
Roanoke County + Salem (VA)	Roanoke County, Va.
Rockbridge, Buena Vista + Lexington (VA)	Rockbridge County, Va.
Rockingham + Harrisonburg (VA)	Rockingham County, Va.
Southampton + Franklin City (VA)	Southampton County, Va.
Spotsylvania + Fredericksburg (VA)	Spotsylvania County, Va.
Washington + Bristol (VA)	Washington County, Va.
Wise + Norton (VA)	Wise County, Va.
York + Poquoson (VA)	York County, Va.

Source: Based on data from Moody's Analytics (2019).

Second, Moody's reports forecast incomes in current year dollars. For example, Moody's forecasts the 2045 median income for Appomattox County to be $109,710—in year 2045 dollars. Accordingly, a customized Virginia-specific statewide deflator table was provided by Moody's staff (Kamins, 2019) for a base year of 2009, where one multiplies dollars reported in any other year by the deflator to obtain forecast income in 2009 dollars. Because the deflator for year 2045 is 0.5229, the Appomattox County median income of $109,710 (in 2045 dollars) is multiplied by 0.5229 to obtain a 2045 forecast median income of $57,367 (in 2009 dollars). The value of 2009 dollars was chosen because the incomes provided by Woods & Poole (2018a) are also in 2009 dollars. The statewide deflator is an estimate in that one could also purchase deflators that are specific to certain metropolitan areas.

Third, Woods & Poole (2018a) reports the mean household income whereas Moody's (2019) reports the median household income. In locations where there were a few households with very large or very small household incomes, there could be a difference between the mean and the median incomes. Mean values are more influenced by extreme values in a distribution than median values.

Fourth, Moody's (2019) and Woods & Poole (2018a, b) do not define income in the same manner. Moody's indicates that for a definition of income, one should examine the corresponding "driver" of this income, which Moody's (2019) then notes is based on four sources: "the U.S. Census Bureau's (BOC) annual American Community Survey (ACS), Decennial Census, the Current Population Survey, and the Small Area Income and Poverty Estimates from the BOC." The U.S. Census Bureau (2018c) reports that personal income includes eight categories of income, abbreviated here as salaries, self-employment, interest/royalties/net rental income, social security income, disability income, public assistance income, retirement income, and all other income (e.g., child support). To be clear, the U.S. Census Bureau (2018c) includes social security retirement income (e.g., income for individuals who have reached a certain age of 62 or older and have elected to start receiving such income); supplemental security income (abbreviated "SSI"), which "guarantees a minimum level of income for needy aged, blind, or disabled individuals"; and public assistance income (which is Temporary Assistance to Needy Families) (abbreviated "TANF") (U.S. Census Bureau, 2018c); this last program was colloquially described as "welfare" until 1996 when TANF replaced a program in place from 1935-1996 known as Aid to Families with Dependent Children (Center on Budget and Policy Priorities, 2018). Although the U.S. Census Bureau (2018c) does not explicitly state whether it includes social security disability income (SSDI), it notes that it includes in its income "permanent disability insurance payments made by the Social Security Administration prior to deductions for medical insurance," which based on a review of how the Social Security Administration (2017) defines SSDI suggests that SSDI is included in incomes from the U.S. Census Bureau and hence would be part of the Moody's (2019) data set.

Although these categories are numerous, it should be noted that as suggested by Woods & Poole (2018b), the incomes based on the U.S. Census (such as Moody's) tend to be smaller than those of Woods & Poole. Examination of incomes for one county in Virginia supports this viewpoint. For Appomattox County, in 2009 dollars, an approximate 2018 household income from three sources was approximately $45,105 (Moody's, 2019), $48,069 (U.S. Census Bureau, 2018d), and $78,468 (Woods & Poole, 2018a), as shown in Table 5.

Table 5. Current Household Incomes for Appomattox County From Three Sources

Source	Period	Type	Income (Year $)	Income (2009 $)
Woods & Poole (2018a)	2017	Mean	$78,468 (2009 $)	$78,468
U.S. Census Bureau (2018d)	2013-2017[a]	Median	$54,875 (2017 $)	$48,069
Moody's Analytics (2019)	2017	Median	$50,851 (2017 $)	$45,105

[a] For jurisdictions with a population under 20,000, the American Community Survey obtains data over a 5-year period.

It should be noted that whereas Woods & Poole (2018a) reports incomes in 2009 dollars, this is not the case for the other two sources; thus, the Moody's income in 2017 dollars was deflated using the value provided by staff associated with Moody's (Kamins, 2019) and the ACS data were deflated using the consumer price index (BLS, 2019) so that 2009 income would be available for all three data sources.

For each modified PDC, a weighted median household income was computed in a manner similar to that used for the Woods & Poole data. After the incomes for each Moody's area were converted to 2009 dollars, for each area in the PDC, the product of the area's households and income was summed and then divided by the number of households in the PDC as provided by Moody's (2019). A similar process was followed for aggregating incomes by VDOT districts. Moody's (2019) frequently updates these data; the household data in this report were updated December 21, 2018, and the income data were updated January 4, 2019. The research team has reported the estimated statewide median income in this manner, where the median household income (by jurisdiction) is multiplied by the number of households for each jurisdiction and then the total is divided by the number of all households in Virginia.

This estimated median was chosen for consistency with the geography used for obtaining specific district and PDC values. It is also possible to obtain from a separate data series what Moody's reports as a statewide median, which is not disaggregated by jurisdiction. The statewide median from this statewide series differs from the estimated median (based on the county series) by approximately 7% for year 2017 and 4% for year 2045. Possible reasons for the difference include the fact that the statewide deflator provided by Moody's to the research team is an estimate (e.g., different deflators could be used for different urban areas) and the fact that the household weighted estimate for a median is not identical to a true computed median value.

Feasibility of Comparing Employment Forecasts From Different Sources

The employment data herein are based on the PDC or VDOT district where the job is located and include wage and salary workers, proprietors, private household employees, and "miscellaneous workers"; because proprietors and military workers and both full- and part-time jobs are included, employment may be higher from this source than from other sources (Woods & Poole, 2018b). Such disparities in employment definitions are not unusual; for example, total 2016 jobs in the United States obtained from the Bureau of Economic Analysis (almost 150 million) is about 6% higher than jobs obtained from the BLS (almost 142 million) because the latter does not include (or fully include) certain types of employment such as religious organizations, rail transportation, some nonprofits with fewer than four employees, and military employees (Bureau of Economic Analysis, 2017).

Woods & Poole (2018b) defines households as occupied housing units and excludes persons in "group quarters" such as university dormitories, prisons, or "military barracks." Because Woods & Poole (2018b) reports a "mean household income," which is the "total personal income less estimated income of group quarters population divided by the number of households," the research team computed a weighted mean household income for each PDC or district. This weighted mean household income was computed by multiplying the number of households for each city or county by the mean household income for each such jurisdiction to obtain a total household income by jurisdiction; summing these total income values by PDC or district; and then dividing by the corresponding number of households for the PDC or district.

Report Error From Previous Forecasts

Because population forecasts are not new, the research team examined literature where population forecasts had been made at some point in the past and the horizon year for which the forecast was made had already passed. This literature reflected forecasts in the Charlottesville area (Albemarle County Department of Planning and Community Development, 1994); the Fredericksburg area (Stafford County Planning Commission, 2010); Hampton Roads (City of Williamsburg, 2013), and the Washington, D.C., area including Northern Virginia (Metropolitan Washington Council of Governments [MWCOG], 2005). The forecast values were compared to observed values, which were in some cases provided by the literature (e.g., Albemarle County Department of Community Development, 2011) and in some cases obtained by the research team (e.g., U.S. Census Bureau [2010a-d]). Related literature that offered explanatory factors such as economic changes (City of Williamsburg, 2013) and land use patterns (Sen, 2017b) was also reviewed.

Address Areas of Interest to Stakeholders

Stakeholders raised questions or offered suggestions when this work was presented at public meetings on November 28 and March 13. Internal reviewers at OIPI also identified related topics when this work was discussed at meetings between the research team and OIPI on November 7, December 19, January 9, February 13, and April 23. Eight main additional areas of interest beyond the forecasts emerged.

One factor of interest noted during an internal review on February 13 was the migration patterns between Virginia and other U.S. states. As a consequence, data sets showing migration based on the ACS (U.S. Census Bureau, 2018e-g) and literature that had examined Virginia migration patterns based on data from the Internal Revenue Service (Lombard, 2017b) were used to determine the effect that movements between Virginia and other states had had on Virginia's population.

At the VTrans Steering Committee Meeting on November 28, 2018, an attendee posed the following question: How do the forecasts account for the arrival of large employers such as Amazon? The question may have been prompted by an announcement 2 weeks earlier (on

November 13) that Amazon had selected a Northern Virginia area identified as National Landing as one of two locations for a second corporate headquarters, or HQ2. A related question is: How might forecast accuracy be affected when Amazon comes to Virginia with its associated impacts on employment and other demographic factors? To investigate these questions, the research team conducted a literature review about the potential socioeconomic impacts of Amazon's arrival in Virginia.

At the same meeting on November 28, 2018, an attendee noted that some localities desire to have transportation investments as a way of reversing declines in population and thus asked what methods other states have used in this regard. Accordingly, the research team first identified examples where transportation investments have been used to try to attract population or employment to a particular region and then reviewed literature that discussed the ability of transportation investments to stimulate such growth.

During an internal review in either December or January, the question arose as to whether lessons could be learned from the interaction of population and employment at the regional level. Given that Virginia data were available for 1975-2017 by district and PDC, the manner in which regional and statewide values of population and employment changed in tandem was examined.

During several meetings, reviewers indicated the value of tying population and employment forecasts to future potential transportation needs. In consultation with OIPI, the research team identified two trends that are related to these forecasts: the aging of Virginia's population and growth in certain employment sectors that might be correlated with longer or shorter commute times. Then, the research team reviewed the literature to determine how these trends might affect future travel demand. For example, Kopf (2016) reports that commuters in certain fields such as computer science, math, and construction and mining tend to have longer commute times than workers in other sectors. Thus, the number of Virginians in these categories with longer commute times was identified.

Following the March 13 presentation, an attendee noted that it is misleading to present forecasts to an exact integer value because this implies an unrealistic level of accuracy. For example, aggregation of data from one source suggests that the 2045 population for the modified Southside PDC is 72,959 (Weldon Cooper, 2017a). Although having this exact number was helpful for the research team to recall how the forecast was devised, it is unrealistic to expect to forecast population for a region to the nearest person. Instead, one should round this number to convey that there is uncertainty associated with this projection. Certainly there are different methods that could be used to convey this uncertainty. For instance, with a single estimate of 72,959, one might find examples of previous population forecasts and apply the error to this estimate. A forecast by a different entity showed a forecast error of 8.78% (City of Charlottesville, 2007); if such an error applied to the 72,959 number, one could present this value as a range where the midpoint was 72,959 but the range was 8.78% less than that number (66,553) or 8.78% more than that number (79,365). Because forecast accuracy is affected by the time horizon, methodology, and level of geography associated with the forecast, however, the research team was not confident they could choose an appropriate level of uncertainty. Instead, the approach chosen in this study was to obtain forecasts from two different sources and present those forecasts as a range, rounding the upper and lower bounds of that range to the nearest thousand so that the upper bound was greater than the larger forecast and the lower bound was less than the smaller forecast. For example, another source forecast the Southside population to be 78,681 (Woods & Poole, 2018b). Accordingly, four steps were taken to present this as a range:

1. The lower forecast for Southside is 72,959, and the upper forecast is 78,681.

2. The nearest thousand that is below the lower bound is 72,000.

3. The nearest thousand that is above the upper bound is 79,000.

4. The forecast for Southside in summary form based on Woods & Poole (2018b) and Weldon Cooper (2017a) is thus 72,000 to 79,000.

During one of the conversations with OIPI staff, a question arose regarding how population and employment forecasts for Virginia compare with those of border states and the District of Columbia. Thus, forecasts from these locations were obtained, and because they reflected periods different than 2017-2045, all forecasts were converted to an annual growth rate in order to make the comparison.

Finally, during a May 2019 review of the draft report, a member of the OIPI staff asked why regional level forecasts for some of the PDCs were so different between two sources. In response, the research team examined the differences in employment by industry for one particular PDC. Because this information was germane to the employment forecasts, it is presented in the "Results and Discussion" section.

RESULTS AND DISCUSSION

Five categories of results are presented. The first three categories concern the major demographic variables of interest: population; employment; and household income. The latter two categories concern retrospective forecast accuracy and areas of interest identified by stakeholders.

Population

Historical Population Trends (1975-2017)

Table 6 shows Virginia's population by VDOT district from 1975-2017 based on data from Weldon Cooper (undated, 1993, 2003, 2011, 2019a). Table 7 shows the population by PDC from 1975-2017 based on the same data source. Some of the results were expected, such as the continual growth of Northern Virginia's population each year. Beginning in the 1970s, Virginia's population center has shifted north because of Northern Virginia's population growing faster than that of Hampton Roads or Richmond (Sen, 2017b).

Table 6. Population by VDOT District, 1975-2017[a]

District	1975	1980	1985	1990	1995	2000	2005	2010	2015	2017
Bristol	361,000	387,056	378,800	360,041	365,700	363,236	359,956	364,661	356,897	348,862
Culpeper	206,800	224,290	240,600	267,956	295,000	319,988	357,149	385,746	404,735	412,685
Fredericksburg	191,600	219,611	242,500	287,606	336,700	374,081	437,616	469,028	492,144	501,541
Hampton Roads	1,226,800	1,266,402	1,366,600	1,491,759	1,575,000	1,621,695	1,678,923	1,705,262	1,764,170	1,766,213
Lynchburg	356,300	363,299	361,400	361,722	375,900	380,728	384,517	398,710	401,945	399,270
Northern Virginia	1,019,200	1,105,714	1,287,500	1,466,409	1,649,300	1,815,197	2,055,150	2,230,623	2,436,146	2,491,299
Richmond	794,600	841,582	879,400	946,067	1,025,700	1,087,582	1,162,116	1,230,462	1,282,919	1,300,765
Salem	546,600	569,586	580,600	596,688	628,600	648,960	663,437	685,388	695,583	694,336
Staunton	353,100	369,278	377,800	409,110	444,100	467,563	501,603	531,144	548,454	555,049
Total	5,056,000	5,346,818	5,715,200	6,187,358	6,696,000	7,079,030	7,600,467	8,001,024	8,382,993	8,470,020

[a] Aggregated from numbers reported by the Weldon Cooper Center for Public Service (undated, 1993, 2003, 2011, 2019a).

Table 7. Population by Planning District Commission, 1975-2017[a]

Planning District Commission	1975	1980	1985	1990	1995	2000	2005	2010	2015	2017
Lenowisco	94,300	99,644	97,900	91,520	92,300	93,105	93,056	94,174	91,830	89,755
Cumberland Plateau	126,900	140,067	135,400	123,580	122,900	117,229	113,726	113,976	110,381	106,569
Mount Rogers	172,400	181,139	179,400	178,205	186,000	188,984	189,661	193,595	191,012	188,498
New River Valley	132,700	141,343	146,000	152,720	158,700	165,146	171,043	178,237	182,991	183,054
Roanoke Valley-Alleghany	280,800	288,523	289,600	293,244	306,100	311,827	319,760	330,918	335,658	335,483
Central Shenandoah	203,000	208,344	211,700	225,025	244,900	258,763	271,162	286,781	297,621	300,228
Northern Shenandoah	122,700	132,492	139,700	159,239	174,800	185,282	207,791	222,152	229,120	233,566
Northern Virginia	1,019,200	1,105,714	1,287,500	1,466,409	1,649,300	1,815,197	2,055,150	2,230,623	2,436,146	2,491,299
Rappahannock-Rapidan	83,300	92,897	100,700	116,524	125,700	134,785	153,839	166,054	171,228	174,369
Thomas Jefferson	135,600	143,597	152,400	164,210	182,700	199,648	217,980	234,712	248,500	253,174
Region 2000 Local Government Council	184,300	194,178	198,900	206,226	220,500	228,616	237,660	252,634	259,900	261,208
West Piedmont	202,800	205,239	202,000	199,288	202,500	202,909	194,900	193,023	190,545	186,811
Southside	83,700	82,768	82,000	81,258	85,600	88,149	87,273	86,402	84,304	83,060
Commonwealth Regional Council	82,400	83,549	84,100	84,905	91,900	97,102	100,148	104,609	104,667	103,451
Richmond Regional	585,700	632,015	671,700	739,735	811,600	865,941	938,519	1,002,696	1,054,636	1,074,374
George Washington	96,800	118,674	133,900	170,410	208,900	241,044	301,102	327,773	350,535	360,264
Northern Neck	39,500	40,950	41,700	44,173	48,100	49,353	49,690	50,429	50,361	50,078
Middle Peninsula	55,300	59,987	66,900	73,023	79,700	83,684	86,823	90,826	91,248	91,199
Crater	161,100	161,959	158,600	156,457	162,300	167,129	168,866	173,463	174,732	173,056
Accomack-Northampton	46,000	45,893	44,800	44,764	48,400	51,398	48,263	45,553	45,692	45,041
Hampton Roads	1,147,500	1,187,846	1,290,300	1,416,443	1,493,100	1,533,739	1,594,054	1,622,394	1,681,88	1,685,483
Total	5,056,000	5,346,818	5,715,200	6,187,358	6,696,000	7,079,030	7,600,467	8,001,024	8,382,993	8,470,020

[a] Aggregated from numbers reported by the Weldon Cooper Center for Public Service (undated, 1993, 2003, 2011, 2019a).

The results show that the populations of the Hampton Roads and Northern Virginia districts together made up 44.5% of Virginia's total population in 1975. By 2017, these two districts accounted for 50.3% of Virginia's total population, which itself had grown by nearly 68% since 1975. Even with Virginia's population undergoing significant growth, these two districts maintained the same portion of the state's population, although this was mostly due to large growth in Northern Virginia's population, rather than in Hampton Roads' population. As shown in Figures 3 and 4, Northern Virginia had a 144% increase in population from 1975-2017. Northern Virginia had the second largest relative increase in population from 1975-2017, behind Fredericksburg, with the latter's 2017 population being 2.44 times that of 1975. As shown in Figure 3, Bristol was the only district to show a decrease in population from 1975-2017, where the 2017 population had dropped 3.4% compared to the 1975 population (i.e., its ratio of 2017/1975 was 0.966). In addition, Figure 5 shows that nearly all VDOT districts had a larger average annual growth rate from 1975-2000 than from 2000-2017. The only exception was Lynchburg, for which the average annual growth rate was nearly equivalent in the two periods. Fredericksburg nearly doubled its average annual growth rate from 1975-2000, as it did from 2000-2017.

In 1975, the Hampton Roads and Northern Virginia PDCs accounted for 43.0% of the state's population, and by 2017 this had increased to 49.3%. The average annual growth rates of PDCs varied a bit more than did those of VDOT districts; however, the majority of PDCs still had larger annual growth rates from 1975-2000 than from 2000-2017, as shown in Figure 6.

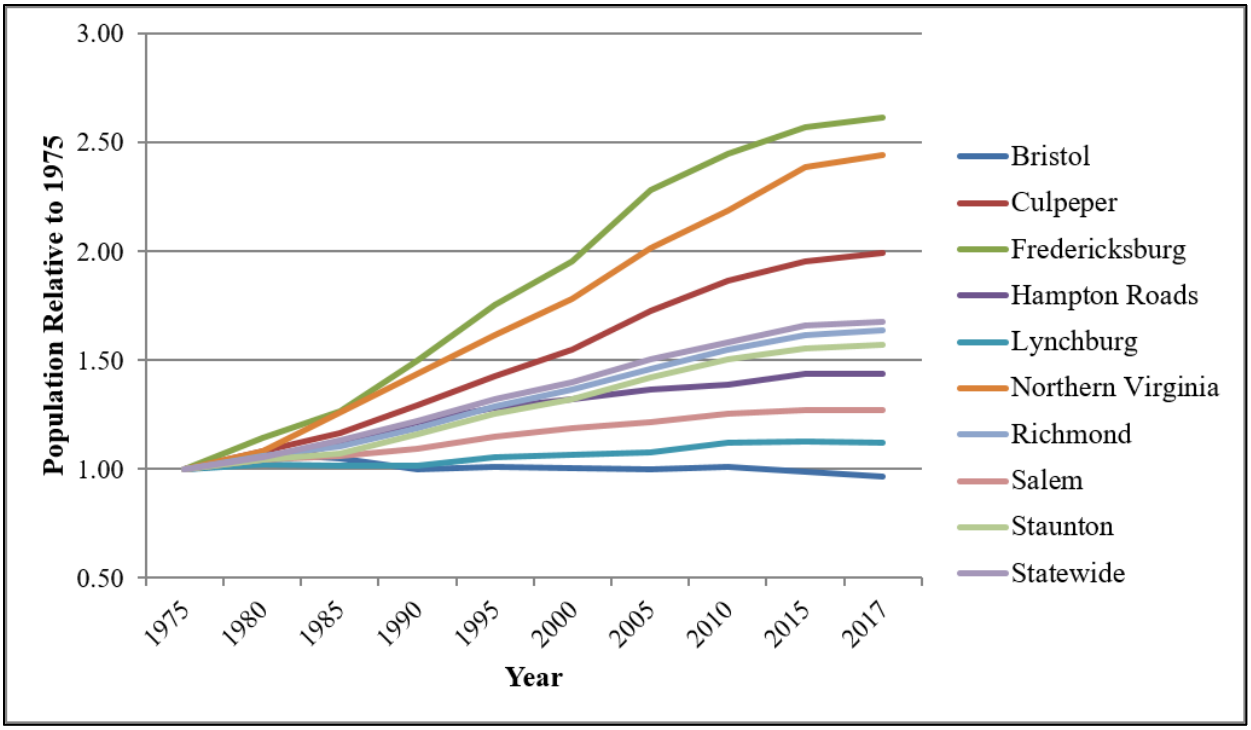


Figure 3. Relative Change in Population, 1975-2017, by VDOT District. For example, the population of the Northern Virginia District of 1,019,200 in 1975 increased by a factor of 2.444 to 2,491,299 in 2017.

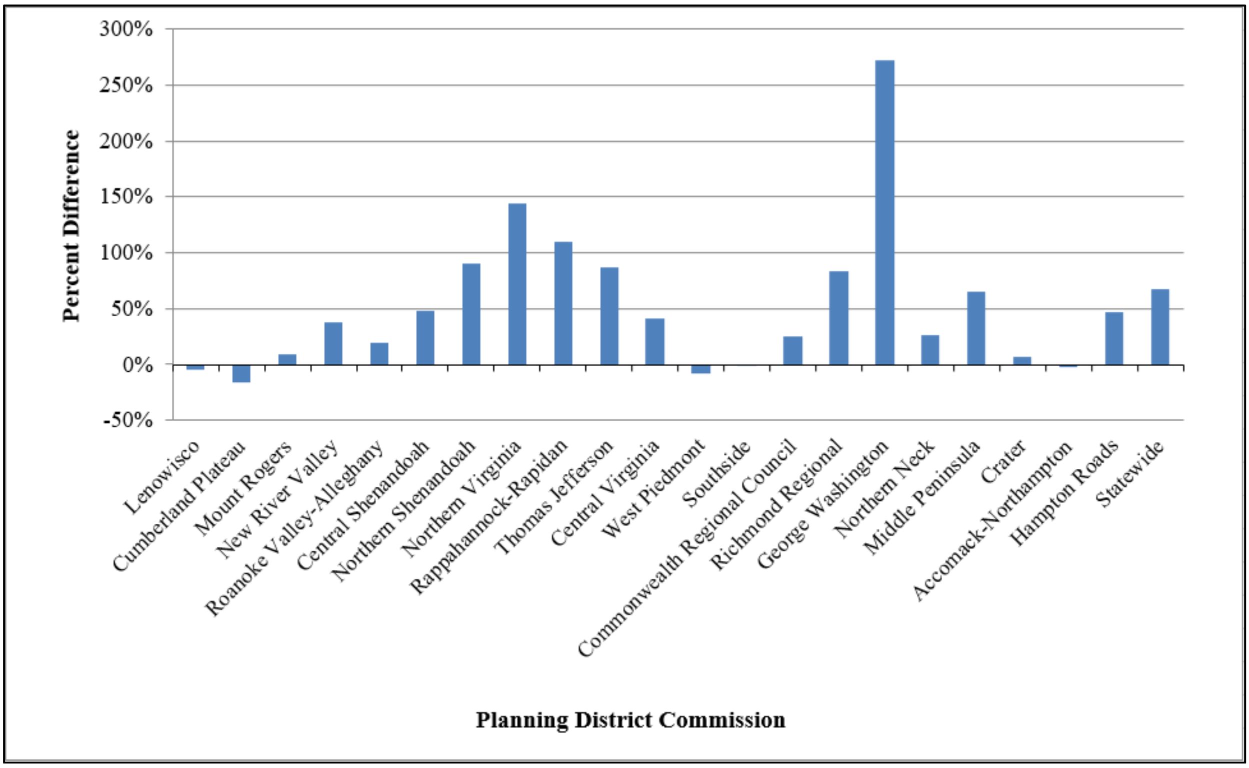


Figure 4. Percent Difference in Population, 2017-1975, by PDC. For example, the population of the Northern Virginia PDC of 1,019,200 in 1975 increased to 2,491,299 in 2017, with a percent difference of [(2,491,299 - 1,019,200) / 1,019,200] * 100 = 144%. PDC = planning district commission.

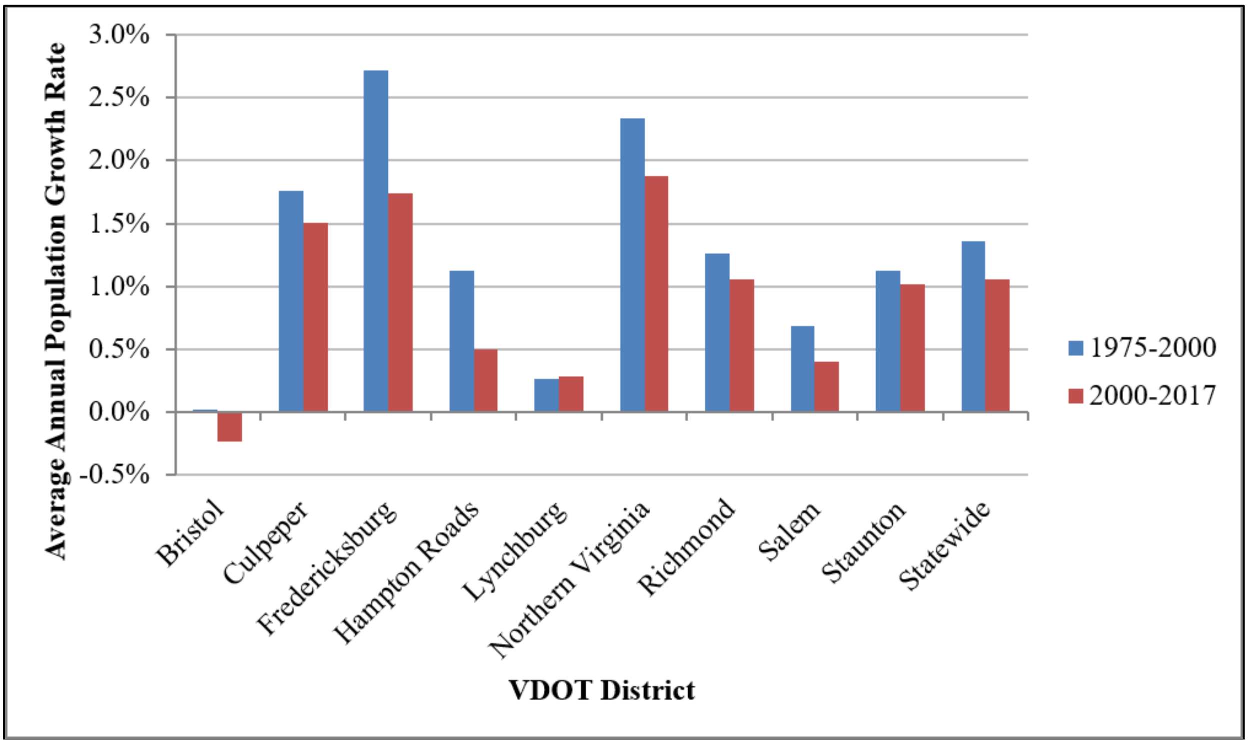


Figure 5. Average Annual Population Growth Rate, 1975-2017, by VDOT District. For example, the population of the Hampton Roads District was 1,226,800 in 1975. With an average annual growth rate of 1.123%, the population in 2000 was 1,226,800 * $(1.01123)^{25}$ ≈ 1,621,695. With an average annual growth rate of 0.503% for 2000-2017, the 2017 population was 1,621,695 * $(1.00503)^{17}$ ≈ 1,766,213.

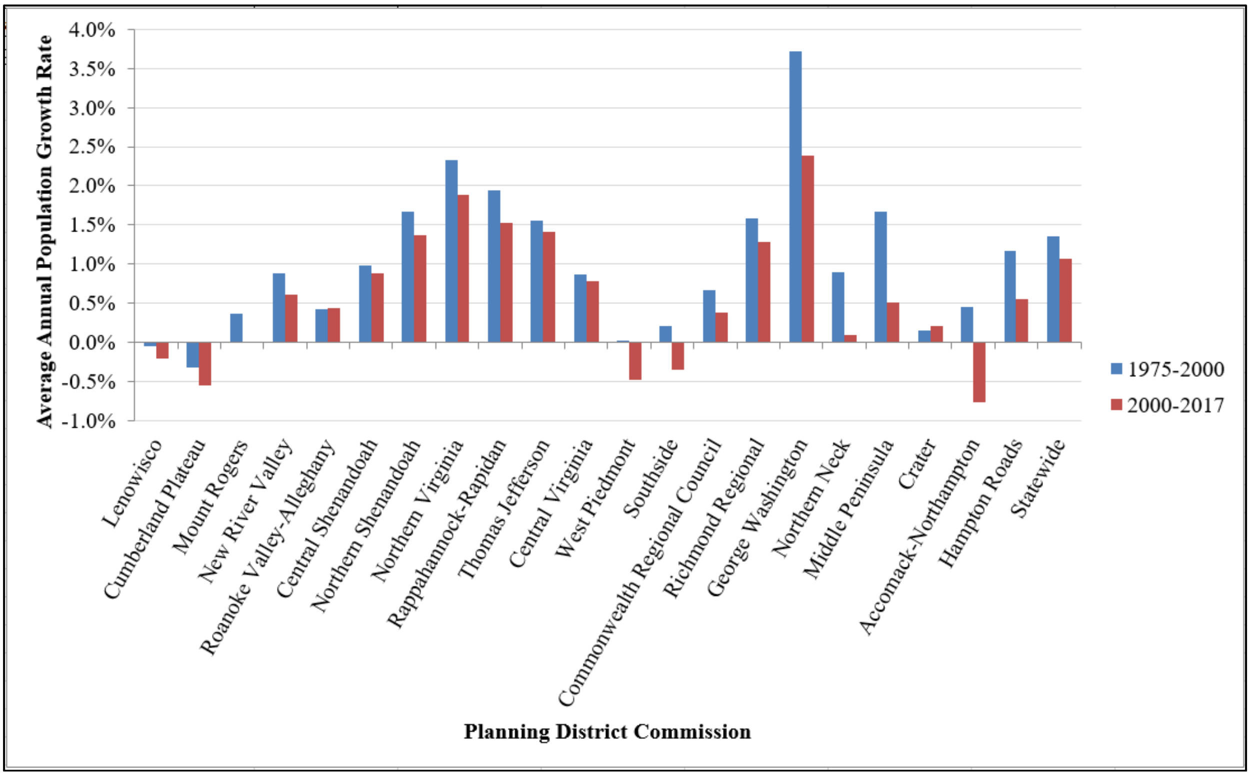


Figure 6. Average Annual Population Growth Rate, 1975-2017, by PDC. For example, the population of the Crater PDC was 161,100 in 1975. With an average annual growth rate of 0.147%, the population in 2000 was 161,100 * $(1.00147)^{25}$ ≈ 167,129. The next 17 years saw an average annual growth rate of 0.205% such that the population in 2017 was 167,129 * $(1.00205)^{17}$ ≈ 173,056. PDC = planning district commission.

George Washington in particular had the largest average annual growth rate of any PDC, as well as a 2017 population that was 3.72 times that of 1975. Although the majority of the PDCs had 2017 populations that showed a relative increase from their 1975 populations, five did not: Lenowisco (2017 population 0.992 times that of 1975), Cumberland Plateau (0.840 times), West Piedmont (0.921 times), Southside (0.992 times), and Accomack-Northampton (0.979 times). These five PDCs accounted for only 11% of Virginia's total 1975 population and 6% of Virginia's 2017 population. The lack of growth in these PDCs manifests in the previously mentioned northward shift in population (Sen, 2017b).

For the period 1970-2010, the geographic center of Virginia's population moved steadily northward from the northern boundary of the City of Richmond (in 1970) to Hanover County (in 1990) to Caroline County (in 2010), with a forecast center of Fredericksburg in 2040 (Sen, 2017b). Part of this trend can be explained by the increased share of the population attributable to Northern Virginia and the reduced share of the population attributable to Southwest Virginia and the central portion of Virginia. In 1975, the population of three VDOT districts (Bristol, Salem, and Lynchburg) accounted for 25% of Virginia's population, easily surpassing Northern Virginia's share at 20% (Weldon Cooper, undated). By 2017, these percentages were reversed: Northern Virginia held 29% of Virginia's population, whereas Bristol, Salem, and Lynchburg combined had a 17% share (Weldon Cooper, 2019a). Further, as pointed out by Sen (2017b), for the period 1970-present, the rate of growth in Northern Virginia exceeded those in Hampton Roads and Richmond.

Current Virginia Population (2017)

Virginia's population is unevenly distributed: 3 of Virginia's 21 PDCs (Northern Virginia, Richmond Regional, and Hampton Roads) and three of VDOT's nine districts (Northern Virginia, Richmond, and Hampton Roads) account for two-thirds of its current population (63% and 66%, respectively; Figures 7 and 8). Of Virginia's 133 cities and counties, 10 account for almost one-half (48%) of the state's population, and these jurisdictions are located in the 3 most populous PDCs: Northern Virginia, Richmond Regional, and Hampton Roads (Tables 8 and 9). The 11th most populous jurisdiction in Virginia (Newport News, with 2% of Virginia's population) is roughly equal to or exceeds the population of 12 of Virginia's 21 PDCs. Fairfax County alone accounts for 14% of Virginia's population.

Within these 3 most populous PDCs, there remains substantial disparity by jurisdiction. Fairfax County accounts for 46% of the Northern Virginia PDC's population. Chesterfield County (32%) and Henrico County (30%) are the highest contributors to the Richmond Regional PDC's population, followed by Richmond City (21%). The jurisdiction with the greatest share of the Hampton Roads PDC's population is Virginia Beach City (27%). The 2017 population estimates for the regions in Virginia acquired from Weldon Cooper (2018) and Woods & Poole (2018b) show similar results, except the latter aggregates Fairfax County, Fairfax City, and Falls Church into a single jurisdiction.

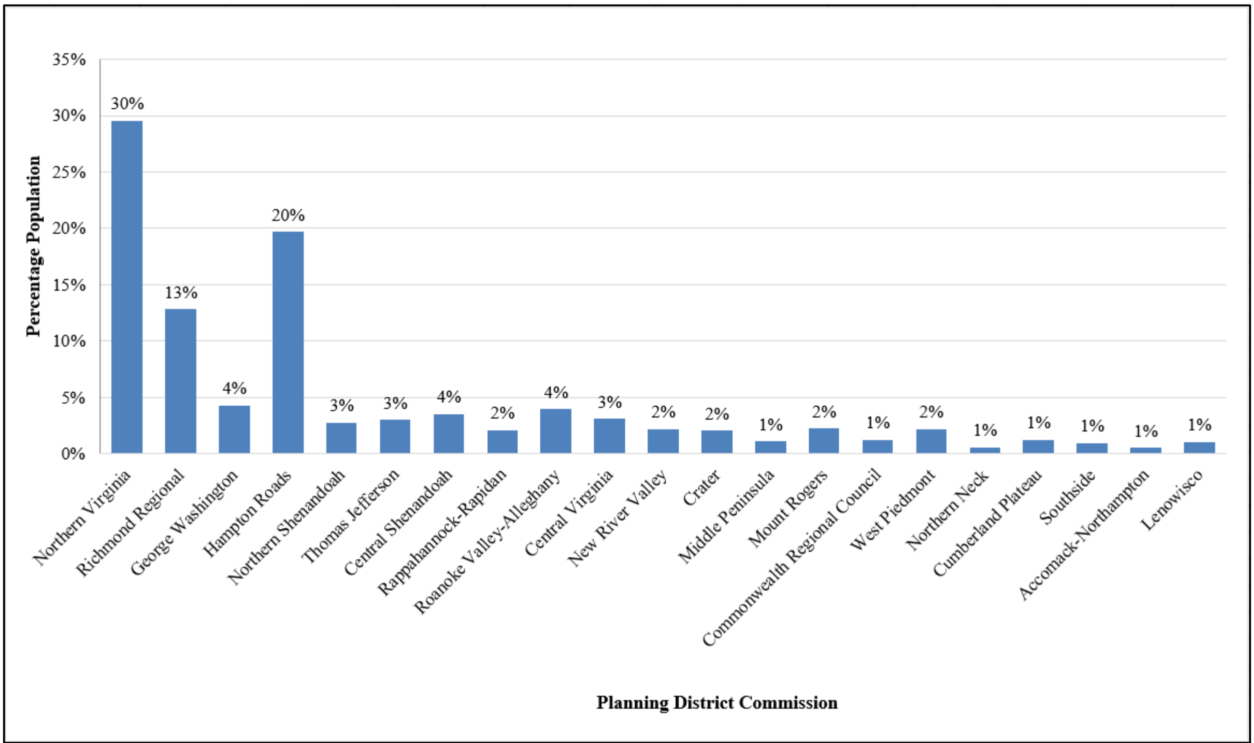


Figure 7. Relative Population of Virginia PDCs. Based on data obtained from the Weldon Cooper Center for Public Service (2018). For example, in 2017, the total Virginia population was 8,470,020, of which 235,443 resided in the Northern Shenandoah PDC (Weldon Cooper Center for Public Service, 2018), which is approximately 3% of Virginia's 2017 population. PDC = planning district commission.

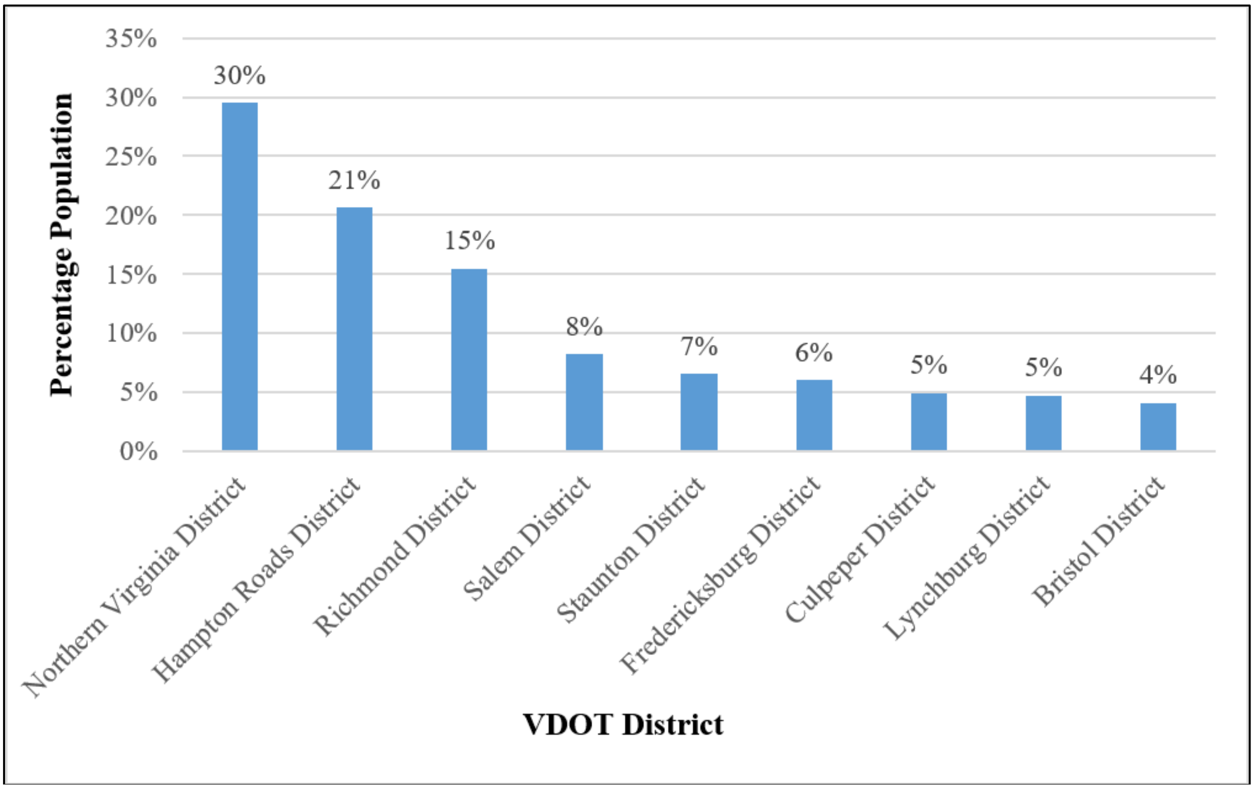


Figure 8. Relative Population of VDOT Districts. Based on data from the Weldon Cooper Center for Public Service (2018). For example, in 2017, the total Virginia population was 8,470,020, of which 345,314 resided in the Bristol District (Weldon Cooper Center for Public Service, 2018), which is approximately 4% of Virginia's 2017 population.

Table 8. Relative Distribution of Population by Jurisdiction for Virginia's Three Most Populous PDCs

PDC[a]	Jurisdiction	% PDC's Population[b c]	% Virginia's Population[b c]
Northern Virginia	Arlington County	9%	3%
	Fairfax County	46%	14%
	Loudoun County	16%	5%
	Prince William County	19%	5%
Richmond Regional	Chesterfield County	32%	4%
	Henrico County	30%	4%
	Richmond City	21%	3%
Hampton Roads	Chesapeake City	14%	3%
	Hampton City	8%	2%
	Newport News City	11%	2%
	Norfolk City	15%	3%
	Virginia Beach City	27%	5%

PDC = planning district commission.
[a] These three PDCs account for 30%, 20%, and 13%, respectively, of Virginia's current population.
[b] Tabulated based on data from the Weldon Cooper Center for Public Service (2018).
[c] Similar percentages are given by Woods & Poole (2018b) except that Henrico County has 31%, rather than 30%, of Richmond Regional's population.

Table 9. Relative Distribution of Population by Jurisdiction for Virginia's Three Most Populous Districts

District	Jurisdiction	% District Population	% Virginia Population
Northern Virginia	Fairfax County	46%	14%
	Prince William County	19%	5%
	Loudoun County	16%	5%
	Arlington County	9%	3%
	Alexandria City	6%	2%
Hampton Roads	Virginia Beach City	26%	5%
	Norfolk City	14%	3%
	Chesapeake City	14%	3%
	Newport News City	10%	2%
	Hampton City	8%	2%
	Portsmouth City	5%	1%
	Suffolk City	5%	1%
Richmond	Chesterfield County	26%	4%
	Henrico County	25%	4%
	Richmond City	17%	3%
	Hanover County	8%	1%

Source: Data obtained from Weldon Cooper Center for Public Service (2018).

Table 9 shows that within the three most populous districts, there remains substantial disparity by jurisdiction. In the Northern Virginia District, Fairfax County alone has 46% of the population. In the second most populous district (Hampton Roads), 3 of the 14 jurisdictions—Virginia Beach City, Norfolk, and Chesapeake—contribute 54% of the total population. In the Richmond Regional PDC, Chesterfield County (with 26% of the population) and Henrico County (with 25%) each contribute more people to the total district population than does the state's capital city (Richmond) with a 17% share. These numbers are approximately equal in the 2017 population estimates from Weldon Cooper (2018) and Woods & Poole (2018b).

Forecast Population (2045)

According to Weldon Cooper (2017a), Virginia's population is forecast to increase 24% by 2045; the forecast by Woods & Poole shows a 33% increase (Tables 10 and 11). Figure 9 shows that 15 of Virginia's 21 PDCs are forecast to see their population increase from 2017-2045, with the greatest relative increases occurring in the George Washington (47%), Northern Virginia (42%), Thomas Jefferson (31%), Rappahannock-Rapidan (29%), Northern Shenandoah (26%), Richmond Regional (26%), and Central Shenandoah PDCs (20%). Declines in population are forecast for almost one-third (6) of Virginia's 21 PDCs, including Accomack-Northampton (a 22% population decrease), Cumberland Plateau (14%), West Piedmont (13%), Southside (10%), Mount Rogers (3%), and Lenowisco (1%). Forecasts from Woods & Poole show that just 1 PDC (Southside) is forecast to have a population decline (4%) from 2017-2045. All other PDCs are forecast to have an increase. For the 3 most populous PDCs combined (Northern Virginia, Richmond Regional, and Hampton Roads), population is expected to grow 30% (Weldon Cooper, 2017a) or 39% (Woods & Poole, 2018b).

The 2017 populations are indeed estimates such that Woods & Poole (2018b) and Weldon Cooper (2017a) show slight differences; for example, for the Lenowisco PDC, these two sources report 2017 populations of 93,105 and 92,892, respectively, for a difference of about 1.4%. Overall, the 2017 populations varied between these sources by an average of 0.6%. There are also slight differences for the 2000 values from these two sources, with an average of 0.4%. Both sources used a July 1 date, and generally PDC and VDOT district boundaries should not have been affected by geographic annexations.

Table 10. Forecast Population Change by PDC[a, b]

PDC	Population 2000[a]	Population 2017[a]	2045 Population		Net Growth (2017-2045)		Percent Growth (2017-2045)	
			Weldon Cooper[a]	Woods & Poole[b]	Weldon Cooper[a]	Woods & Poole[b, c]	Weldon Cooper[a]	Woods & Poole[b, c]
Lenowisco	93,105	88,145	87,537	93,049	-608	4,904	-0.7%	5.6%
Cumberland Plateau	117,229	104,439	90,196	108,534	-14,243	4,095	-13.6%	3.9%
Mount Rogers	188,984	189,063	182,897	204,837	-6,166	15,774	-3.3%	8.3%
New River Valley	165,146	182,993	208,993	202,913	26,000	19,920	14.2%	10.9%
Roanoke Valley-Alleghany	311,827	334,781	365,274	386,317	30,493	51,536	9.1%	15.4%
Central Shenandoah	258,763	299,042	358,808	372,547	59,766	73,505	20.0%	24.6%
Northern Shenandoah	185,282	235,443	297,472	307,533	62,029	72,090	26.3%	30.6%
Northern Virginia	1,815,197	2,501,308	3,546,256	3,870,499	1,044,948	1,369,191	41.8%	54.7%
Rappahannock-Rapidan	134,785	177,418	228,219	251,646	50,801	74,228	28.6%	41.8%
Thomas Jefferson	199,648	252,588	330,711	323,373	78,123	70,785	30.9%	28.0%
Central Virginia	222,317	261,254	306,881	325,873	45,627	64,619	17.5%	24.7%
West Piedmont	202,909	184,422	160,864	192,144	-23,558	7,722	-12.8%	4.2%
Southside	88,149	81,493	72,959	78,681	-8,534	-2,812	-10.5%	-3.5%
Commonwealth Regional Council	97,102	102,387	112,874	111,130	10,487	8,743	10.2%	8.5%
Richmond Regional	865,941	1,084,424	1,366,353	1,503,263	281,929	418,839	26.0%	38.6%
George Washington	241,044	364,840	535,363	613,297	170,523	248,457	46.7%	68.1%
Northern Neck	49,353	49,782	49,953	55,290	171	5,508	0.3%	11.1%
Middle Peninsula	83,684	91,489	100,294	109,228	8,805	17,739	9.6%	19.4%
Crater	167,129	173,092	181,355	174,268	8,263	1,176	4.8%	0.7%
Accomack-Northampton	51,398	44,391	34,765	45,700	-9,626	1,309	-21.7%	2.9%
Hampton Roads	1,533,739	1,667,226	1,910,793	1,953,027	243,567	285,801	14.6%	17.1%
Virginia (Total)	7,079,030	8,470,020	10,528,817	11,283,149	2,058,797	2,813,129	24.3%	33.2%

[a] Tabulated based on data from the Weldon Cooper Center for Public Service (2011, 2017a, 2018).
[b] Tabulated based on data from Woods & Poole (2018b).
[c] Tabulated based on 2045 Woods & Poole (2018b) and 2017 Weldon Cooper (2018). For example, Lenowisco had a 2017 population of 88,145 and a 2045 forecast of 93,049 with a difference of 4,904 and an increase of 5.6%.

Table 11. Forecast Population Change by VDOT District[a]

District	Population 2000[a]	Population 2017[a]	2045 Population		Net Growth (2017-2045)		% Growth (2017-2045)	
			Weldon Cooper[a]	Woods & Poole[b]	Weldon Cooper[a]	Woods & Poole[b, c]	Weldon Cooper[a]	Woods & Poole[b, c]
Bristol	363,236	345,314	325,987	364,412	-19,327	19,098	-5.6%	5.5%
Salem	642,661	693,462	752,932	822,009	59,470	128,547	8.6%	18.5%
Lynchburg	380,728	396,872	423,421	425,827	26,549	28,955	6.7%	7.3%
Richmond	1,087,582	1,310,261	1,596,976	1,732,422	286,715	422,161	21.9%	32.2%
Hampton Roads	1,621,695	1,746,491	1,980,157	2,033,689	233,666	287,198	13.4%	16.4%
Fredericksburg	374,081	506,111	685,611	777,815	179,500	271,704	35.5%	53.7%
Culpeper	319,988	415,063	543,665	558,203	128,602	143,140	31.0%	34.5%
Staunton	467,563	555,138	673,812	698,273	118,674	143,135	21.4%	25.8%
Northern Virginia	1,815,197	2,501,308	3,546,256	3,870,499	1,044,948	1,369,191	41.8%	54.7%
Virginia (Total)	7,079,030	8,470,020	10,528,817	11,283,149	2,058,797	2,813,129	24.3%	33.2%

[a] Tabulated based on data from the Weldon Cooper Center for Public Service (2011, 2017a, 2018).
[b] Tabulated based on data from Woods & Poole (2018b).
[c] Tabulated based on 2045 Woods & Poole (2018b) and 2017 Weldon Cooper (2018). For example, the Bristol District had a 2017 population of 345,314 and a 2045 forecast population of 364,412 with a difference of 19,098 and an increase of 5.5%.

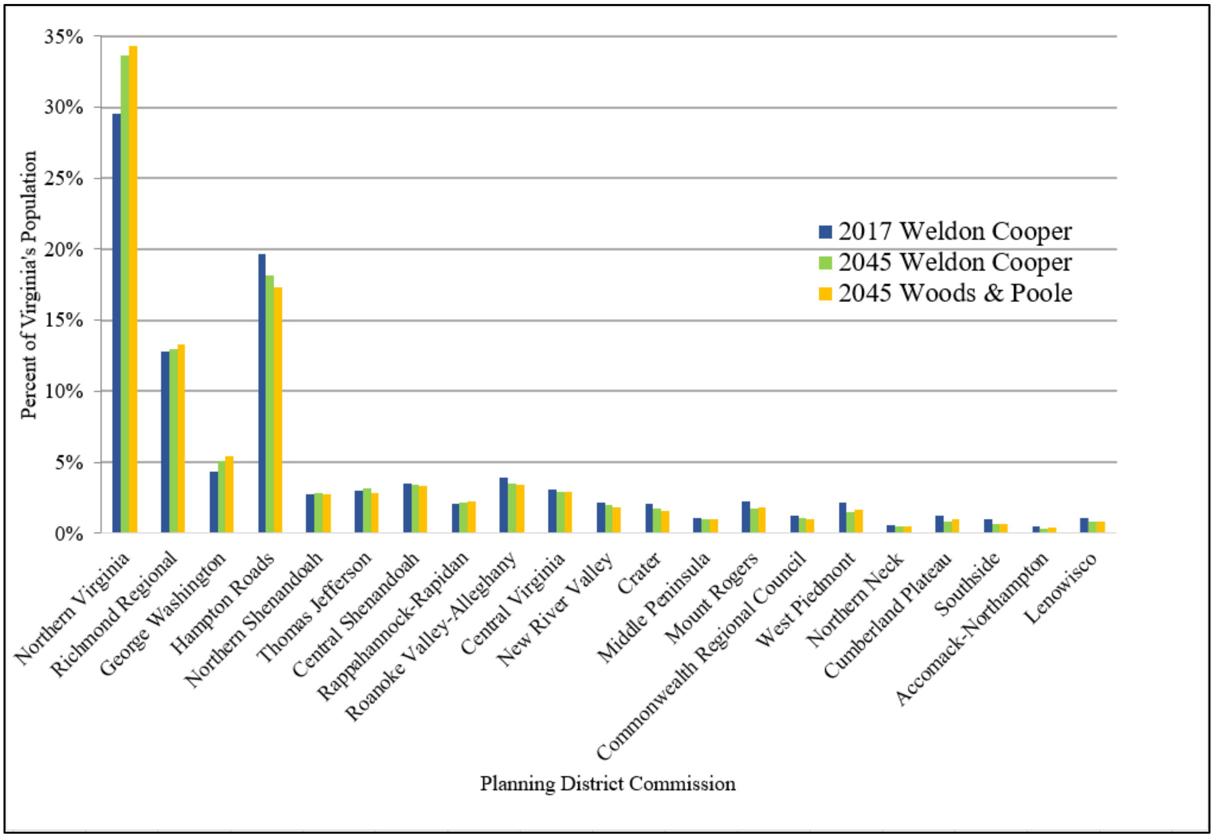


Figure 9. Share of Virginia Population by PDC for 2017 (Estimate) and 2045 (Forecast). Based on data from the Weldon Cooper Center for Public Service (2017a, 2018) and Woods & Poole (2018b). For example, in 2017, the total Virginia population was 8,470,020, of which 88,145 resided in the Lenowisco PDC (Weldon Cooper Center for Public Service, 2018), which is approximately 1% of Virginia's 2017 population. For 2045, the projected total Virginia population is 10,528,816, of which 88,145 would reside in the Lenowisco PDC (Weldon Cooper Center for Public Service, 2045), which is approximately 1% of Virginia's 2045 population. Based on Woods & Poole (2018b), for 2045, the projected total Virginia population is 11,283,149, of which 93,049 would reside in the Lenowisco PDC, which is approximately 1% of Virginia's 2045 population. PDC = planning district commission.

Figure 10 shows that all VDOT districts except Bristol are forecast to have an increase in population; for Bristol, Weldon Cooper shows a 6% decline in population (2017-2045) and Woods & Poole shows an increase of 4%.

Table 12 compares forecasts from Weldon Cooper (2017a) and forecasts used by George Washington, which were provided to the research team (Bentley, 2019). The latter source gives higher forecasts for the two largest counties in Table 12 (Stafford and Spotsylvania); the former source has higher forecasts for the remaining three jurisdictions (Caroline County, King George County, and the City of Fredericksburg). Because Spotsylvania and Stafford have a majority of the region's population, the fact that George Washington has a higher forecast for just those two counties leads to George Washington having a higher forecast for the entire region. In terms of explaining the source of the 8.61% difference between the regional population totals in Table 12, it should be noted that roughly four-fifths of the difference can be attributed to different forecasts for Spotsylvania. That is, if Weldon Cooper had the same forecast for Spotsylvania as George Washington had, there would be less than a 2% difference in the regional totals for 2045, rather than an 8.61% difference, as shown in Table 12. It should be noted that the percent difference shown to the right in the table is largest for a relatively large county (Spotsylvania) rather than a smaller jurisdiction (e.g., Caroline or Fredericksburg). Reasons for this uncertainty may be the fact that Spotsylvania is a fast growing county (a 10% increase in population over the past decade) and its proximity to the Northern Virginia economy (Tribbitt, 2018).

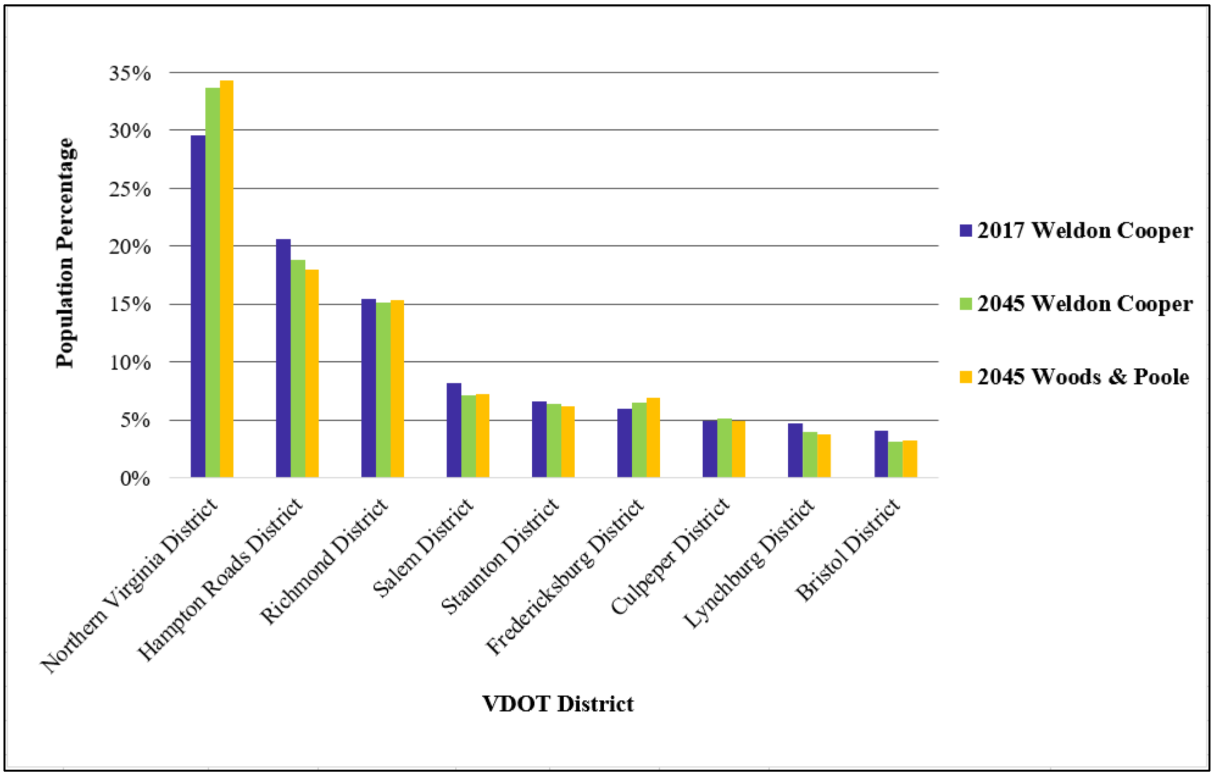


Figure 10. 2045 Population Forecasts and 2017 Population Estimates for VDOT Districts. Based on data from the Weldon Cooper Center for Public Service (2017a, 2018) and Woods & Poole (2018b). For example, in 2017, the total Virginia population was 8,470,020, of which 415,063 resided in the Culpeper District (Weldon Cooper Center for Public Service, 2018), which is approximately 5% of Virginia's 2017 population. For 2045, the projected total Virginia population is 10,528,817, of which 543,665 would reside in the Culpeper District (Weldon Cooper Center for Public Service, 2017a), which is approximately 5% of Virginia's 2045 population.

Table 12. Comparison of Population Forecasts for Year 2045

Jurisdiction	George Washington (Bentley, 2019)	Weldon Cooper (2017a)	% Difference[a]
Fredericksburg	38,622	40,944	6.01%
Stafford	243,407	222,554	8.57%
Spotsylvania	232,364	192,503	17.15%
Caroline	38,560	42,177	9.38%
King George	32,866	37,185	13.14%
Total	585,819	535,363	8.61%

[a] Calculated using the George Washington 2045 forecast as the denominator.

Population Distribution by Age (2017-2045)

From 2017-2045, the proportion of Virginians statewide under age 20 is forecast to remain relatively constant at about 24% to 25%. However, a shift is forecast for Virginians from the age 20-64 group to the age 65+ group: the younger group may decrease from 60% of the total population (2017) to 56% of the population (2045), accompanied by persons age 65+ increasing from 15% of the population (2017) to 19% to 20% of the population (2045), as shown in Table 13. The percentage of persons age 65+ in Virginia is thus expected to increase 56%, from 1.27 million (in 2017) to 1.99 million (in 2045) based on Weldon Cooper (2018, 2017a, 2017b); Woods & Poole (2018b) shows a larger increase of 78%.

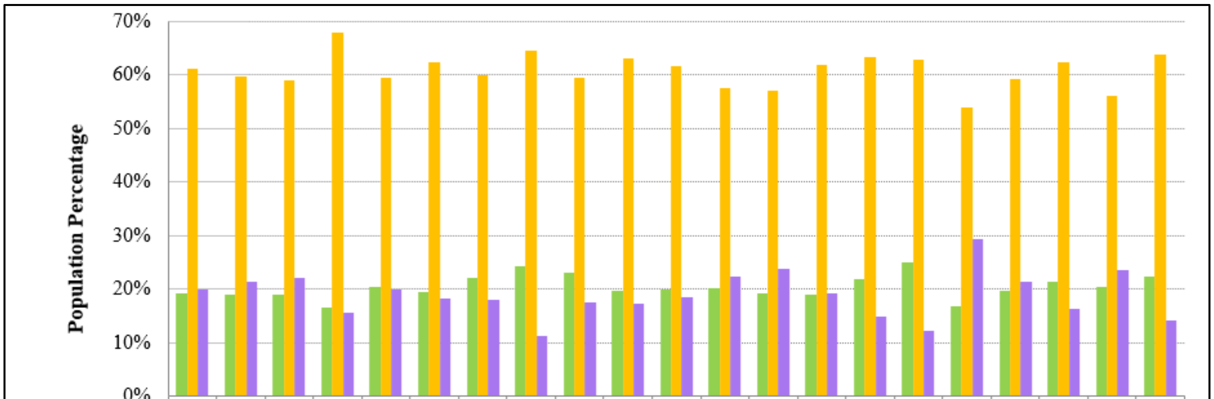
For the older portion of the age 65+ cohort, the change is more dramatic on a percentage basis. The population of Virginians age 75+ is forecast to double almost, from 0.5119 million (in 2017) to 1.013 million (in 2040) (Weldon Cooper, 2017b), for a percent growth rate of 98%; for year 2045, the research team interpolates the 2045 value as 1.045 million, for a growth rate of 104%. For 2045, Woods & Poole (2018b) suggest a much higher growth rate in the 75+ population of 150%—that is, increasing from 0.51 million in 2017 to 1.28 million in 2045.

Figure 11 (U.S. Census Bureau, 2018a) suggests that there is substantial variation in the percentage of persons age 65+ by PDC, with values ranging from 11% of persons age 65+ (Northern Virginia PDC) to 29% (Northern Neck PDC). The proportion of persons age 65+ is lowest in the four most populated, and arguably the most urban, PDCs: Northern Virginia (11%), George Washington (12%), Hampton Roads (14%), and Richmond Regional (15%). Currently, higher percentages of persons age 65+ tend to reside in the less populated PDCs (e.g., Lenowisco with 20% and Southside with 24%). Less variation is found in the proportion of persons under age 18, which ranges from 17% (Northern Neck PDC) to 25% (George Washington PDC). Figure 11 uses the age group "under 18" rather than "under 20" because of the way in which the 2017 data are presented in summary form by the U.S. Census Bureau (2018a); Figure 12 shows the results by VDOT district.

Table 13. Relative Population Distribution by Age Group for 2000, 2017, 2040, and 2045

Age Group	2000[a]	2017[a, b]	2040[b]	2045[a]
Under 20	27%	25%	25%	24%
20-64	62%	60%	56%	56%
65+	11%	15%	19%	20%
75+	5%	6%	10%	11%

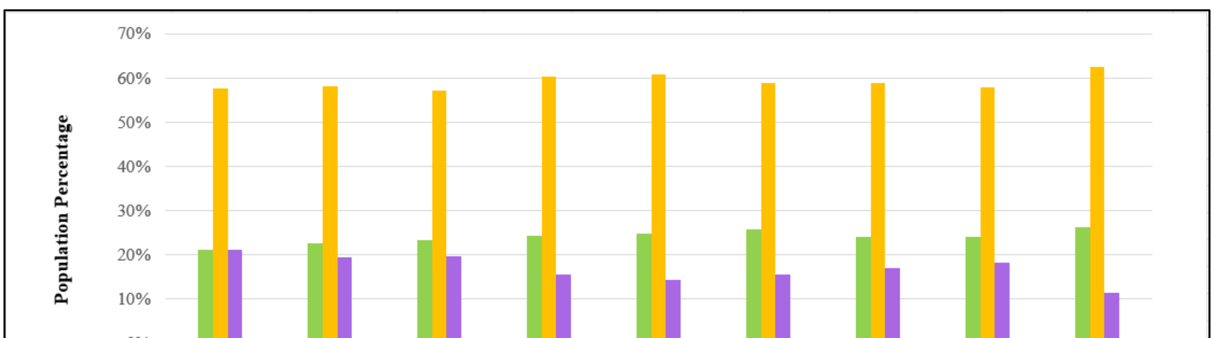
[a] Based on data from Woods & Poole (2018b).
[b] Based on data from the Weldon Cooper Center for Public Service (2017b) and the U.S. Census Bureau (2018a).



PDC No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	22	23
Under 18	19%	19%	19%	17%	20%	19%	22%	24%	23%	20%	20%	20%	19%	19%	22%	25%	17%	20%	21%	20%	22%
18-64	61%	60%	59%	68%	60%	62%	60%	65%	60%	63%	62%	58%	57%	62%	63%	63%	54%	59%	62%	56%	64%
65 and above	20%	21%	22%	16%	20%	18%	18%	11%	18%	17%	18%	22%	24%	19%	15%	12%	29%	21%	16%	24%	14%
	Lenowisco	Cumberland Plateau	Mount Rogers	New River Valley	Roanoke Valley-Alleghany	Central Shenandoah	Northern Shenandoah	Northern Virginia	Rappahannock-Rapidan	Thomas Jefferson	Central Virginia	West Piedmont	Southside	Commonwealth Regional Council	Richmond Regional	George Washington	Northern Neck	Middle Peninsula	Crater	Accomack-Northampton	Hampton Roads

Planning District Commission

Figure 11. Percent Population by Age for Virginia PDCs in 2017. Based on data from the U.S. Census Bureau (2018a). For example, the Mount Rogers PDC has 35,910 people under age 18 in its total population of 189,063. Thus, approximately 19% [(35,910/189,063) * 100] of the population is under age 18. PDC = planning district commission.



	Bristol District	Salem District	Lynchburg District	Richmond District	Hampton Roads District	Fredericks-burg District	Culpeper District	Staunton District	Northern Virginia District
Under 20	21%	23%	23%	24%	25%	26%	24%	24%	26%
20 - 64	58%	58%	57%	60%	61%	59%	59%	58%	62%
65 & above	21%	19%	20%	15%	14%	16%	17%	18%	11%

Figure 12. Percent Population by Age for VDOT Districts in 2017. Based on data from the U.S. Census Bureau (2018a). For example, the Lynchburg District has 92,433 people under age 20 in its total population of 396,872. Thus, approximately 23% [= (92,433/396,872) * 100] of the population is under age 20.

Figures 13 and 14 show forecast growth in the percentage of persons age 65+ by PDC and district, respectively. Of interest is that the PDCs and districts with relatively low proportions of persons age 65+ at present are forecast to see the greatest relative increases. Such forecasts suggest that rather than an extrapolation of current trends (e.g., persons age 65+ tending to reside in some of the same rural PDCs and districts), it is the urban PDCs and districts that will see the greatest change in the 65+ age group by 2045. For example, the number of persons age 65+ is forecast to double almost in the George Washington PDC: 111% forecast from Weldon Cooper (2017a, 2017b) and 168% forecast from Woods & Poole (2018b). With regard to the Northern Virginia PDC, the forecast is 92% from the former source and 132% from the latter source. By contrast, some of the PDCs with relatively large proportions of persons age 65+ at present (e.g., Northern Neck, Accomack-Northampton, and Southside) are forecast to see only modest increases or declines in the number of persons age 65+. The latter forecasts are higher than those of the former (see Figures 13 through 15).

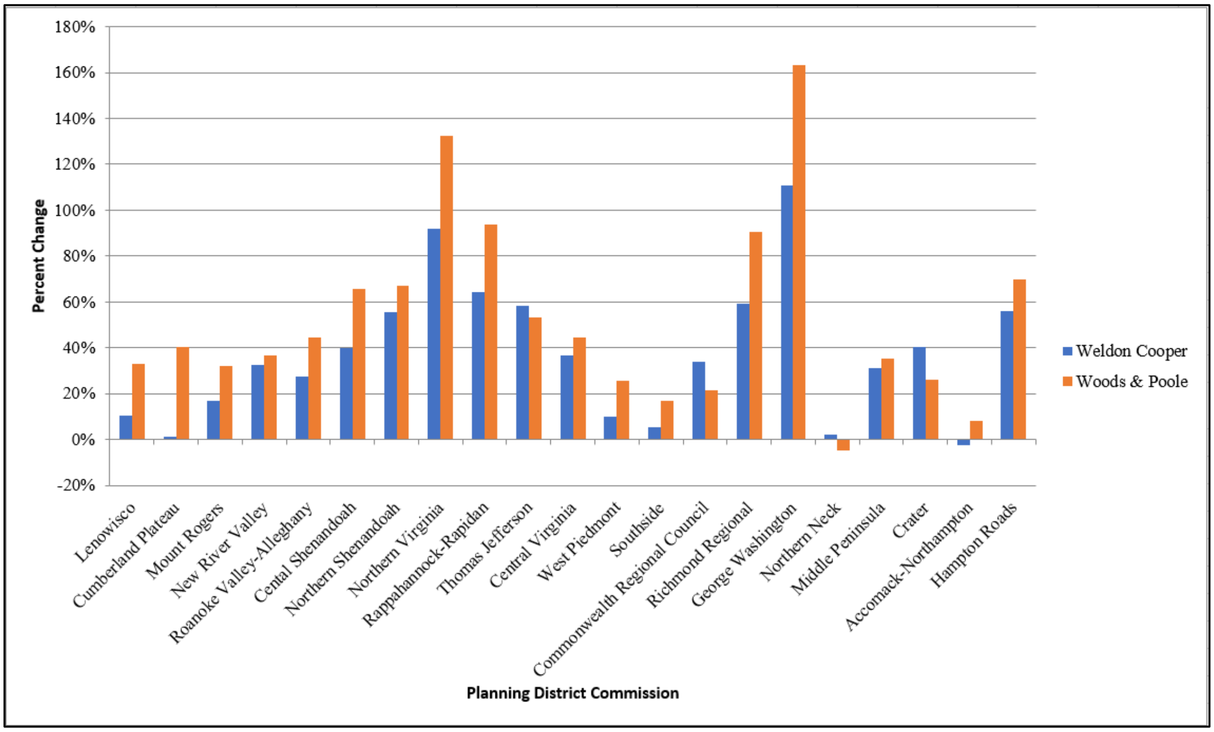


Figure 13. Forecast % Change in Population Age 65+ by PDC, 2017-2045. Based on data from the U.S. Census Bureau (2018a); Weldon Cooper Center for Public Service (2017b) [with interpolation by the research team using the method suggested by Cai (2018) and data from the Weldon Cooper Center for Public Service (2017a)]; and Woods & Poole (2018b). For example, for the Crater PDC, the population age 65+ was 28,370 in 2017 and is projected to increase to 39,805 by 2045 based on data from the Weldon Cooper Center for Public Service (2017a, b). Thus, there will be approximately 40% {[(39,805 - 28,370) / 28,370] * 100} growth in the population age 65+ from 2017-2045 based on those sources. PDC = planning district commission.

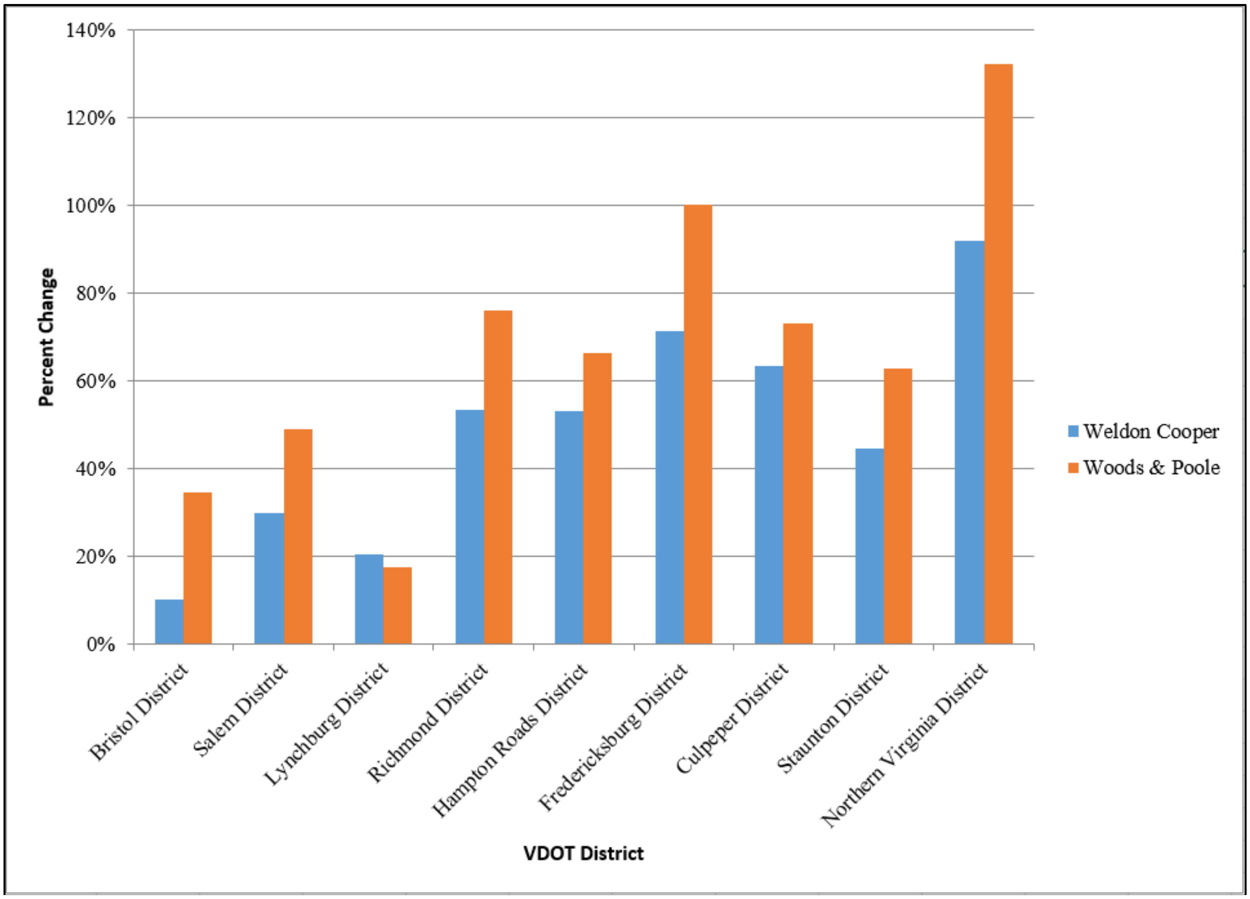


Figure 14. Forecast % Change in Population Age 65+ by VDOT District, 2017- 2045. Based on data from the U.S. Census Bureau (2018a); the Weldon Cooper Center for Public Service (2017b) [with interpolation by the research team using the method suggested by Cai (2018) and data from the Weldon Cooper Center for Public Service (2017a)]; and Woods & Poole (2018b). For example, for the Hampton Roads District, in 2017, the population age 65+ was 250,597 and is projected to increase to 383,636 by 2045 based on data from the Weldon Cooper Center for Public Service (2017a, b). Thus, there will be approximately 53% {[(383,636 - 250,597) / 250,597] * 100} growth in the population age 65+ in the Hampton Roads District from 2017-2045 based on those sources.

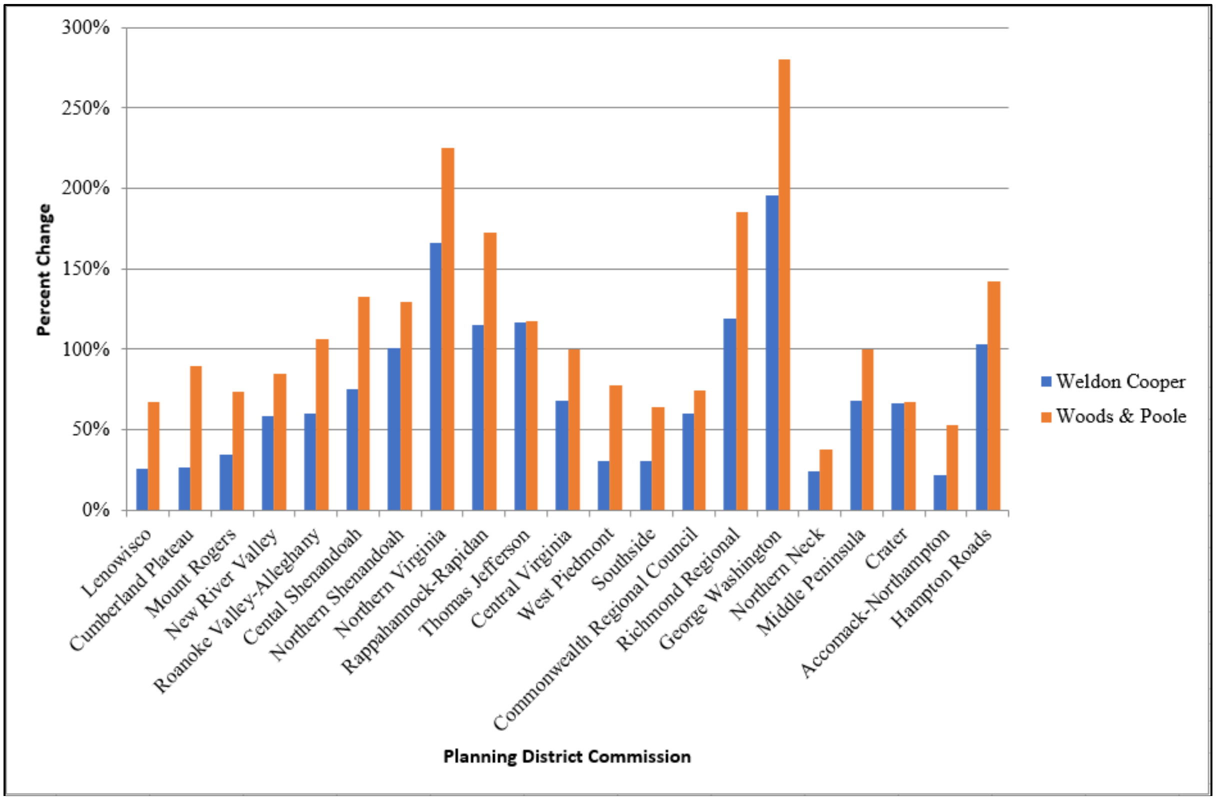


Figure 15. Forecast % Change in Population Age 75+ by PDC, 2017-2045. Based on data from the U.S. Census Bureau (2018a); the Weldon Cooper Center for Public Service (2017b) [with interpolation by the research team using the method suggested by Cai (2018) and the Weldon Cooper Center for Public Service (2017a)]; and Woods & Poole (2018b). For example, for the George Washington PDC, in 2017, the population age 75+ was 16,606 and is projected to increase to 49,159 by 2045 based on data from the Weldon Cooper Center for Public Service (2017a, b). Thus, there will be approximately 196% {[(49,159 - 16,606) / 16,606] * 100} growth in the population age 75+ in the George Washington PDC from 2017-2045 based on those sources. PDC = planning district commission.

Employment

Historical Employment Trends (1975-2017)

Tables 14 and 15 show employment by VDOT district and modified PDC based on the BLS (2018a). Several characteristics may not be surprising: in 1975, the PDC with the highest employment (Northern Virginia) had more than 50 times the employment of the PDC with the lowest employment (Northern Neck), and a similar ratio of 90:1 is observed for year 2017 for these 2 PDCs. The recession of 2007-2008 is evident in that Virginia's employment dropped from 2005-2010, and this drop, not surprisingly, occurred in 16 of Virginia's 21 PDCs: the exceptions and corresponding increases were Northern Neck (127 jobs), Lenowisco (1,432 jobs), Thomas Jefferson (2,945 jobs), George Washington (5,429 jobs), and Northern Virginia (25,557 jobs). Similar trends are observed at the district level: only three of VDOT's nine districts (Northern Virginia, Culpeper, and Fredericksburg) did not see a drop of employment from 2005-2010.

Table 14. Employment by VDOT District, 1975-2017[a, b]

District	1975	1980	1985	1990	1995	2000	2005	2010	2015	2017
Bristol	79,297	108,464	106,612	117,430	124,085	125,571	126,738	123,847	116,696	114,088
Culpeper	54,226	78,836	87,884	107,118	114,377	132,158	144,906	145,679	159,612	165,542
Fredericksburg	26,947	54,448	64,067	82,421	97,166	120,592	138,593	142,413	151,326	157,169
Hampton Roads	343,610	459,889	536,886	615,454	645,320	719,156	754,134	727,600	751,128	763,215
Lynchburg	103,824	133,494	134,535	145,334	153,235	164,474	154,995	146,707	150,836	152,028
Northern Virginia	289,711	446,235	597,681	759,924	819,531	1,008,277	1,101,677	1,127,234	1,187,488	1,221,898
Richmond	305,016	391,106	421,701	496,556	520,715	578,460	594,115	578,090	626,559	644,602
Salem	167,444	217,852	238,812	267,220	280,606	295,040	284,596	269,676	280,786	281,287
Staunton	102,888	138,619	143,412	168,873	183,317	210,002	218,140	208,972	220,915	227,589
Total	1,472,963	2,028,943	2,331,590	2,760,330	2,938,352	3,353,730	3,517,894	3,470,218	3,645,346	3,727,418
Percent missing[b]	4.1%	2.3%	2.4%	2.4%	2.3%	2.1%	1.7%	1.9%	2.4%	2.9%

[a] Aggregated from numbers reported by the Bureau of Labor Statistics (2018b).

[b] Percent missing reflects jobs not located in any district but that are part of the statewide total. For example, in 1985, the sum of all jobs in VDOT districts was 2,331,590. The reported statewide total for Virginia was 2,388,355. The difference (56,765) reflects 2.4% of the statewide total of 2,388,355. The jobs categorized as "Unknown or Undefined, Virginia" reflect most (55,174) but not all of this difference (56,765).

Table 15. Employment by Modified Planning District Commission, 1975-2017[a, b]

Planning District Commission	1975	1980	1985	1990	1995	2000	2005	2010	2015	2017
Lenowisco	16,290	23,585	23,593	25,250	26,632	26,523	28,319	29,751	25,212	24,115
Cumberland Plateau	27,253	37,701	34,349	35,931	35,766	35,602	35,654	35,489	32,860	31,578
Mount Rogers	45,272	59,344	60,891	70,718	77,207	79,012	76,792	71,014	71,172	70,983
New River Valley	37,465	49,393	54,027	58,950	60,938	67,541	67,767	63,786	69,153	69,250
Roanoke Valley-Alleghany	91,500	114,767	127,360	141,926	154,015	163,087	160,036	152,774	158,330	158,688
Central Shenandoah	60,062	80,621	82,182	97,650	104,969	119,258	122,688	118,575	124,153	127,705
Northern Shenandoah	35,659	48,604	52,155	63,084	69,595	81,945	86,110	82,409	88,862	92,054
Northern Virginia	289,711	446,235	597,681	759,924	819,531	1,008,277	1,101,677	1,127,234	1,187,488	1,221,898
Rappahannock-Rapidan	15,114	24,090	27,252	33,919	36,623	42,580	50,009	47,758	50,870	52,337
Thomas Jefferson	40,067	56,827	63,047	75,959	80,735	92,974	98,377	101,322	113,021	117,146
Central Virginia	55,585	77,470	79,991	91,470	95,541	102,959	98,908	97,124	98,464	99,144
West Piedmont	66,324	82,272	83,564	89,249	87,826	85,893	75,568	66,844	68,449	68,716
Southside	20,658	26,475	26,741	26,135	29,327	33,449	30,592	28,720	27,846	27,434
Commonwealth Regional Council	15,746	20,479	21,017	24,206	25,310	27,410	27,846	26,011	26,854	27,387
Richmond Regional	248,638	321,067	353,802	419,918	441,914	493,421	510,829	498,310	544,925	563,510
George Washington	12,777	30,369	38,034	52,605	63,837	84,835	100,510	105,939	115,812	120,770
Northern Neck	5,731	10,607	10,770	11,985	12,513	13,368	13,995	14,122	13,039	13,314
Middle Peninsula	8,439	13,472	15,263	17,831	20,816	22,389	24,088	22,352	22,475	23,085
Crater	43,683	55,778	53,455	60,401	63,312	68,556	67,844	67,114	69,329	69,113
Accomack-Northampton	10,236	14,869	15,457	17,334	17,920	19,285	19,064	18,471	18,195	18,125
Hampton Roads	326,753	434,918	510,959	585,885	614,025	685,366	721,221	695,099	718,837	731,066
Total	1,472,963	2,028,943	2,331,590	2,760,330	2,938,352	3,353,730	3,517,894	3,470,218	3,645,346	3,727,418
Percent missing	4.1%	2.3%	2.4%	2.4%	2.3%	2.1%	1.7%	1.9%	2.4%	2.9%

[a] Aggregated from numbers reported by the Bureau of Labor Statistics (2018b).

[b] Percent missing reflects jobs not located in any planning district commission but that are part of the statewide total. For example, in 1985, the sum of all jobs in the PDCs was 2,331,590. The reported statewide total for Virginia was 2,388,355. The difference (56,765) reflects 2.4% of the statewide total of 2,388,355. The jobs categorized as "Unknown or Undefined, Virginia" reflect most (55,174) but not all of this difference (56,765).

As one might expect, the employment growth rate has slowed: for 1975-1980, 1980-1985, and 1985-1990, total statewide employment showed annual growth rates of 6.2%, 2.8%, and 3.4%, respectively; for the periods 2005-2010, 2010-2015, and 2015-2017, these growth rates were -0.2%, 1.1%, and 1.4%, respectively. Using year 2000 as a demarcation, Virginia's average annual employment growth rate slowed from 3.3% (1975-2000) to 0.62% (2000-2017).

Three trends further illustrate that changes in employment have been uneven during the 1975-2017 interval. First, since 1975, employment by PDC and VDOT district has not increased at the same rate. Relative to 1975 values, employment increased everywhere but by smaller amounts in the PDCs of West Piedmont, Cumberland Plateau, Southside, Lenowisco, and Mount Rogers than in the PDCs of George Washington, Northern Virginia, and Rappahannock-Rapidan. The most extreme disparity is between George Washington and West Piedmont: the former in 2017 has more than 9 times its employment in 1975; the latter in 2017 has just 1.04 times its 1975 employment level. At the VDOT district level, Fredericksburg in 2017 had almost 6 times its 1975 employment in contrast to Bristol, which in 2017 had slightly less than 1.5 times its 1975 employment level (Figure 16).

Second, regional disparities have increased. Since 2000, although Virginia's employment increased by 373,688 jobs, almost one-half (10 of the 21) of the PDCs saw a drop in employment: Lenowisco, Cumberland Plateau, Mount Rogers, Roanoke Valley-Alleghany, Central Virginia, West Piedmont, Southside, Commonwealth Regional Council, Northern Neck, and Accomack-Northampton. Prior to 2000, no PDC saw a drop in employment (Figure 17). No VDOT district saw a drop in employment for 1975-2000, but three (Bristol, Salem, and Lynchburg) saw a drop from 2000-2017 (Figure 18).

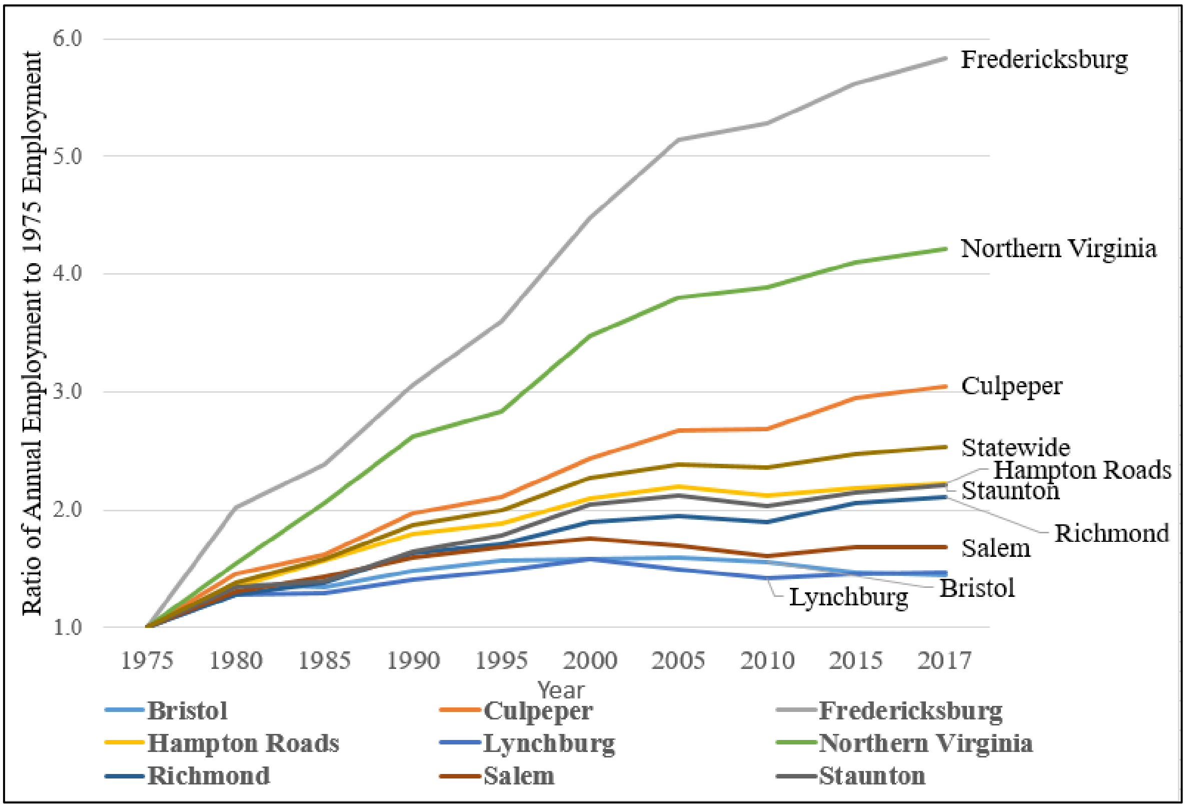


Figure 16. Relative Change in Employment, 1975-2017, by VDOT District. For example, employment in the Salem District in 1975 was 167,444. By 2017, this value had increased by a factor of 1.68 to 281,287. Aggregated from numbers reported by the Bureau of Labor Statistics (2018b).

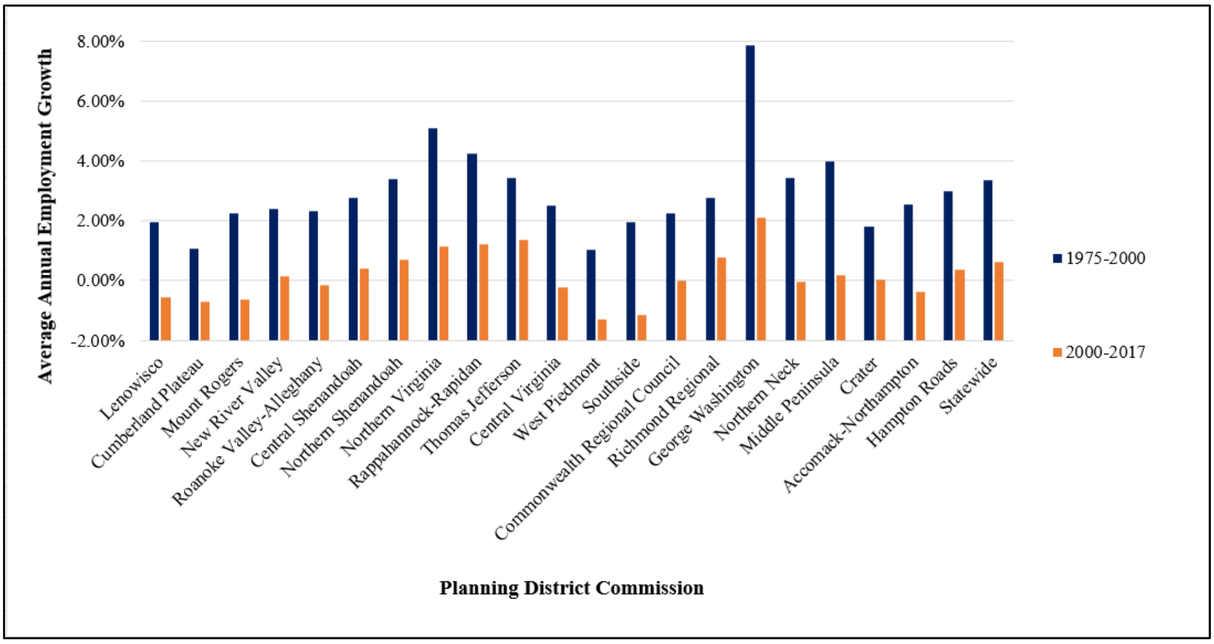


Figure 17. Average Annual Employment Growth Rate by PDC. For example, in 2020, employment in the Central Shenandoah PDC was 119,258. With an average annual growth rate of 0.403%, in 2017, employment in this PDC was 119,258 * $(1.0040)^{17} \approx$ 127,705. Aggregated from numbers reported by the Bureau of Labor Statistics (2018b). PDC = planning district commission.

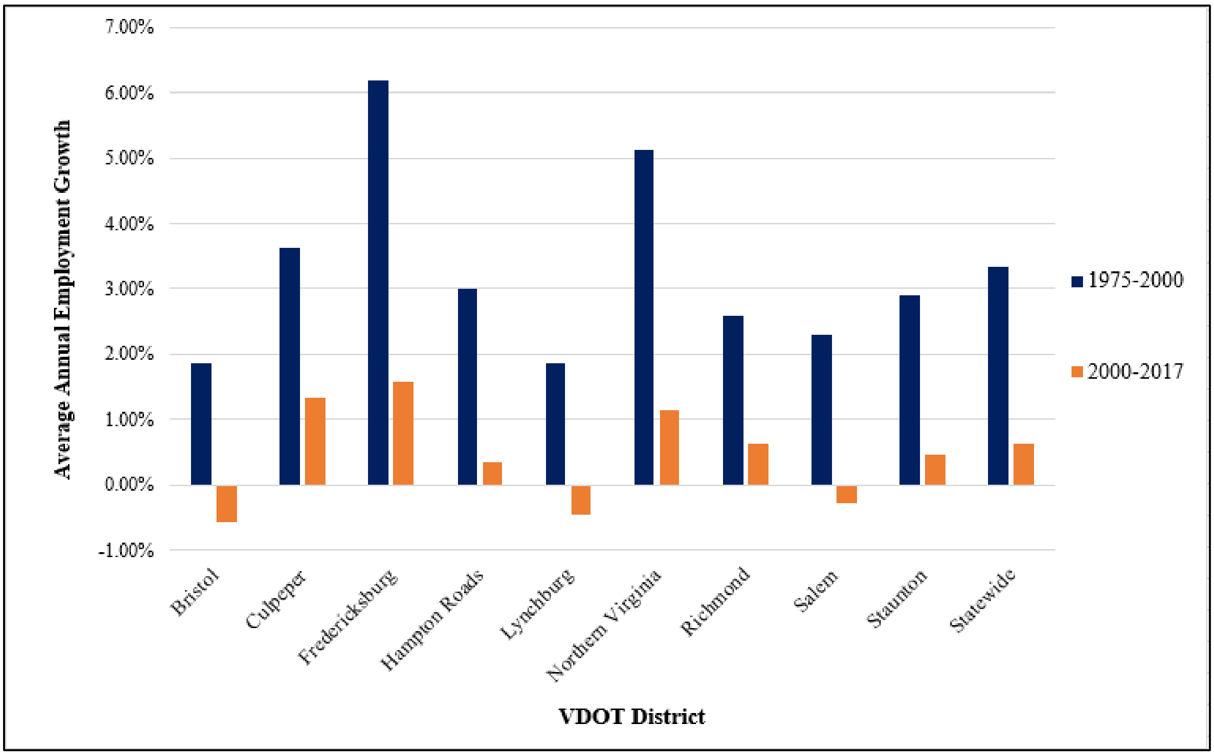


Figure 18. Average Annual Employment Growth Rate by VDOT District. For example, in 1975, employment in the Bristol District was 79,297. With an average annual growth rate of 1.856%, in 2000, the district's employment was 79,297 * $(1.01856)^{25} \approx$ 125,571. Aggregated from data reported by the Bureau of Labor Statistics (2018b).

Third, the share of employment contributed by PDCs or districts has become more disparate. Of the 21 PDCs, 15 saw their share of the state's employment drop from 1975-2017. Of the 6 PDCs whose share of statewide employment increased, 4 had relatively modest changes: Northern Shenandoah and Middle Peninsula increased their share of statewide employment by 0.05% from 1975-2017, and Rappahannock-Rapidan and Thomas Jefferson increased their share of employment by 0.4% over the same period. The 2 PDCs that saw sizeable increases in their share of statewide employment were George Washington (which went from 0.9% to 3.2% of Virginia's employment from 1975-2017) and Northern Virginia (which went from 20% to 33% of Virginia's employment over that interval). Since these 2 PDCs are adjacent, it should be noted that they went from contributing about one-fifth (21%) of the state's employment in 1975 to more than one-third (36%) in 2017. The increase in Northern Virginia's share of the statewide total is sufficiently large that if one considers the largest 3 PDCs in terms of employment (Northern Virginia, Hampton Roads, and Richmond Regional), their share of Virginia employment increased from 59% (in 1975) to 68% (in 2017).

Current and Forecast Employment (2017-2045)

Total Employment

Virginia's 2017 employment is concentrated in the three most populous PDCs, i.e., Northern Virginia, Hampton Roads, and Richmond Regional, based on data from Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018), as shown in Tables 16 and 17.

Table 16. Forecast Employment by Planning District Commission

No.	Planning District Commission	2017	2045	Growth	New Jobs	% New Jobs
1	Lenowisco	34,745	42,769	23.1%	8,024	0.3%
2	Cumberland Plateau	43,153	51,344	19.0%	8,191	0.4%
3	Mount Rogers	100,303	119,503	19.1%	19,200	0.8%
4	New River Valley	96,630	121,907	26.2%	25,277	1.1%
5	Roanoke Valley-Alleghany	214,525	280,520	30.8%	65,995	2.8%
6	Central Shenandoah	177,971	243,015	36.5%	65,044	2.8%
7	Northern Shenandoah	129,823	180,494	39.0%	50,671	2.2%
8	Northern Virginia	1,756,035	2,746,961	56.4%	990,926	42.6%
9	Rappahannock-Rapidan	86,185	126,907	47.2%	40,722	1.8%
10	Thomas Jefferson	166,318	222,628	33.9%	56,310	2.4%
11	Central Virginia	140,329	197,168	40.5%	56,839	2.4%
12	West Piedmont	93,747	116,416	24.2%	22,669	1.0%
13	Southside	39,058	46,396	18.8%	7,338	0.3%
14	Commonwealth Regional Council	41,709	51,888	24.4%	10,179	0.4%
15	Richmond Regional	759,909	1,150,963	51.5%	391,054	16.8%
16	George Washington	170,468	285,512	67.5%	115,044	4.9%
17	Northern Neck	22,331	27,988	25.3%	5,657	0.2%
18	Middle Peninsula	36,740	46,823	27.4%	10,083	0.4%
19	Crater	98,383	114,439	16.3%	16,056	0.7%
22	Accomack-Northampton	25,877	32,932	27.3%	7,055	0.3%
23	Hampton Roads	1,041,008	1,394,797	34.0%	353,789	15.2%
Statewide		5,275,247	7,601,370	44.1%	2,326,123	100.0%

[a] Aggregated from data provided by Woods & Poole (2018b).

Table 17. Forecast Employment by Planning District Commission

No.	Planning District Commission	2017	2045	Growth	New Jobs	% New Jobs
1	Lenowisco	30,099	30,691	2.0%	592	0.1%
2	Cumberland Plateau	37,344	31,598	-15.4%	-5,746	-0.8%
3	Mount Rogers	83,033	87,584	5.5%	4,551	0.6%
4	New River Valley	81,129	89,105	9.8%	7,976	1.1%
5	Roanoke Valley-Alleghany	169,783	173,240	2.0%	3,457	0.5%
6	Central Shenandoah	136,473	149,465	9.5%	12,992	1.8%
7	Northern Shenandoah	101,843	111,115	9.1%	9,272	1.3%
8	Northern Virginia	1,293,486	1,690,425	30.7%	396,939	54.2%
9	Rappahannock-Rapidan	61,922	69,782	12.7%	7,860	1.1%
10	Thomas Jefferson	125,463	158,984	26.7%	33,521	4.6%
11	Central Virginia	108,254	116,201	7.3%	7,947	1.1%
12	West Piedmont	75,811	84,101	10.9%	8,290	1.1%
13	Southside	32,858	26,725	-18.7%	-6,133	-0.8%
14	Commonwealth Regional Council	33,539	32,476	-3.2%	-1,063	-0.1%
15	Richmond Regional	598,022	706,346	18.1%	108,324	14.8%
16	George Washington	126,033	165,370	31.2%	39,337	5.4%
17	Northern Neck	15,975	14,726	-7.8%	-1,249	-0.2%
18	Middle Peninsula	25,641	26,564	3.6%	923	0.1%
19	Crater	75,717	94,824	25.2%	19,107	2.6%
22	Accomack-Northampton	22,934	17,023	-25.8%	-5,911	-0.8%
23	Hampton Roads	782,271	873,686	11.7%	91,415	12.5%
Statewide		4,017,630	4,750,031	18.2%	732,401	100.0%

[a] Aggregated from data provided by IHS Markit (Jeafarqomi, 2018).

By 2045, these three PDCs are forecast to account for 70% of Virginia's jobs and to account for three-fourths of the growth in jobs during the intervening years (Woods & Poole, 2018b). IHS Markit (Jeafarqomi, 2018) shows similar quantities: by 2045, these three PDCs are forecast to account for 69% of Virginia's jobs and slightly more than four-fifths of new jobs created from 2017-2045.

The former source suggests that relative to existing employment levels, PDCs forecast to have the highest growth in employment are George Washington (67%), Northern Virginia (56%), Richmond Regional (51%), and Rappahannock-Rapidan (47%). Six PDCs are forecast for employment growth between 30% and 40% and seven for between 20% and 30%; four are forecast to have less than 20% employment growth, with Crater PDC (16%) having the least, as shown in Figure 19. The forecasts by IHS Markit (Jeafarqomi, 2018) are similar in that George Washington, Northern Virginia, Richmond Regional, and Rappahannock-Rapidan are showing higher growth rates relative to other PDCs (Figure 20).

However, overall, IHS Markit (Jeafarqomi, 2018) shows comparatively less growth in employment than Woods & Poole (2018b). Only two PDCs are forecast to have more than 30% employment growth: George Washington (31%) and Northern Virginia (31%). They are followed by Thomas Jefferson (27%) and Crater (25%). Twelve PDCs are forecast to have less than 20% employment growth. Although Woods & Poole (2018b) forecasts that all PDCs will have employment growth, IHS Markit (Jeafarqomi, 2018) shows five declines: Accomack-Northampton (26%), Southside (19%), Cumberland Plateau (15%), Northern Neck (8%), and Commonwealth Regional Council (3%).

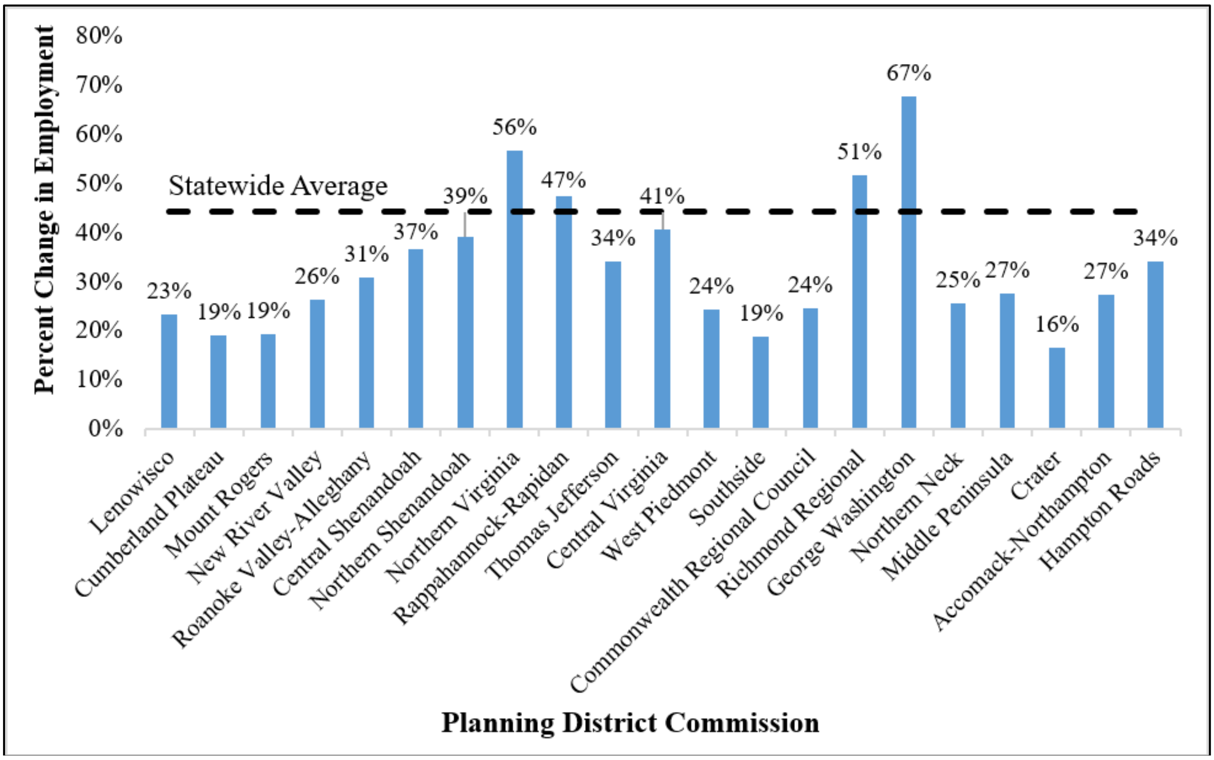


Figure 19. Forecast % Change in Employment by PDC, 2017-2045. Data provided by Woods & Poole (2018b). For example, in 2017, West Piedmont PDC had employment estimated at 93,747, which was projected to be 116,416 by 2045. Thus, from 2017-2045, this PDC is projected to have approximately 24% {[(116,416 - 93,747) / 93,747] * 100} growth in employment. PDC = planning district commission.

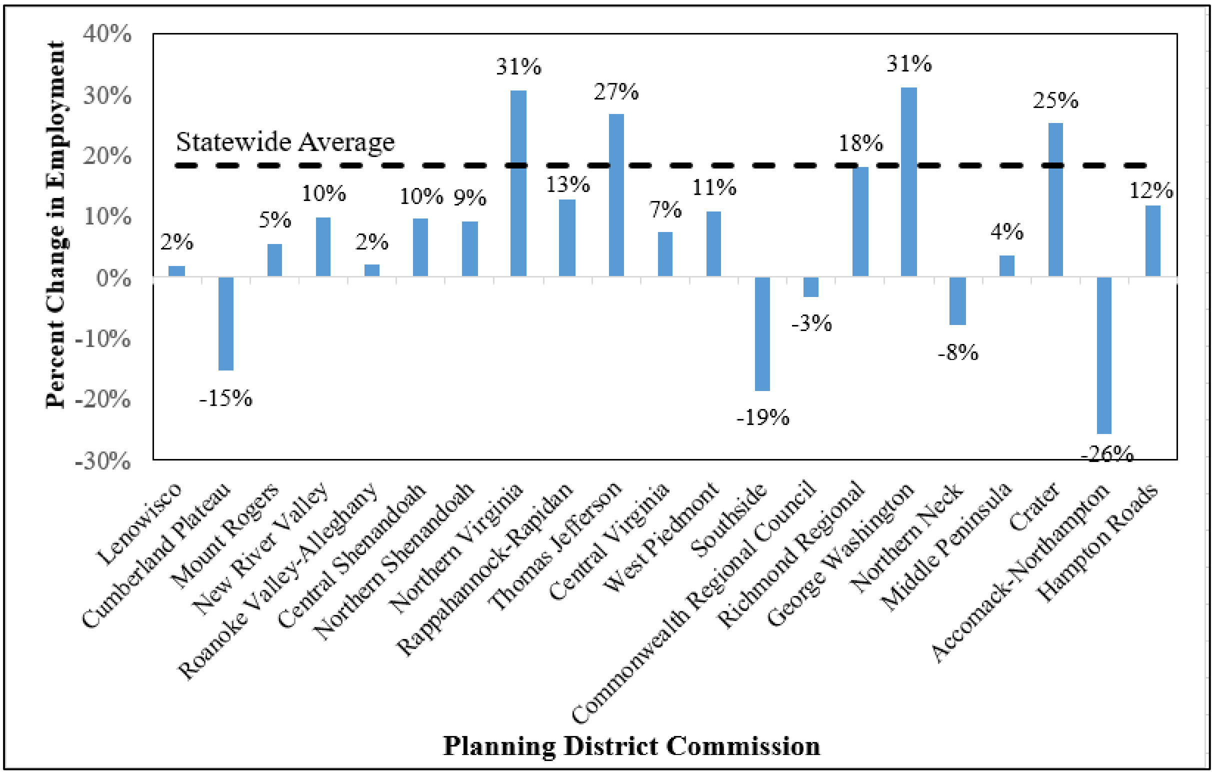


Figure 20. Forecast % Change in Employment by PDC, 2017-2045. Data provided by IHS Markit (Jeafarqomi, 2018). For example, in 2017, West Piedmont PDC had employment estimated at 75,811, which was projected to be 84,101 by 2045. Therefore, from 2017-2045, this PDC is projected to have an approximate 11% {[(84,101 - 75,811) / 75,811] * 100} growth in employment. PDC = planning district commission.

At the district level, Northern Virginia, Hampton Roads, and Richmond account for 70% to 71% of existing jobs at present and 72% by 2045; further, these districts account for 76% to 83% of all new jobs forecast for 2017-2045 (Tables 18 and 19). By contrast, the Bristol District has only 3% of Virginia's 2017 employment and is forecast to see its employment either increase by 18% or decrease by 3%. As is the case with the PDCs, the employment growth in most districts is below the statewide average (Figures 21 and 22). For example, whereas IHS Markit (Jeafarqomi, 2018) forecasts an average employment growth of 18.2% for the period 2017-2045, six districts are below that value: a drop for Bristol (3.0%) and increases for Hampton Roads (10.6%), Lynchburg (3.3%), Richmond (17.5%), Salem (6.7%), and Staunton (10.1%). Woods & Poole (2018b) shows a higher statewide average employment growth rate of 44.1%, but again, most districts (i.e., six districts) are below this value, from 18.6% for the Bristol District to 38.8% for the Culpeper District.

Table 18. Forecast Employment by VDOT District

No.	District	2017	2045	Growth	New Jobs	% New Jobs
1	Bristol	160,837	190,791	18.6%	29,954	1.3%
2	Culpeper	245,104	340,085	38.8%	94,981	4.1%
3	Fredericksburg	229,539	360,323	57.0%	130,784	5.6%
4	Hampton Roads	1,084,989	1,449,070	33.6%	364,081	15.7%
5	Lynchburg	211,032	277,339	31.4%	66,307	2.9%
6	Northern Virginia	1,756,035	2,746,961	56.4%	990,926	42.6%
7	Richmond	878,820	1,289,150	46.7%	410,330	17.6%
8	Salem	390,909	512,624	31.1%	121,715	5.2%
9	Staunton	317,982	435,027	36.8%	117,045	5.0%
Statewide		5,275,247	7,601,370	44.1%	2,326,123	100.0%

[a] Aggregated from data provided by Woods & Poole (2018b).

Table 19. Forecast Employment by VDOT District

No.	District	2017	2045	Growth	New Jobs	% New Jobs
1	Bristol	137,963	133,790	-3.0%	-4,173	-0.6%
2	Culpeper	182,501	223,952	22.7%	41,451	5.7%
3	Fredericksburg	167,649	206,660	23.3%	39,011	5.3%
4	Hampton Roads	820,225	906,968	10.6%	86,743	11.8%
5	Lynchburg	169,564	175,139	3.3%	5,575	0.8%
6	Northern Virginia	1,293,486	1,690,425	30.7%	396,939	54.2%
7	Richmond	690,926	812,072	17.5%	121,146	16.5%
8	Salem	309,107	329,935	6.7%	20,828	2.8%
9	Staunton	246,209	271,090	10.1%	24,881	3.4%
Statewide		4,017,630	4,750,031	18.2%	732,401	100.0%

[a] Aggregated from data provided by IHS Markit (Jeafarqomi, 2018).

Tables 20 and 21 compare percent growth rates from two sources, with greater variation by PDC or VDOT district compared to the statewide level. For example, Woods & Poole (2018b) forecasts that Richmond Regional will grow from 759,909 to 1,150,963 jobs (an increase of about 51%) whereas data from IHS Markit (Jeafarqomi, 2018) suggest this same region will grow from about 598,022 to 706,346 jobs (an increase of about 18%). In both cases, however, this region's percentage of the statewide total in 2045 is forecast to be about 15%. Southside's percentage of the statewide employment total in 2045 also remains constant regardless of which data source is used, but relative growth rate differs from -19% to 19%. Thus, from the statewide perspective, the proportion of jobs held by each PDC is similar; however, from the PDC's perspective, the expected change in employment varies by source.

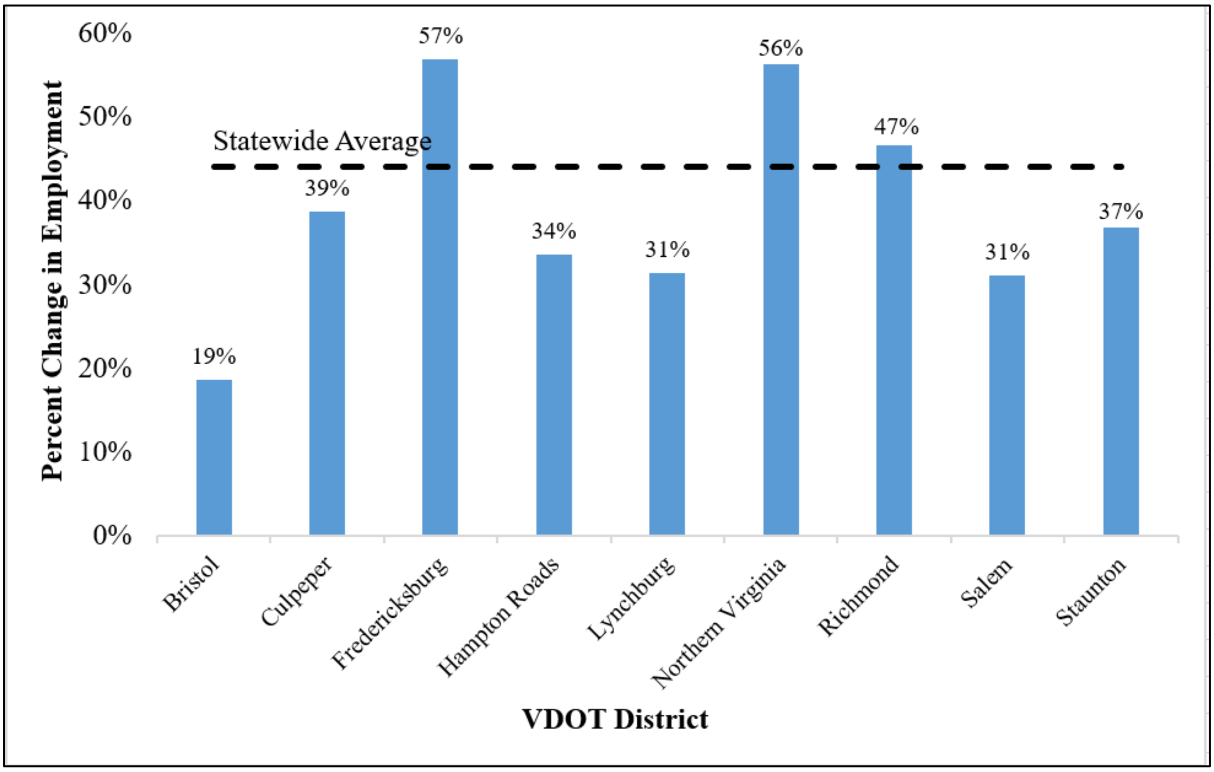


Figure 21. Forecast % Change in Employment by VDOT District, 2017-2045. Data provided by Woods & Poole (2018b). For example, in 2017, the Richmond District had employment estimated at 878,820, which was projected to be 1,289,150 by 2045. Thus, from 2017-2045, this district is projected to have approximately 47% = {[(1,289,150 - 878,820) / 878,820] * 100} growth in employment.

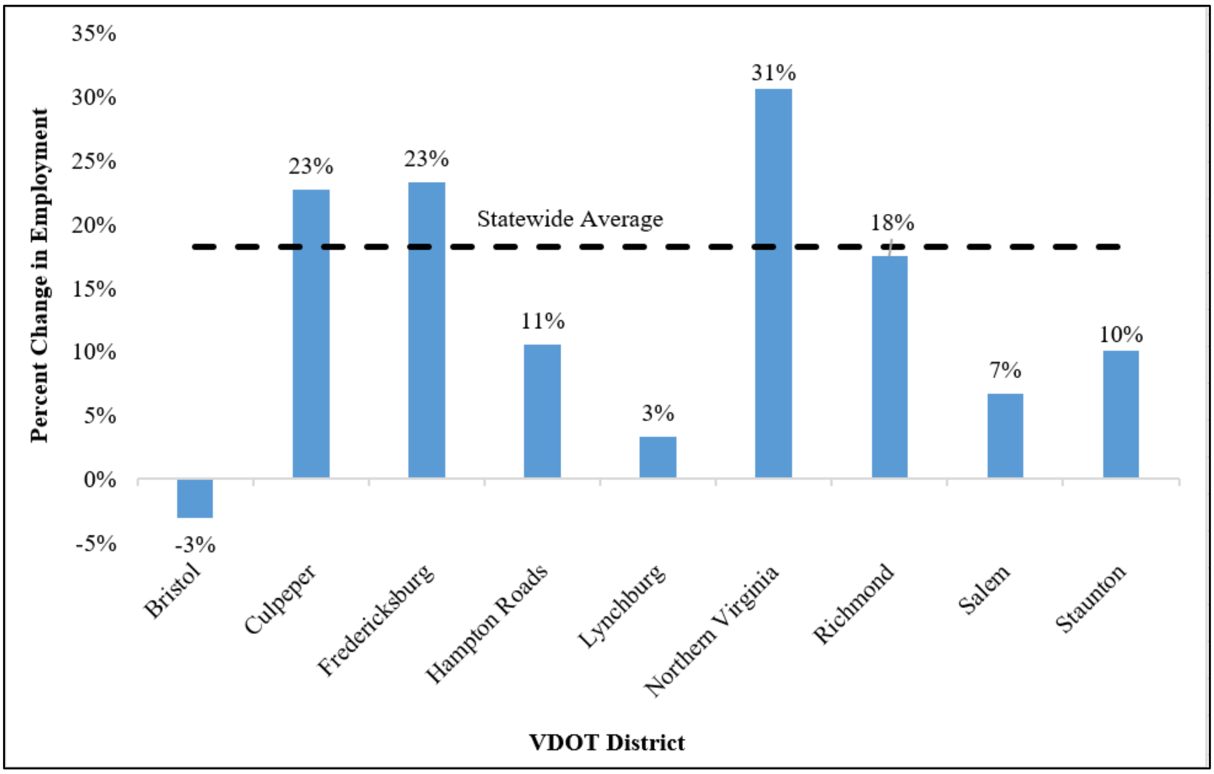


Figure 22. Forecast % Change in Employment by VDOT District, 2017-2045. Data provided by IHS Markit (Jeafarqomi, 2018). For example, in 2017, the Richmond District had employment estimated at 690,926, which was projected to be 812,072 by 2045. Thus, from 2017-2045, this district is projected to have approximately 18% {[(812,072 - 690,926) / 690,926]*100} growth in employment.

Table 20. Percent Employment of Planning District Commissions for 2000, 2017, and 2045 and Percent Growth in Employment From 20172045[a]

Planning District Commission	% Virginia's Employment 2000		% Virginia's Employment 2017		% Virginia's Employment 2045		% Growth 2017-2045	
	IHS Markit	Woods & Poole	IHS Markit	Woods & Poole	IHS Markit	Woods & Poole	IHS Markit	Woods & Poole
Lenowisco	1%	1%	1%	1%	1%	1%	2%	23%
Cumberland Plateau	1%	1%	1%	1%	1%	1%	-15%	19%
Mount Rogers	3%	2%	2%	2%	2%	2%	5%	19%
New River Valley	2%	2%	2%	2%	2%	2%	10%	26%
Roanoke Valley-Alleghany	5%	5%	4%	4%	4%	4%	2%	31%
Central Shenandoah	4%	4%	3%	3%	3%	3%	10%	37%
Northern Shenandoah	3%	2%	3%	2%	2%	2%	9%	39%
Northern Virginia	28%	30%	32%	33%	36%	36%	31%	56%
Rappahannock-Rapidan	1%	1%	2%	2%	1%	2%	13%	47%
Thomas Jefferson	3%	3%	3%	3%	3%	3%	27%	34%
Central Virginia	3%	3%	3%	3%	2%	3%	7%	41%
West Piedmont	3%	2%	2%	2%	2%	2%	11%	24%
Southside	1%	1%	1%	1%	1%	1%	-19%	19%
Commonwealth Regional Council	1%	1%	1%	1%	1%	1%	-3%	24%
Richmond Regional	14%	14%	15%	14%	15%	15%	18%	51%
George Washington	2%	3%	3%	3%	3%	4%	31%	67%
Northern Neck	1%	0%	0%	0%	0%	0%	-8%	25%
Middle Peninsula	1%	1%	1%	1%	1%	1%	4%	27%
Crater	2%	2%	2%	2%	2%	2%	25%	16%
Accomack-Northampton	1%	1%	1%	0%	0%	0%	-26%	27%
Hampton Roads	20%	21%	19%	20%	18%	18%	12%	34%

[a] Based on data from Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018).

Table 21. Percentage Statewide Employment by VDOT District[a]

District	% Virginia's Employment 2000		% Virginia's Employment 2017		% Virginia's Employment 2045		% Growth 2017-2045	
	Woods & Poole	**IHS Markit**	**Woods & Poole**	**IHS Markit**	**Woods & Poole**	**IHS Markit**	**Woods & Poole**	**IHS Markit**
Fredericksburg	4%	4%	4%	4%	5%	4%	57%	23%
Northern Virginia	30%	28%	33%	32%	36%	36%	56%	31%
Richmond	16%	17%	17%	17%	17%	17%	47%	18%
Culpeper	4%	4%	5%	5%	4%	5%	39%	23%
Staunton	6%	7%	6%	6%	6%	6%	37%	10%
Hampton Roads	22%	22%	21%	20%	19%	19%	34%	11%
Lynchburg	5%	5%	4%	4%	4%	4%	31%	3%
Salem	9%	9%	7%	8%	7%	7%	31%	7%
Bristol District	4%	5%	3%	3%	3%	3%	19%	-3%

[a] Based on data from Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018).

Employment by Industry

Virginia's employment is not evenly distributed by industry. Figures 23 and 24 show the percentage contribution of each employment industry to Virginia's employment for 2000, 2017, and 2045 according to IHS Markit (Jeafarqomi, 2018) and Woods & Poole (2018b).

As shown in Table 22 (Jeafarqomi, 2018), three industries account for 42% of Virginia's 2017 employment: public administration (18%); health care and social assistance (11%); and professional, scientific, and technical services (10%). By 2045, these same industries are forecast to account for 42% of Virginia's growth and relative to 2017 are expected to increase substantially by 31% (professional, scientific, and technical services), 33% (health care and social assistance), and 10% (public administration).

Table 23 (Woods & Poole, 2018b) suggests that a similar amount of 2017 employment (41%) is represented by four industries: state and local government (10%), professional and technical services (11%), retail trade (10%), and health care and social assistance industry. The same source forecasts that industries with significant growth during the 2017-2045 interval are health care and the social assistance industry (91% relative to the 2017 value), professional and technical services (61%), retail trade (46%), and state and local government (33%).

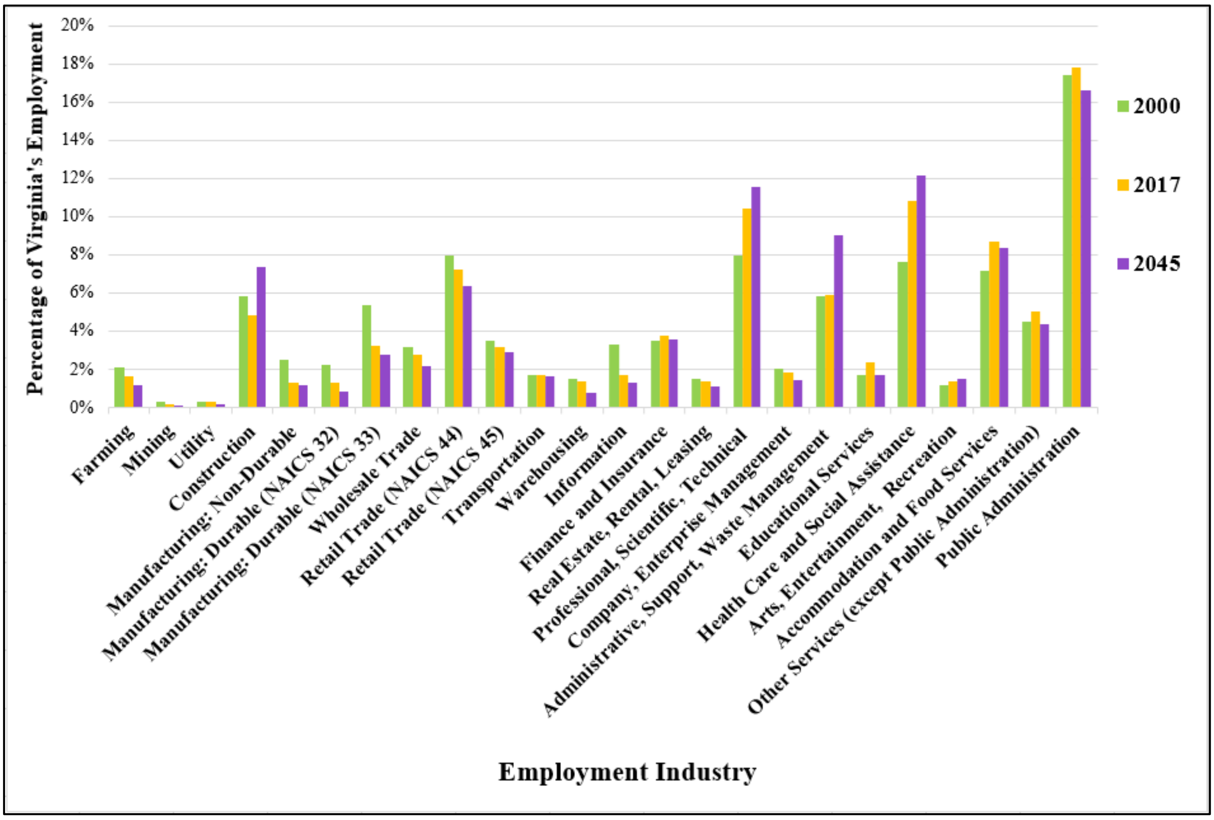


Figure 23. Contribution of Each Employment Industry to Virginia's Total Employment in 2000, 2017, and 2045 (Projected). Based on data from IHS Markit (Jeafarqomi, 2018). For example, in 2017, 66,476 of 4,017,630 total jobs in Virginia were estimated to be in the farming industry. Thus, the farming industry contributed 2% [i.e., (66,476 / 4,017,630) * 100] of Virginia's jobs in 2017. Parentheses indicate the North American Industry Classification System (NAICS) code, which is shown only because that is how IHS Markit differentiates the otherwise similar categories of durable manufacturing and retail trade.

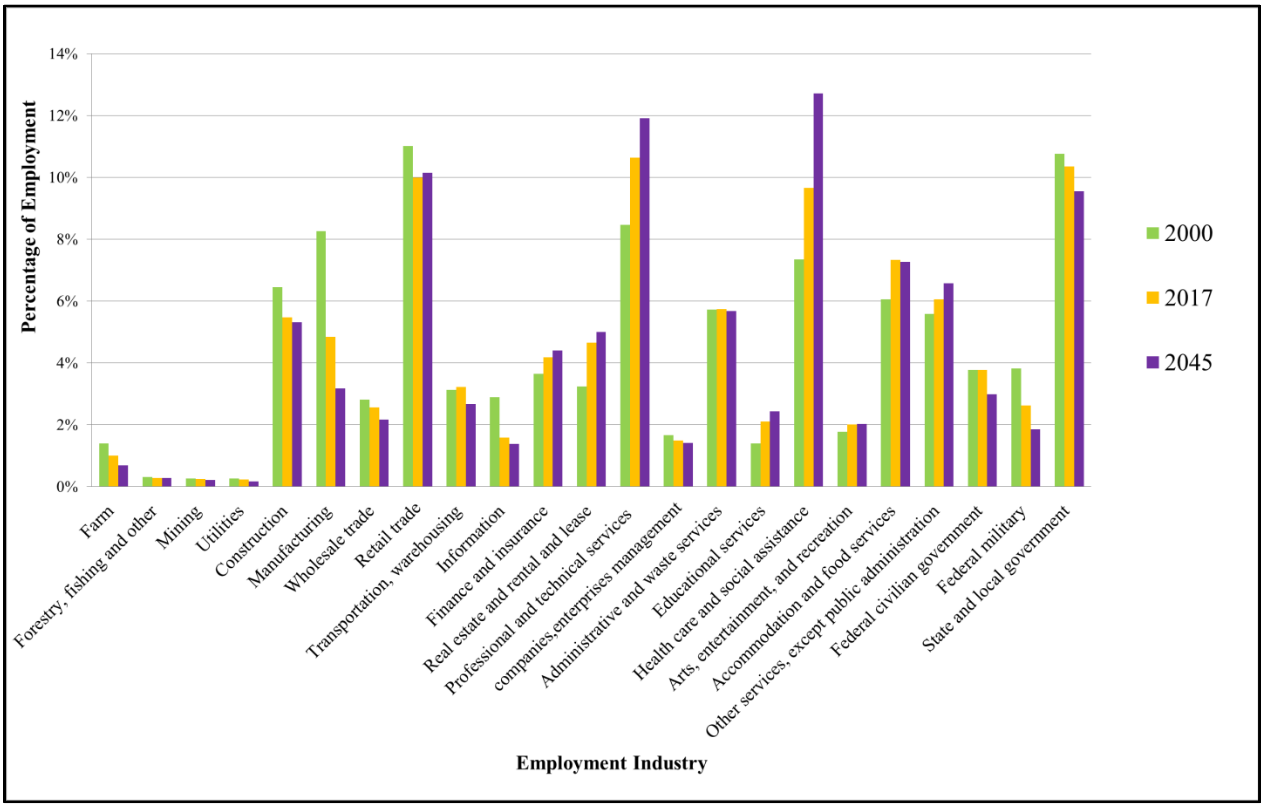


Figure 24. Contribution of Each Employment Industry to Virginia's Total Employment in 2000, 2017, and 2045 (Projected). Based on data from Woods & Poole (2018b). For example, in 2017, of 5,275,247 total jobs in Virginia, 52,596 jobs were estimated to be in the farming industry. Thus, farming contributed approximately 1% [(52,596 / 5,275,247) * 100] of Virginia's jobs in 2017.

Table 22. Contribution of Each Industry to Virginia's Total Employment[a]

NAICS Code	Employment Industry	% Virginia's Total Employment			% Change
		2000	**2017**	**2045**	**2017-2045**
54	Professional, scientific, and technical services	8%	10%[b]	12%[b]	31%[b]
90	Public administration	17%	18%	17%	10%
62	Health care and social assistance	8%	11%	12%	33%
72	Accommodation and food services	7%	9%	8%	14%
44	Retail trade	8%	7%	6%	3.2%
56	Administrative and support, waste management and remediation services	6%	6%	9%	81%
81	Other services (except public administration)	4%	5%	4%	2.3%
23	Construction	6%	5%	7%	80%
52	Finance and insurance	3%	4%	4%	11.2%
45	Retail trade	3%	3%	3%	8.0%
51	Information	3%	2%	1%	-7.1%
61	Educational services	2%	2%	2%	-15.3%
42	Wholesale trade	3%	3%	2%	-8.9%
48	Transportation	2%	2%	2%	13.2%
55	Management of companies and enterprises	2%	2%	1%	-10.2%
33	Manufacturing: Durable	5%	3%	3%	0.83%
53	Real estate and rental and leasing	2%	1%	1%	-2.7%
71	Arts, entertainment, and recreation	1%	1%	1%	30%
11	Farming	2%	2%	1%	-15.1%
31	Manufacturing: Non-durable	3%	1%	1%	4.8%
49	Warehousing	2%	1%	0.8%	-32.1%
32	Manufacturing: Durable	2%	1%	1%	-24.0%
22	Utility	0.3%	0.3%	0.1%	-34.6%
21	Mining	0.3%	0.2%	0.1%	2.4%

NAICS = North American Industry Classification System.

[a] Based on data from IHS Markit (Jeafarqomi, 2018). Numbers are rounded to the nearest percentage point except for instances where employment was less than one-half percent.

[b] For example, in 2017, there were 4,017,630 total jobs, of which 417,731 (10%) are classified as professional, scientific, and technical services. These are forecast to grow to 548,896 in 2045, which would be 12% of the total forecast employment for 2045 (4,750,031 jobs). The net change in professional and technical services jobs during the 2017-2045 interval (131,165) represents a 31% increase over the 2017 value.

Table 23. Contribution of Each Industry to Virginia's Total Employment[a]

Industry	% Virginia's Total Employment			% Growth 2017-2045
	2000	2017	2045	
Virginia	100%	100%	100%	
Farm employment	1%	1%	1%	0.1%
Forestry, fishing, related activities and other employment	0.3%	0.3%	0.3%	45%
Mining employment	0.3%	0.2%	0.2%	27%
Utilities employment	0.3%	0.2%	0.2%	6%
Construction employment	6%	5%	5%	40%
Manufacturing employment	8%	5%	3%	-6%
Wholesale trade employment	3%	3%	2%	22%
Retail trade employment 1	11%	10%	10%	46%
Transportation and warehousing employment	3%	3%	3%	20%
Information employment	3%	2%	1%	25%
Finance and insurance employment	4%	4%	4%	52%
Real estate and rental and lease employment	3%	5%	5%	55%
Professional and technical services employment	8%	11%	12%	61%
Management of companies and enterprises employment	2%	1%	1%	37%
Administrative and waste services employment	6%	6%	6%	43%
Educational services employment	1%	2%	2%	66%
Health care and social assistance employment	7%	10%	13%	90%
Arts, entertainment, and recreation employment	2%	2%	2%	45%
Accommodation and food services employment	6%	7%	7%	43%
Other services, except public administration employment	6%	6%	7%	56%
Federal civilian government employment	4%	4%	3%	14%
Federal military employment	4%	3%	2%	2%
State and local government employment	11%	10%	10%	33%

[a] Based on data from Woods & Poole (2018b). Numbers are rounded to the nearest percentage point except for instances where employment was less than one-half percent.

Explanation of Differences in Employment Forecasts

Although it is not possible to know which employment forecast will prove to be more accurate in 2045, it is possible to examine the reasons for the disparity in employment forecasts. Both Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018) forecast an increase in employment statewide (44.1% and 18.2%, respectively), but within professions, some forecasts differ substantially. Although there is a difference of 26 percentage points between these statewide forecasts, there are some industrial classifications where these two sources are more similar, as shown in Table 24: arts, entertainment, and recreation (45% and 30%); manufacturing (decreases of 4% and 6%); and government (24% and 10%). The Woods & Poole government category shown in Table 24 includes the three categories of state and local, federal civilian, and federal military; the IHS Markit government category is a single category of public administration. Notable differences include health care and social assistance (increases of 90% and 33% are forecast between 2017 and 2045); professional and technical services (61% and 31%); retail trade (46% and 5%); other services (e.g., churches, dry cleaning, pet care, dating services, machinery repairing, and advocacy [Woods & Poole, 2018a]) (56% and 2%); and real estate and rental and leasing (97% and 55%). If these last five differences were eliminated, the percentage difference overall for these two sources for statewide employment would be between 7 and 9 percentage points depending on the exact manner of tabulation, rather than 26 percentage points.

In recognition of the fact that these two sources have different job totals, Table 24 and Figure 25 show one way to visualize the differences between these sources. For each two-digit industrial classification that corresponds to the North American Industrial Classification System (NAICS), the horizontal axis in Figure 25 shows the percent growth from 2017-2045 based on Woods & Poole (2018b) and the vertical axis shows the percent growth for that same period based on IHS Markit (Jeafarqomi, 2018). The size of each bubble is roughly proportionate to the importance of the particular profession in explaining the difference in total forecast employment between the two sources, which are IHS Markit and Woods & Poole. For example, for NAICS 11, which is defined as farming, forestry, fishing, and related activities, Woods & Poole forecasts a 10.1% increase in employment from 2017-2045 and IHS Markit forecasts a 15.1% decrease, as shown near the lower left corner of Figure 25. The size of this bubble, however, is considerably smaller than the bubble that corresponds to government employment because although the increases in government employment are more similar (24% and 10%) than is the case for farming, forestry, and fishing (positive 10% and negative 15%), government employment is a much larger portion of Virginia's economy than farming, forestry, and fishing.

Figure 25 thus suggests that statewide, the two biggest contributors to these different statewide forecasts in total employment are health care and retail trade. These are followed by five employment categories that are much closer to each other (in terms of their importance to the difference in statewide employment as forecast by Woods & Poole and IHS Markit): professional and technical services; other services (e.g., churches, dry cleaning, pet care, dating services, machinery repairing, and advocacy [Woods & Poole, 2018a]); accommodation and food services; government; and administrative and waste services.

Returning to the differences between Figure 19 (which showed employment increasing in all PDCs by 2045) and Figure 20 (which showed employment decreasing in 5 of Virginia's 21 PDCs), these differences by sector can be magnified in PDCs with relatively small employment totals. For example, Accomack-Northampton showed a 27% increase in employment according to Woods & Poole (2018b) and a 26% decrease in employment according to IHS Markit (Jeafarqomi, 2018) for the period 2017-2045. The latter 26% decrease in employment would change to an 8% increase in employment if differences were eliminated in just four employment categories: health care (which more than doubles according to Woods & Poole but shrinks by 18% based on IHS Markit), government employment (a 16% increase vs. a 34% decrease), manufacturing (a 5% increase vs. a 32% decrease), and other services (a 32% increase vs. a 50% decrease).

The differences in employment by type are also useful for understanding differences by VDOT district. The following question arose with regard to Table 21: Why does one source show employment as increasing from 2017-2045 while another source shows a decrease over the same period? A more detailed examination of the employment forecasts by sector for the Bristol District suggests that the single largest contributor to the differences in forecasts is the expected change in public administration, as shown in Table 25. IHS Markit (Jeafarqomi, 2018) reports a single category of "public administration"; Woods & Poole (2018b) reports three separate categories ("federal civilian," "federal military," and "state and local government") that the research team aggregated into a single category to render it comparable to the IHS Markit category of "public administration."

Table 24. Forecast Percent Employment Growth, 2017-2045) Based on Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018)

Industry	Woods & Poole			IHS Markit			Comparison	
	2017	2045	% Change	2017	2045	% Change	Absolute Importance[a]	Relative Importance[b]
Forestry, fishing, related activities, and other	67,404	74,201	10.1%	66,476	56,448	-15.1%	16,731[a]	0.017[b]
Mining employment	12,789	16,240	27.0%	6,252	6,402	2.4%	1,537	0.002
Utilities employment	12,084	12,836	6.2%	10,792	7,060	-34.6%	4,404	0.004
Construction employment	288,560	403,513	39.8%	193,884	349,629	80.3%	-78,508	0.078
Manufacturing employment	255,419	240,946	-5.7%	234,159	225,366	-3.8%	-4,475	0.004
Wholesale trade employment	135,152	164,470	21.7%	111,539	101,622	-8.9%	34,113	0.034
Retail trade employment	527,217	771,855	46.4%	417,941	437,443	4.7%	174,430	0.174
Transportation and warehousing employment	169,696	203,512	19.9%	122,636	113,802	-7.2%	33,272	0.033
Information employment	83,268	104,290	25.2%	67,614	62,781	-7.1%	21,903	0.022
Finance and insurance employment	220,957	334,817	51.5%	151,035	167,878	11.2%	60,986	0.061
Real estate and rental and leasing employment	245,220	380,462	55.2%	54,248	52,759	-2.7%	31,407	0.031
Professional and technical services employment	561,362	904,983	61.2%	417,731	548,896	31.4%	124,537	0.124
Management of companies and enterprises	78,148	107,017	36.9%	74,425	66,850	-10.2%	35,069	0.035
Administrative and waste services employment	302,481	431,941	42.8%	237,285	430,089	81.3%	-91,247	0.091
Educational service employment	111,097	184,722	66.3%	94,896	80,407	-15.3%	77,377	0.077
Health care and social assistance employment	509,642	966,987	89.7%	434,341	577,077	32.9%	247,035	0.246
Arts, entertainment, and recreation employment	106,050	154,094	45.3%	54,571	70,722	29.6%	8,571	0.009
Accommodation and food services employment	386,551	551,768	42.7%	348,055	396,619	14.0%	100,199	0.100
Other services, except public administration	319,145	499,369	56.5%	202,886	207,500	2.3%	109,958	0.109
Government	883,005	1,093,347	23.8%	716,864	790,681	10.3%	96,948	0.097
Total	5,275,247	7,601,370	44.1%	4,017,630	4,750,031	18.2%	1,004,247	1.000

[a] Computed as the difference in the Woods & Poole % change and the IHS Markit % change multiplied by the IHS Markit 2017 value. For instance, the rough importance of "forestry, fishing, related activities, and other" is [(10.1% - (-15.1%)(66,476)] ≈ 16,731.

[b] Computed as the rough importance for each industry divided by the sum of all rough importance values. For instance, the relative importance of "forestry, fishing, related activities, and other" is 16,731 / 1,004,247 ≈ 0.017.

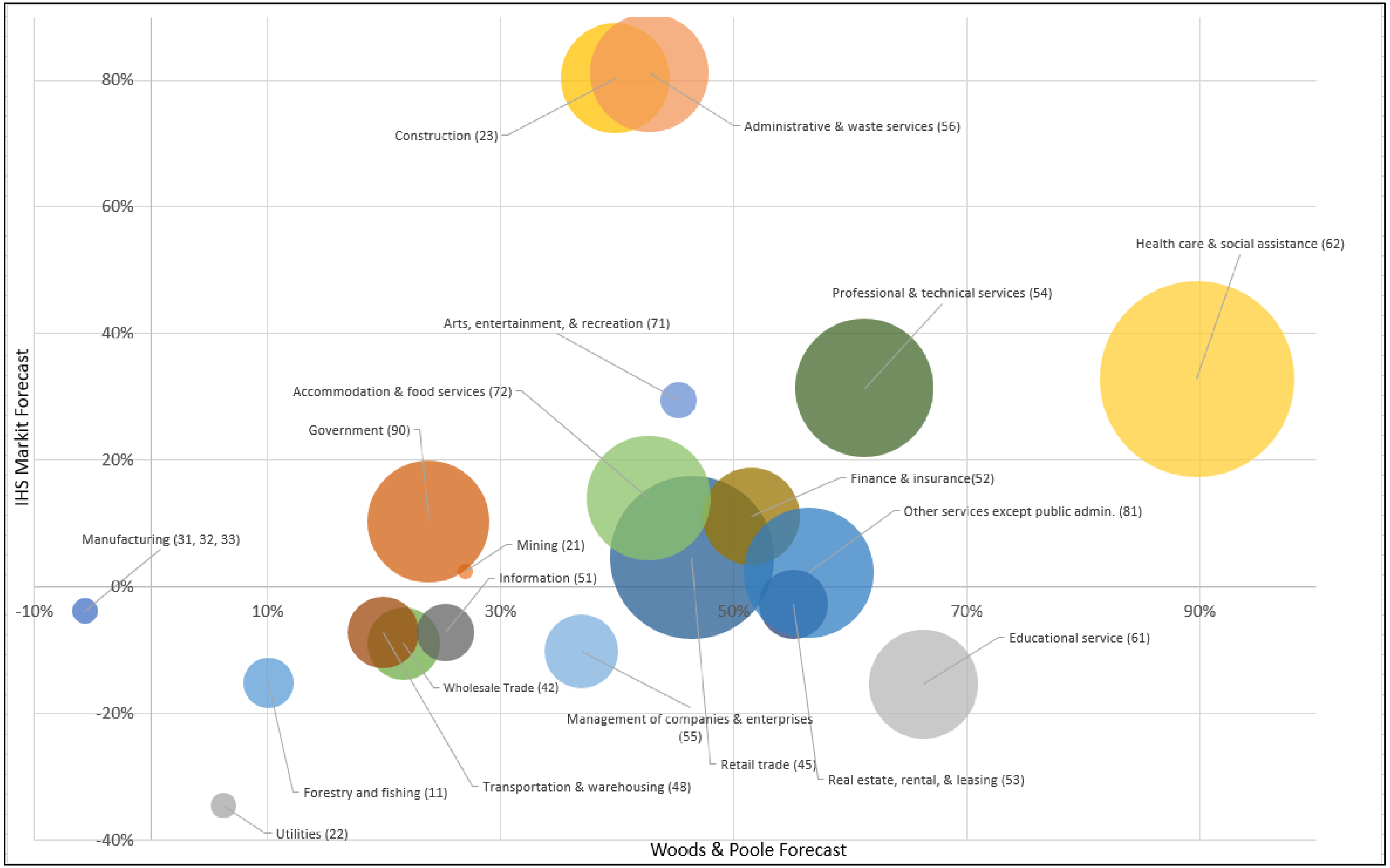


Figure 25. Forecast % Growth in Employment, 2017-2045, Based on Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018). The size of each bubble roughly indicates the relative importance of the different forecasts for each sector's employment with regard to statewide total employment. For example, health care and social assistance employment (North American Industry Classification System Code 62) is forecast to increase 90% based on the former source and 33% based on the latter source.

Table 25. Detailed Occupational Category Contributions to Differences in Employment Forecasts (2017-2045) Between IHS Markit and Woods & Poole

Industry	2017 IHS	2045 IHS	2017 Woods & Poole	2045 Woods & Poole	Change 2017-2045 IHS	Change 2017-2045 Woods & Poole	Change 2017-2045 as % 2017 Employment IHS	Change 2017-2045 as % 2017 Employment Woods & Poole	Difference
Farm, forestry, fishing, related activities	10,632	10,582	9,851	11,442	-50	1,591	-0.04%	0.99%	1.03%
Mining	4,212	4,260	4,146	4,617	48	471	0.03%	0.29%	0.26%
Utility	345	291	496	541	-54	45	-0.04%	0.03%	0.07%
Construction	4,031	9,037	7,347	9,151	5,006	1,804	3.63%	1.12%	-2.51%
Manufacturing	17,155	19,614	15,732	14,938	2,459	-794	1.78%	-0.49%	-2.28%
Wholesale trade	4,006	2,872	4,537	5,250	-1,134	713	-0.82%	0.44%	1.27%
Retail trade	16,678	13,736	20,965	25,577	-2,942	4,612	-2.13%	2.87%	5.00%
Transportation and warehousing	3,310	2,644	4,489	4,865	-666	376	-0.48%	0.23%	0.72%
Information	802	579	1,156	1,089	-223	-67	-0.16%	-0.04%	0.12%
Finance and insurance	3,155	2,881	4,791	6,608	-274	1,817	-0.20%	1.13%	1.33%
Real estate and rental and leasing	877	1,207	4,705	6,374	330	1,669	0.24%	1.04%	0.80%
Professional, scientific, and technical services	5,368	3,175	5,437	6,617	-2,193	1,180	-1.59%	0.73%	2.32%
Management of companies and enterprises	1,331	680	1,723	2,498	-651	775	-0.47%	0.48%	0.95%
Administrative and support, waste management And remediation services	4,355	5,944	6,942	8,285	1,589	1,343	1.15%	0.84%	-0.32%
Educational services	1,543	1,337	1,928	2,162	-206	234	-0.15%	0.15%	0.29%
Health care and social assistance	16,542	17,321	16,938	23,843	779	6,905	0.56%	4.29%	3.73%
Arts, entertainment, and recreation	814	1,199	1,688	1,914	385	226	0.28%	0.14%	-0.14%
Accommodation and food services	9,466	7,851	10,537	12,050	-1,615	1,513	-1.17%	0.94%	2.11%
Other services (except public administration)	7,069	5,401	9,462	9,544	-1,668	82	-1.21%	0.05%	1.26%
Public administration[a]	26,272	23,179	27,967	33,426	-3,093	5,459	-2.24%	3.39%	5.64%
Total	137,963	133,790	160,837	190,791	-4,173	29,954	-3.02%	18.62%	21.65%

[a] For example, IHS Markit (Jeafarqomi, 2018) forecast that public administration employment will decrease from 26,272 (2017) to 23,179 (2045), a decrease of 3,093. Given a total 2017 employment of 137,963, the decrease in public administration contributes a 3,093 / 137,963 = 2.24% decrease in jobs. Woods & Poole (2018b) forecast that public administration employment (aggregated by the research team from state government, federal government, and military) will increase by 5,459 from 27,967 (2017) to 33,426 (2045), which relative to a 2017 total employment of 160,837, reflects a 3.39% (i.e., 5,459 / 160,837) increase in total employment. The difference between these two percentages (i.e., public administration increases total employment by 3.39% for one source minus the 2.24% decrease in total employment attributed to public administration from another source) is shown as 5.64% for public administration in the rightmost column.

Figure 26 shows the contributors, by sector, to the differences in employment forecasts by IHS Markit (Jeafarqomi, 2018) and Woods & Poole (2018b), where the former shows total employment dropping by 3% and the latter shows total employment increasing by 19%. If the former source were assigned the same percent increase in public administration employment as the latter source, the forecast total employment for the former source would change from -3% to 3% (compared to the 19% employment forecast for the latter source). Making both public administration and the second largest discrepant sector (retail trade) have the same percent increase in employment would mean that the former source would now forecast an 8% increase in employment; repeating this with the third largest discrepant sector (health care and social assistance) would now mean that the former source forecasts total employment to grow by 12%. In short, if these three sectors—public administration, retail trade, and health care and social assistance—had the same forecast growth from both sources, Table 21 would have indicated the forecast change in employment for the Bristol District to range from 12% to 19% (rather than from a 3% drop to 19%).

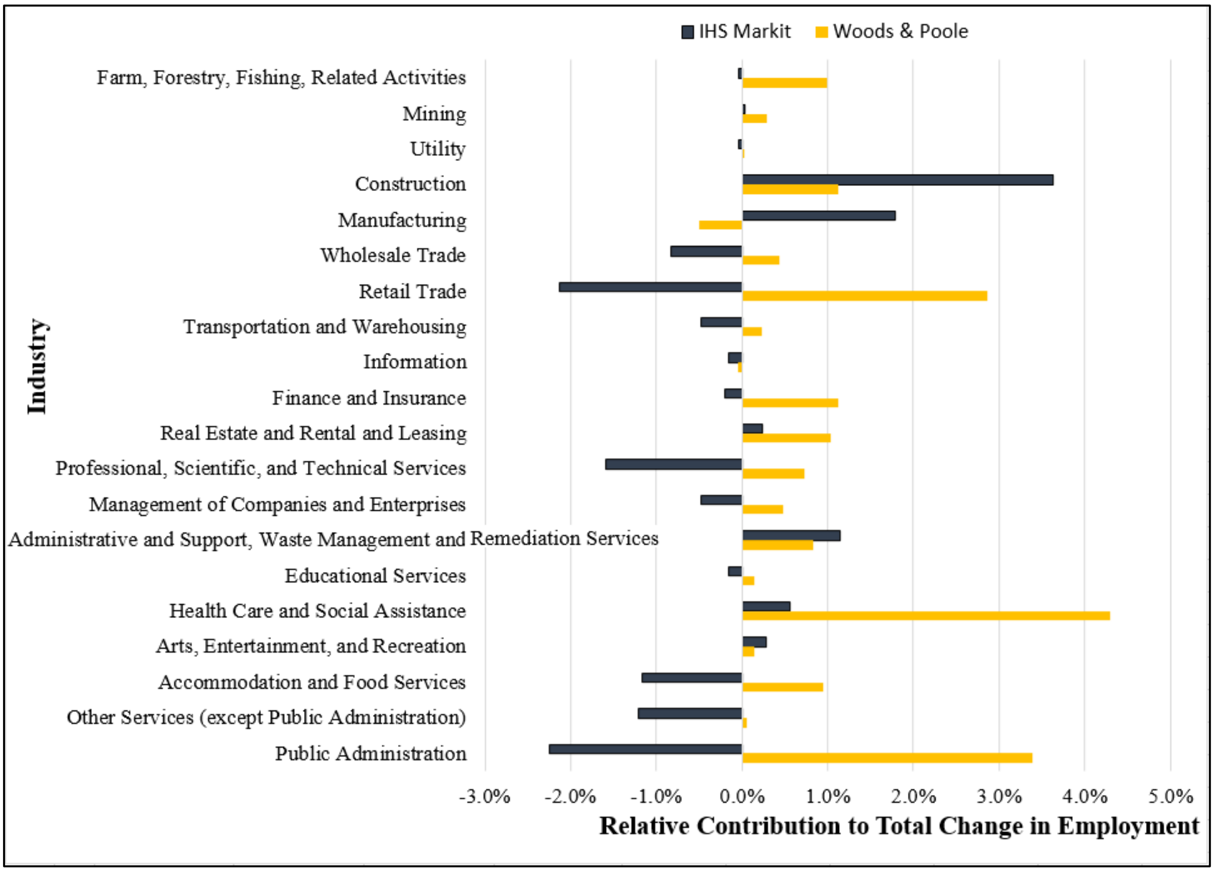


Figure 26. Detailed Occupational Category Contributions to Differences in Employment Forecasts (2017-2045) Between IHS Markit (Jeafarqomi, 2018) and Woods & Poole (2018b). For example, IHS Markit forecast that public administration employment will decrease from 26,272 (2017) to 23,179 (2045), a decrease of 3,093. Given a total 2017 employment of 137,963, the decrease in public administration alone contributes a 3,093 / 137,963 = 2.24% decrease in total employment. Woods & Poole (2018b) forecast that public administration employment will increase by 5,459 from 27,967 (2017) to 33,426 (2045), which relative to a 2017 total employment of 160,837 reflects a 3.39% (i.e., 5,459 / 160,837) increase in total employment. Compared to other industries, the forecast change in public administration employment is the largest contributor to the overall forecast decrease in employment (IHS Markit [(Jeafarqomi, 2018]) and the second largest contributor to the overall forecast increase in employment (Woods & Poole, 2018b).

Household Income

Weighted Mean Household Income

Virginia's weighted mean household income is forecast to grow from 2017-2045 by 38%, with PDC increases ranging from 25% to 40%. Visual inspection does not immediately suggest a geographic pattern for these ranges; for example, two rural PDCs have both the highest forecast growth rate (Southside at 39%) and the lowest growth rate (Middle Peninsula at 24%), as shown in Table 26 and Figure 27. These percentage increases can be both useful and misleading: they are useful in that relative to the present day, household incomes are forecast to increase by roughly one-third (plus or minus about 7 percentage points). The rates of increase can be misleading, however, because the 2017 mean income values vary widely by PDC: the highest income (Northern Virginia) is about 2.85 times the value of the lowest income (Lenowisco), and the PDC with the 75th percentile income (Hampton Roads) is 1.48 times the value of the PDC with the 25th percentile income (Mount Rogers). Thus, although there is not substantial variation among the rates of increase, there remains variation by PDC regarding the mean incomes themselves. Generally, this disparity by PDC is forecast to remain in 2045: the highest PDC is forecast to have 2.76 times the income of the lowest PDC, and the ratio of the 75th percentile / 25th percentile PDC is forecast to be 1.52.

Table 26. Weighted Mean Household Income (2009 Dollars)

	Weighted Mean Household Income (2009 $)		
Planning District Commission	**2000**	**2017**	**2045**
Lenowisco	53,519	60,582	82,469
Cumberland Plateau	58,806	63,893	86,968
Mount Rogers	62,245	73,164	96,054
New River Valley	60,927	74,194	98,370
Roanoke Valley-Alleghany	78,026	90,024	123,882
Central Shenandoah	72,376	84,524	107,818
Northern Shenandoah	80,905	98,865	130,661
Northern Virginia	153,295	172,388	227,461
Rappahannock-Rapidan	104,357	119,278	154,414
Thomas Jefferson	94,282	120,204	153,176
Central Virginia	75,293	80,534	109,342
West Piedmont	62,940	70,094	91,768
Southside	59,716	69,878	97,414
Commonwealth Regional Council	60,624	69,800	92,374
Richmond Regional	101,449	120,482	163,575
George Washington	98,370	123,298	164,866
Northern Neck	72,252	84,637	109,504
Middle Peninsula	81,274	95,167	118,114
Crater	73,345	84,047	113,054
Accomack-Northampton	60,596	80,544	111,527
Hampton Roads	88,679	108,505	148,086
Virginia (Mean)	100,897	120,910	166,467

[a] Based on data from Woods & Poole (2018b).

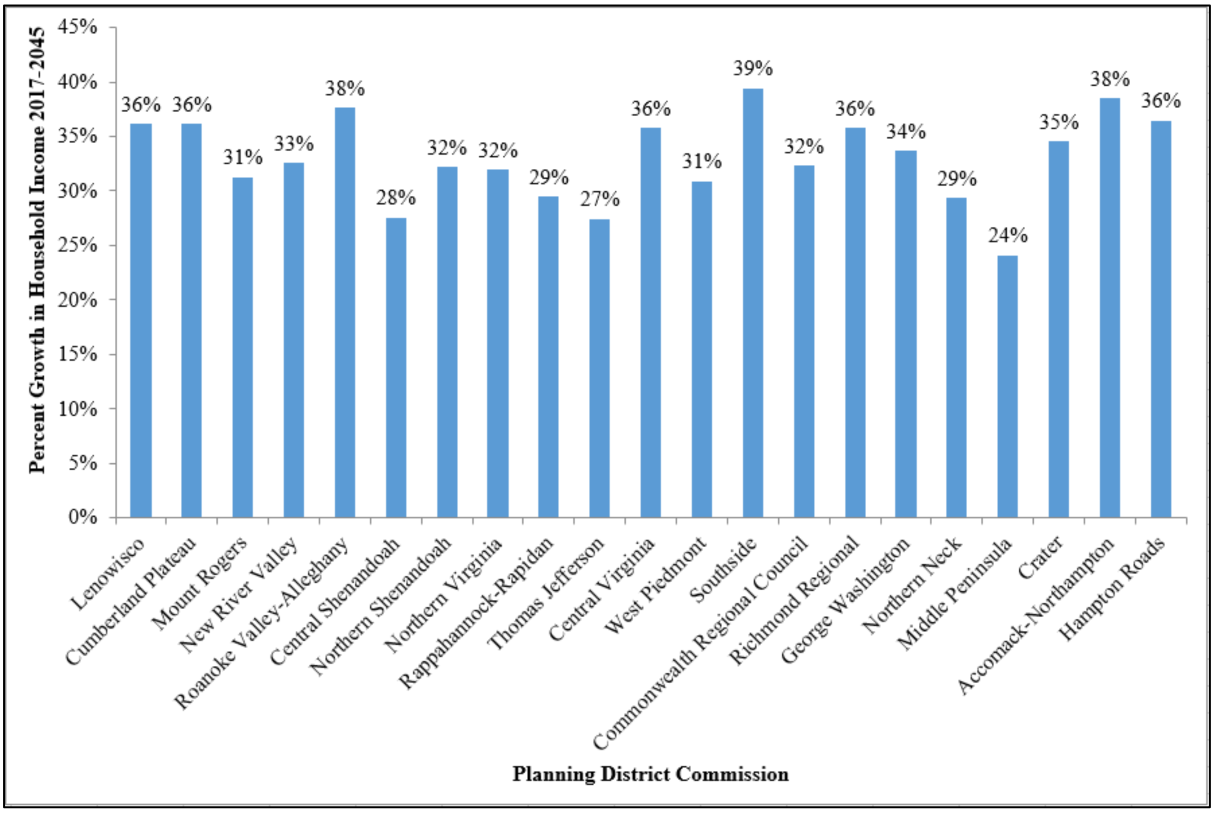


Figure 27. Forecast % Growth in Weighted Mean Household Income by PDC, 2017-2045. Based on data from Woods & Poole (2018b). For example, in 2000 the Middle Peninsula PDC had 32,947 households and a total household income of $2,677,744,032. The weighted mean household income was calculated by dividing total household income by the total number of households, such that (2,677,744,032 / 32,947) = $81,274 per household. Similar calculations yielded the weighted mean household income of this PDC for years 2017 and 2045 as $118,114 and $95,167, respectively. The growth in weighted mean household income for this PDC from 2017-2045 is calculated as [($118,114 - $95,167) / $95,167] * 100 = 24%. PDC = planning district commission.

A similar observation can be made about the distribution of household income by VDOT district. As shown in Figure 28, all districts show forecast growth in mean household incomes; however, as shown in Table 27, the 2017 incomes vary widely (by a factor of more than 2 from the lowest to the highest). Further, only one district (Northern Virginia) has a household income that exceeds the mean value for Virginia.

Table 27. Weighted Mean Household Income of VDOT Districts (2009 Dollars) for 2000, 2017 and 2045

	Weighted Mean Household Income (2009 $)		
District	**2000**	**2017**	**2045**
Bristol	59,247	67,950	91,147
Salem	71,712	82,339	109,938
Lynchburg	65,868	73,571	102,413
Richmond	95,393	113,744	156,125
Hampton Roads	87,128	106,960	146,272
Fredericksburg	90,439	113,106	152,346
Culpeper	99,285	121,092	155,098
Staunton	75,443	90,182	117,615
Northern Virginia	153,295	172,388	227,461
Virginia (Mean)	100,897	120,910	166,467

Drawn based on data from Woods & Poole (2018b).

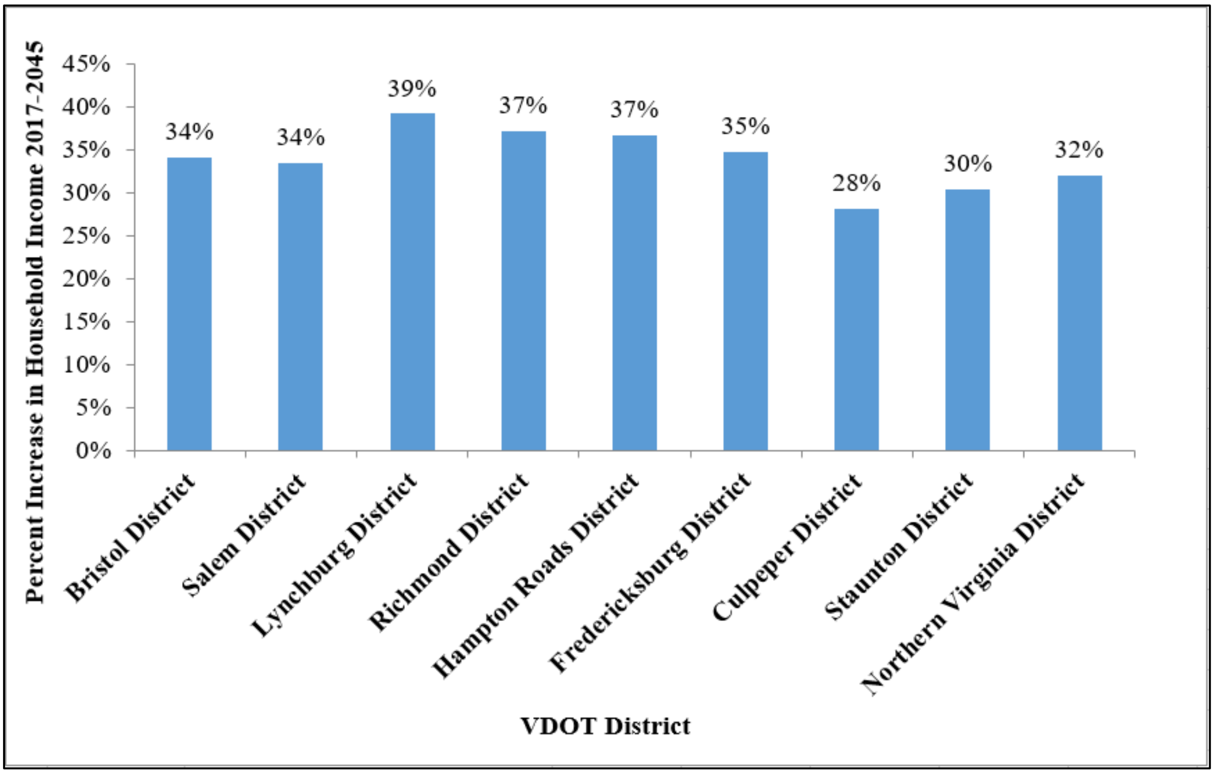


Figure 28. Forecast % Growth in Weighted Mean Household Income by VDOT District, 2017-2045. Based on data from Woods & Poole (2018b). For example, in 2000 the Salem District had 264,113 households and a total household income of 18,940,097,700. The weighted mean household income was calculated by dividing total household income by the number of households as (18,940,097,700 / 264,113) = $71,712 per household. Similar calculations yielded weighted mean household incomes for 2017 and 2045 of $82,339 and $109,938, respectively. Thus, the growth in weighted mean household income for this district from 2017-2045 is {[(109,938 - 82,339) / 82,339] * 100} = 34%.

Median Household Income

Tables 28 and 29 show the household-weighted median income by PDC and district, respectively. Although the weighted median household incomes themselves are lower than the weighted mean incomes obtained from Woods & Poole (2018a), there are at least three key trends that can be compared to results from the Woods & Poole data.

Virginia incomes are not evenly distributed: most PDCs or districts are below the median value. For year 2017, with a statewide median household income of $68,351, only 3 of Virginia's 21 PDCs exceed that value: Rappahannock-Rapidan ($68,849), George Washington ($80,235), and Northern Virginia ($104,225). For year 2045, only the latter 2 PDCs are forecast to exceed the statewide median household income. A similar result occurs by VDOT district: for both 2017 and 2045, only the Fredericksburg and Northern Virginia districts exceed the statewide median household income.

The growth in household income tells a slightly different story. In absolute terms (e.g., the difference between 2045 and 2017 incomes, all in year 2009 dollars), 5 PDCs exceed the average change in median income of $17,390: George Washington ($18,410), Northern Shenandoah ($18,897), Northern Virginia ($19,918), Northern Neck ($22,207), and Thomas Jefferson ($22,340). Three of the nine VDOT districts (Fredericksburg, Culpeper, and Northern Virginia), all exceed the average statewide increase in median income but by lesser amounts of $2,243, $2,497, and $2,528, respectively.

Table 28. Forecast Change in Median Household Income by Planning District Commission[a]

No.	Planning District Commission	2000	2017	2045	Increase (2017-2045)	Difference (2017-2045)
1	Lenowisco	$30,386	$30,356	$40,856	35%	$10,500
2	Cumberland Plateau	$30,220	$31,986	$39,061	22%	$7,076
3	Mount Rogers	$36,918	$36,139	$46,380	28%	$10,241
4	New River Valley	$39,849	$46,208	$54,105	17.1%	$7,897
5	Roanoke Valley-Alleghany	$47,633	$48,139	$57,262	19.0%	$9,123
6	Central Shenandoah	$46,135	$44,286	$59,988	35%	$15,701
7	Northern Shenandoah	$51,470	$58,491	$77,388	32%	$18,897
8	Northern Virginia	$93,690	$104,225	$124,142	19.1%	$19,918
9	Rappahannock-Rapidan	$62,668	$68,849	$85,352	24%	$16,503
10	Thomas Jefferson	$53,514	$60,642	$82,982	37%	$22,340
11	Central Virginia	$45,863	$43,515	$53,778	24%	$10,263
12	West Piedmont	$37,286	$34,612	$50,430	46%	$15,818
13	Southside	$36,656	$36,607	$51,905	42%	$15,298
14	Commonwealth Regional Council	$37,658	$38,382	$51,926	35%	$13,544
15	Richmond Regional	$59,927	$61,807	$74,893	21%	$13,085
16	George Washington	$71,355	$80,235	$98,644	23%	$18,410
17	Northern Neck	$42,508	$44,327	$66,535	50%	$22,207
18	Middle Peninsula	$51,905	$53,696	$67,646	26%	$13,950
19	Crater	$45,244	$52,116	$57,065	9%	$4,949
22	Accomack-Northampton	$35,900	$36,220	$52,930	46%	$16,710
23	Hampton Roads	$53,504	$57,641	$68,900	20%	$11,259
Estimated Statewide Median[b]		$61,502	$68,351	$85,741	25%	$17,390

[a] Calculated based on data from Moody's Analytics (2019). Incomes are in year 2009 dollars.
[b] Estimated as the household-weighted mean of the median incomes reported by jurisdiction. For example, if the state contained only 2 jurisdictions where jurisdiction A has 5,000 households with a median income of $50,000 and jurisdiction B has 20,000 households with a median income of $60,000, the estimated statewide median income is ($50,000 * 5,000 + $60,000 * 20,000) / (5,000 + 20,000) = $58,000. This $58,000 is an approximation and is not identical to a true median based on individual incomes from all 25,000 households.

Table 29. Forecast Change in Median Household Income by VDOT District[a]

No.	District	2000	2017	2045	Increase (2017-2045)	Difference (2017-2045)
1	Bristol	$33,247	$33,923	$43,039	27%	$9,116
2	Culpeper	$57,700	$64,524	$84,411	31%	$19,887
3	Fredericksburg	$62,479	$70,703	$90,336	28%	$19,633
4	Hampton Roads	$52,610	$56,719	$68,287	20%	$11,567
5	Lynchburg	$40,017	$37,297	$48,518	30%	$11,221
6	Northern Virginia	$93,690	$104,225	$124,142	19%	$19,918
7	Richmond	$56,646	$59,469	$72,087	21%	$12,618
8	Salem	$44,073	$46,261	$57,443	24%	$11,183
9	Staunton	$48,042	$50,053	$67,381	35%	$17,327
Estimated Statewide Median[b]		$61,502	$68,351	$85,741	25%	$17,390

[a] Calculated based on data provided by Moody's Analytics (2019). Incomes are in year 2009 dollars.
[b] Estimated as the household-weighted mean of the median incomes reported by jurisdiction.

On a percentage basis, the 2 PDCs that show the highest relative increases in median income are Northern Neck (a 50% increase from 2017 to 2045) and Accomack-Northampton (a 46% increase). The question of whether increases are best represented by percentages or absolute differences is illustrated well by the Northern Virginia District, which although having the highest increase in income in terms of absolute difference (an increase of $19,918) has the lowest increase in income in terms of a percentage (an increase of 19%).

Third, it is notable that incomes (again in real dollars) are all forecast to rise. The lowest percentage increase is in the Crater PDC (a 9% increase from $52,116 to $57.065 for the period 2017-2045); all other PDCs show double-digit increases.

Retrospective Forecast Accuracy

It is not unusual for population estimates to shift. For example, where Weldon Cooper (2017b) forecast a 2040 Virginia population of 10,201,530, 2 years later Weldon Cooper (2019b) forecast a 2040 Virginia population of 9,876,728—a drop of approximately 3.2%. Sen (2019) does not explicitly name the 2017 forecast but notes that "the pace of growth may be a little slower than what was earlier projected," explaining that at least through year 2030, three factors—fewer people moving to Virginia, a lower birth rate, and more deaths—are expected to yield lower population growth rates than had been observed for the period 2000-2010.

Generally speaking, forecasts for smaller entities tend to have a larger percent error than those of larger entities. For example, the Albemarle County Department of Planning and Community Development (1994) reported 2010 forecasts for the county's total population and forecasts by five age groups (under 5, 5-19, 20-39, 40-64, and 65+). The Albemarle County Department of Community Development (2011) subsequently reported the observed 2010 population values for the county. With error defined as the difference between the forecast and the observed values divided by the observed value, the forecast total population for Albemarle County (90,148) differed from the observed value (98,970) by about 9%. As expected, the forecast errors for the age groups were generally larger: 12% (under age 5), 11% (age 5-19), 13% (age 40-64), and 15% (age 65+). However, there can be exceptions to this rule: Table 30 shows that for Albemarle County, there was one age group (20-39) where the forecast error (3%) was smaller than for the county as a whole.

A second factor that affects forecast error is stability of the jurisdiction being forecast. For example, from the Albemarle County Department of Planning and Community Development (1994), the population forecast error for Albemarle County (9%) was about twice as large as that of the City of Charlottesville (5%). In this case, a contributing factor may have been that the City of Charlottesville was relatively stable. For the period from 1990-2010, Charlottesville's population was forecast to grow only 2%; by contrast, Albemarle County's population was forecast to grow 32%.

Table 30. Albemarle County Population Forecasts for Year 2010[a]

Entity	1990	2010 Forecast	2010 Observed	Percent Error[b]
Albemarle County (0-4)	4,655	4,858	5,527	12%
Albemarle County (5-19)	14,670	18,704	21,032	11%
Albemarle County (20-39)	24,807	25,706	25,062	-3%[d]
Albemarle County (40-64)	17,310	28,876	33,225	13%
Albemarle County (age 65+)	6,598	12,004	14,124	15%
Albemarle County (all ages)	68,040[c]	90,148	98,970	9%
Charlottesville City (all ages)	40,341	41,225	43,475	5%
Virginia (all ages)	6,187,358	7,451,158	8,001,024	7%

[a] Forecasts were based on Albemarle County Department of Planning and Community Development (1994), and observed values were based on Albemarle County Department of Community Development (2011).
[b] Percent error is computed as (Forecast value – Observed value) / Observed value.
[c] The reported value is 68,040; however, the total of these age groups is 68,172.
[d] This is the only instance where the observed value is less than the forecast value.

The results of population forecasts done by the Stafford County Planning Commission (2010) shown in Table 31 also show the trend of how population forecasts are typically more accurate (lower percent error) for larger populations than for smaller ones. For example, the projected population of the entire state of Virginia had a percent error of 0.12%. In addition, the projected population of Prince William County, the largest jurisdiction on the list, had a percent error of 0.17%. Comparatively, the population forecast for Fauquier County, which has one of the smaller populations on this list, had a percent error of 11.47%. However, King George County has the smallest population on this list yet its population forecast had a percent error of only 0.02%. Other than this one county, percent errors were smaller for larger jurisdictions.

All of the counties in Table 31 have population projections reflecting relatively high growth from 2000-2010. In this case, it would appear that stability does not play a large role in affecting the differences in forecast accuracy. For example, even though King George County was projected to grow from only 16,803 to 23,580, this 40% increase was similar to the 41% projected growth of Prince William County.

Population projections are generally more accurate for large populations. This is not always the case, however, as shown in the forecasts by MWCOG (2005). For example, Table 32 shows a 4.63% error in the 2010 projection of the population of Fairfax County (inclusive of the cities of Fairfax and Falls Church) whereas for smaller Loudoun County the error in the population projection is only 1.86%. Since all forecasts were higher than the observed value, one possible factor might be the economic recession that began in 2008.

Table 31. Stafford County Population Forecasts for Year 2010[a]

Jurisdiction	2000 Census	2010 Projection	2010 Observed	Percent Error[b]
Stafford County	92,446	135,806	128,961	-5.31%
Fauquier County	55,577	72,685	65,203	-11.47%
King George County	16,803	23,580	23,584	0.02%
Prince William County	283,811	401,323	402,002	0.17%
Spotsylvania County	90,395	134,163	122,397	-9.61%
City of Fredericksburg	19,279	22,371	24,286	7.89%
State of Virginia	7,104,078	8,010,342	8,001,024	-0.12%

[a] Forecasts are based on past data in Stafford County's 2010 Comprehensive Plan (Stafford County Planning Commission, 2010), and observed values are based on data from the U.S. Census Bureau (2010c).
[b] Percent error is computed as 100 * (|Projection value – Observed value| / Observed value).

Table 32. Metropolitan Washington Council of Governments Population Forecasts for Year 2010[a]

Jurisdiction	2000 Population	2010 Projection	2010 Observed	Percent Error[b]
Arlington County	190,314	212,231	207,627	- 2.22%
City of Alexandria	128,283	143,903	139,966	- 2.81%
Fairfax County, Fairfax City, and City of Falls Church	1,000,726	1,168,296	1,116,623	- 4.63%
Loudoun County	169,599	318,134	312,311	- 1.86%
Prince William Co. / Manassas / Manassas Park	326,712	470,362	454,096	- 3.58%

[a] Projections based on Metropolitan Washington Council of Governments (2005), and observed values based on data from the U.S. Census Bureau (2010a, b).
[b] Percent error was computed as 100 * (Projection - Observed value / Observed value).

Occasionally, unpredictable external factors such as economic patterns will lead to different than expected population growth and thus greater uncertainty. For example, the City of Williamsburg thinks the majority of the 7% error in the 1981 forecast (Table 33) can be accounted for by the unanticipated population growth that followed the establishment of Anheuser-Busch Brewery, Busch Gardens, and the Kingsmill development prior to 1981 (City of Williamsburg, 2013). The 1989 projection, although closer to the forecast year of 2000, did have a higher percent error of 13%. The average projection during this year was 13,552, but projections ranged from 12,620 to 14,423, all of which were overestimates of the actual population of 11,998. Language from the 1989 plan, which is reported in Appendix A1 of City of Williamsburg (2013), and subsequent events illustrate types of changes that might not be evident at the time a forecast is made: the aforementioned 1989 plan includes two major transportation investments that were ultimately not made: an extension of Monticello Avenue (which was rejected by the city council 3 years later) and a "Parkway Drive/Merrimac Trail connection" (which was omitted from the next comprehensive plan completed in 1998) (City of Williamsburg, 2013).

Similar developments and plans in future comprehensive plans led to uncertainties in the forecast 2010 populations, as shown in Table 34. The 1998 plan featured a new chapter on urban design that focused on quality of new development. In addition, the population of 2010 was greatly affected by the recession of 2007-2009 (City of Williamsburg, 2013). This recession may have significantly suppressed the population growth that was originally predicted, leading to a large percent error of 18%. Although it is generally expected for population projections conducted several years in advance to have a greater percent error than those conducted closer to the projected year, this is not always the case because of unexpected outside economic factors and expectations such as these discussed for the City of Williamsburg.

The forecasts made in 2007 for the 2010 populations of Charlottesville City, Albemarle County, and the Charlottesville Metropolitan Statistical Area (MSA) are shown in Table 35 (City of Charlottesville, 2007). The Charlottesville MSA is much larger than either Charlottesville or Albemarle individually, but its 2010 forecast has a percent error of 8.78%, which is larger than those for Charlottesville City (7.77%) and Albemarle County (1.79%). This reflects the uneven nature of growth among the jurisdictions that comprise the Charlottesville MSA. From 1990-2005, the population of the Charlottesville MSA grew nearly 43%, the population of Albemarle County grew 32%, and the population of Charlottesville City decreased 2%.

Table 33. Williamsburg Population Forecasts for Year 2000[a]

Year of Comprehensive Plan	2000 Projection	2000 Census	Percent Error[b]
1981	11,200	11,998	7%
1989	13,522	11,998	13%

[a] Projections and census values based on data from Williamsburg Comprehensive Plan: Appendix A1—Past Comprehensive Plans (City of Williamsburg, 2013).
[b] Percent error computed as (|Projection - Census value| / Census value) *100.

Table 34. Williamsburg Population Forecasts for Year 2010[a]

Year of Comprehensive Plan	2010 Projection	2010 Census	Percent Error[b]
1998	13,813	14,068	-2%
2006	16,600	14,068	18%

[a] Projections and census values based on data from City of Williamsburg (2013).
[b] Percent error computed as 100 * (Projection - Census value / Census value).

Table 35. Population Forecast for Year 2010[a]

Area	1990 Census	2005 Estimate	2010 Projection	2010 Census	Percent Error[b]
Charlottesville City	40,341	39,610	40,099	43,475	7.77%
Albemarle County	68,040	90,100	97,200	98,970	1.79%
Charlottesville MSA	131,107	186,709	199,500	218,705	8.78%
Virginia	6,187,358	7,564,327	7,892,884	8,001,024	1.35%

[a] Forecasts are based on past data in the Charlottesville Comprehensive Plan (City of Charlottesville, 2007); census values for Charlottesville City, Albemarle County, and Virginia are based on data from the U.S. Census Bureau (2010d); census values for the Charlottesville MSA are based on data from the Virginia Employment Commission (2018).
[b] Percent error is computed as 100 * (Projection value – Census value / Census value).

Differences in projections for the same forecast year may be related to differences in forecasting techniques. For instance, an MWCOG document associated with the earlier (Round 7) forecasts for year 2030 (MWCOG, 2005) points out that these forecasts are based on a cooperative process that aligns regional level forecasts with local forecasts (which incorporate planned projects) developed by each jurisdiction and that a subcommittee composed of representatives from these jurisdictions and MWCOG staff work to "reconcile" these local and regional projections. Weldon Cooper (2019c) uses several data inputs but not such local plans. Table 36 shows a comparison of forecasts made by MWCOG (2018) and Weldon Cooper (2017a) for the populations of different Virginia jurisdictions in the year 2045. The average percent difference of these two forecasts across 13 jurisdictions was 19.7%, with a 7.3% difference in the regional total. However, several individual jurisdictions have greater differences, such as City of Fairfax (37.59%), City of Manassas Park (36.92%), Loudoun County (32.59%), and Spotsylvania County (31.74%).

Table 36. Comparison of MWCOG (2018) and Weldon Cooper (2017a) Population Projections for 2045[a]

Jurisdiction	MWCOG (thousands)	Weldon Cooper (thousands)	Percent Difference[b]
Arlington County	301.2	325.124	7.36%
City of Alexandria	208.5	223.281	6.62%
Fairfax County	1,416.80	1,386.476	-2.19%
City of Fairfax	35.2	25.584	-37.59%
City of Falls Church	17.6	21.629	18.63%
Loudoun County	507.4	755.869	32.87%
Prince William County	584	729.137	19.91%
City of Manassas	52.1	53.948	3.43%
City of Manassas Park	15.9	25.206	36.92%
King George County	47	37.185	-26.40%
Spotsylvania County	253.6	192.503	-31.74%
Stafford County	267.9	222.554	-20.38%
City of Fredericksburg	36.2	40.944	11.59%
Total	3,743.4	4,039.440	7.33%

[a] Forecasts based on data in Metropolitan Washington Council of Governments (MWCOG) Final Round 9.1 Cooperative Forecasts (MWCOG, 2018) and Weldon Cooper Center for Public Service (2017a).
[b] Percent error is computed as 100 * (Weldon Cooper projection value – MWCOG projection value / Weldon Cooper projection value).

Areas of Interest to Stakeholders

Stakeholders identified seven main areas of interest:

1. With regard to migration patterns for moving to or from Virginia, which states are donors and which are donees?

2. How would the arrival of an unexpected employer affect regional and local forecasts?

3. How has transportation been used to attract jobs and population?

4. What lessons can be learned from the interaction of population and employment changes?

5. What are the impacts of population and employment trends on transportation needs?

6. Given that forecasts have uncertainty, what are appropriate forecast ranges for 2045?

7. How do population and employment forecasts compare to those of Virginia's border states?

Migration Patterns

Examination of changes in the state of residence provided by the U.S. Census Bureau (2018g) shows that based on 2017 year data when the American Community Survey (ACS) was conducted, about one-quarter million individuals 1 year or older (250,490 people) moved to Virginia from another U.S. state (including the District of Columbia) 1 year prior to the 2017 ACS data being collected. A slightly greater number (262,563 people) moved from Virginia to another state over the same period. This population loss where outmigration from Virginia to another U.S. state exceeds in-migration to Virginia from another U.S. state (12,073 people) represents about 0.14% of Virginia's population that was reported by the U.S. Census Bureau (2018g) at the time the 2017 ACS was conducted.

Figure 29 illustrates the net loss of Virginians who moved to another state and the net gain of Virginians who came from another state. For instance, in 2016 (such that these values were collected in the 2017 ACS and thus reported by the U.S. Census Bureau [2018g]), 17,864 Floridians moved to Virginia and 28,232 Virginians moved to Florida, making Florida represent a net loss of 10,368 Virginians, as shown in Table 37. Thus, as indicated in Figure 29, of all U.S. states, Florida is the largest net capturer of Virginia residents. In contrast is Pennsylvania (as seen in Figure 29); 13,350 Pennsylvanians moved to Virginia and 8,417 Virginians moved to Pennsylvania, for a net gain of 4,933. The named states in Figure 29 reflect about 85% of the total of state-by-state losses and gains; the "other" category reflects the remaining 15% of state-by-state losses and gains. Of interest in Figure 29 is that four border states reflect a substantial portion of this change in migration: with regard to people's movement in 2016 (such that the movements were recorded in the 2017 ACS), Virginia was attracting residents from Maryland and the District of Columbia and was losing them to North Carolina and Tennessee.

Although Figure 29 is based on only 1 year of data (i.e., persons who in 2016 moved to or from Virginia and were thus tabulated in the 2017 ACS [U.S. Census Bureau, 2018g], Figure 29 appears to show a trend that Lombard (2017b) notes began in 2012: Virginia shifted from being a net importer of individuals from U.S. states (1990-2011) to being a net exporter to other U.S. states (2012-2015). Based on this earlier data set that captures persons moving to or from Virginia from 1990-2015 inclusive, Lombard (2017b) found that Virginia had a net gain of residents from Maryland and a net loss of residents to the states of North Carolina, Tennessee, and Florida, as Figure 29 also shows for persons moving to or from Virginia in 2016.

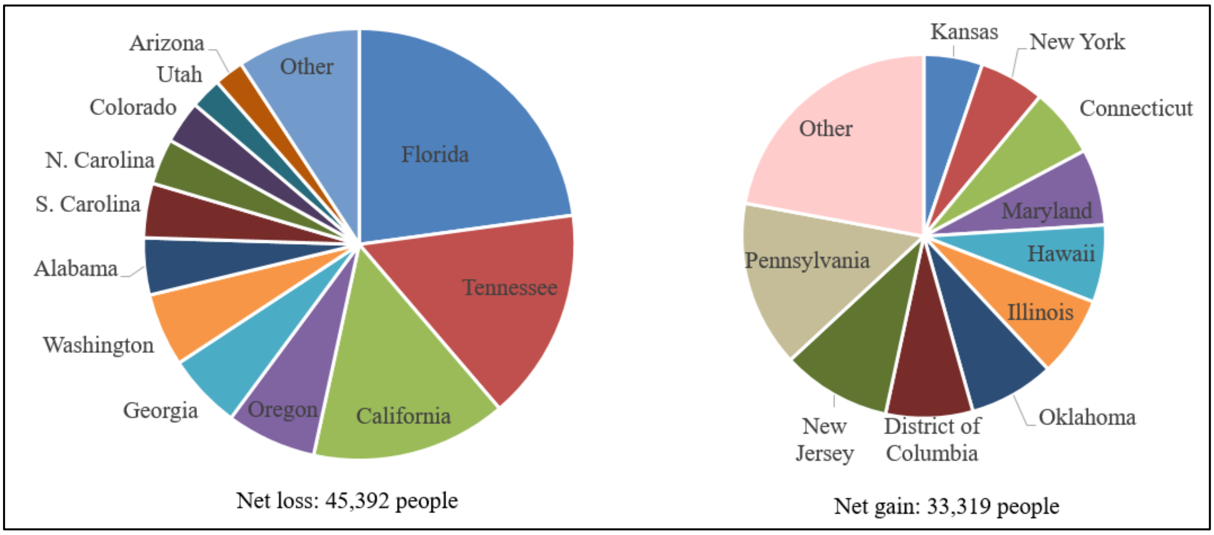


Figure 29. Net Loss (left) and Net Gain (right) in Virginia's Population for Select States. Drawn from the data provided by the U.S. Census Bureau (2018g). For example, 10,088 people from the District of Columbia moved to Virginia compared to 7,509 Virginians who moved to the District of Columbia. Because Virginia thus had a net gain of 2,579 persons from this city, the District of Columbia is shown on the right side of Figure 29. This net gain from the District of Columbia was about one-half of the net gain from Pennsylvania (4,933 people).

Table 37. Net Losses (Negative) and Net Gains (Positive) in Virginia's Population: 2016-2017

State That Donated or Provided People to Virginia	Change to Virginia's Population
Florida	-10,368
Tennessee	-7,218
California	-6,653
Oregon	-3,055
Georgia	-2,548
Washington	-2,488
Alabama	-1,936
South Carolina	-1,855
North Carolina	-1,556
Colorado	-1,455
Utah	-1,064
Arizona	-1,006
Other states to which Virginia lost population	-4,190
Kansas	1,742
New York	1,937
Connecticut	2,054
Maryland	2,263
Hawaii	2,291
Illinois	2,388
Oklahoma	2,532
District of Columbia	2,579
New Jersey	3,242
Pennsylvania	4,933
Other states from which Virginia gained population	7,358

[a] Data extracted from the U.S. Census Bureau (2018g). States (and the District of Columbia) with losses or gains exceeding 1,000 persons are shown. For example, 10,088 persons moved from the District of Columbia to Virginia compared to 7,509 persons who moved from Virginia to the District of Columbia. Because Virginia thus had a net gain of 2,579 persons from this city, the District of Columbia has a positive value.

Lombard (2017b) attributed the net losses to Virginia in large part to three factors: (1) budget sequestration (which adversely affects the economies of Northern Virginia); (2) high home prices in Northern Virginia compared to locations where economies are strong but home prices are substantially lower (e.g., Raleigh, North Carolina); and (3) the popularity of Florida and other warm-weather locations as retirement spots. A graphic that illustrates net migration between Virginia and other states, shown in Lombard (2017b), differs from Figure 29 in at least one respect: the former indicated Texas as a large net importer of Virginians (more than 2,000 people in 2015) whereas the more recent data set indicated that Virginia gained a small number of Texans (e.g., 15,596 Texans came to Virginia and 15,436 Virginians went to Texas in 2016 relative to the 2017 ACS data collection effort). That said, a contributing factor may be differences in data sets: Lombard (2017b) uses annual data from the Internal Revenue Service (except for 1 year where Lombard indicates "Census migration data" were used), whereas Figure 29 uses data based on the ACS (U.S. Census Bureau, 2018g).

County-by-county migrations were not available for the 2017 ACS that was used to develop Figure 29. However, county-by-county migrations are available for the 2012-2016 ACS (U.S. Census Bureau, 2018f), which reflect movements of individuals 1 year prior to these data being collected. Tabulation of these data indicates that Virginia gained more people than it lost, with a net migration of 6,854 persons to Virginia. Although it is possible to graph these migrations by PDC (Figure 30), caution should be exercised in comparing the net gain to Virginia of 6,854 (for the 2012-2016 ACS) and the net loss to Virginia of 12,073 (for the 2017 ACS) as the margins of error are not the same (U.S. Census Bureau, 2018e). Instead, a chief implication of Figure 30 appears to be that it supports a finding of Lombard (2017b): during the 2012-2016 period, Northern Virginia lost residents to other locations in contrast to the other large regions of Hampton Roads, Richmond Regional, and George Washington.

Impact of the Arrival of an Unexpected Employer

The arrival of Amazon in Virginia provides an opportunity to examine what happens when a large employer comes to a region and such an employer is not incorporated in the earlier forecasts. One of the two locations initially chosen by Amazon in November 2018 for the construction of an HQ2 is National Landing in Northern Virginia. National Landing is composed of neighborhoods in southern Arlington County and northern parts of the City of Alexandria (Potomac Yards, Crystal City, and Pentagon City). These areas comprise six census tracts and currently have a collective population of 24,000 (Bateman et al., 2019). Although the portion of Northern Virginia inside the Beltway is generally a very densely populated and highly developed region, "the Crystal City area [had] been a relative ghost town since 2005," when the Department of Defense's Base Realignment and Closure Project resulted in the loss of many employees (Rifkin, 2018). Although the research team used regional population, employment, and income forecasts for 2045 from sources such as Woods & Poole (2018b) and IHS Markit (Jeafarqomi, 2018), it should be noted that some localities perform their own forecasts. Such local forecasts provide greater focus on the impact of new employers, such as Amazon, at the local level and are thus the focus of the next five subsections.

Local Employment Forecasts

One view of Amazon's HQ2 is that it will ultimately result in the hiring of 25,000 employees by 2030, with an estimated 400 jobs to be created in 2019 and 1,200 more in 2020. It is anticipated that the remainder of the jobs will be filled from 2020-2025 (Sullivan, 2018).

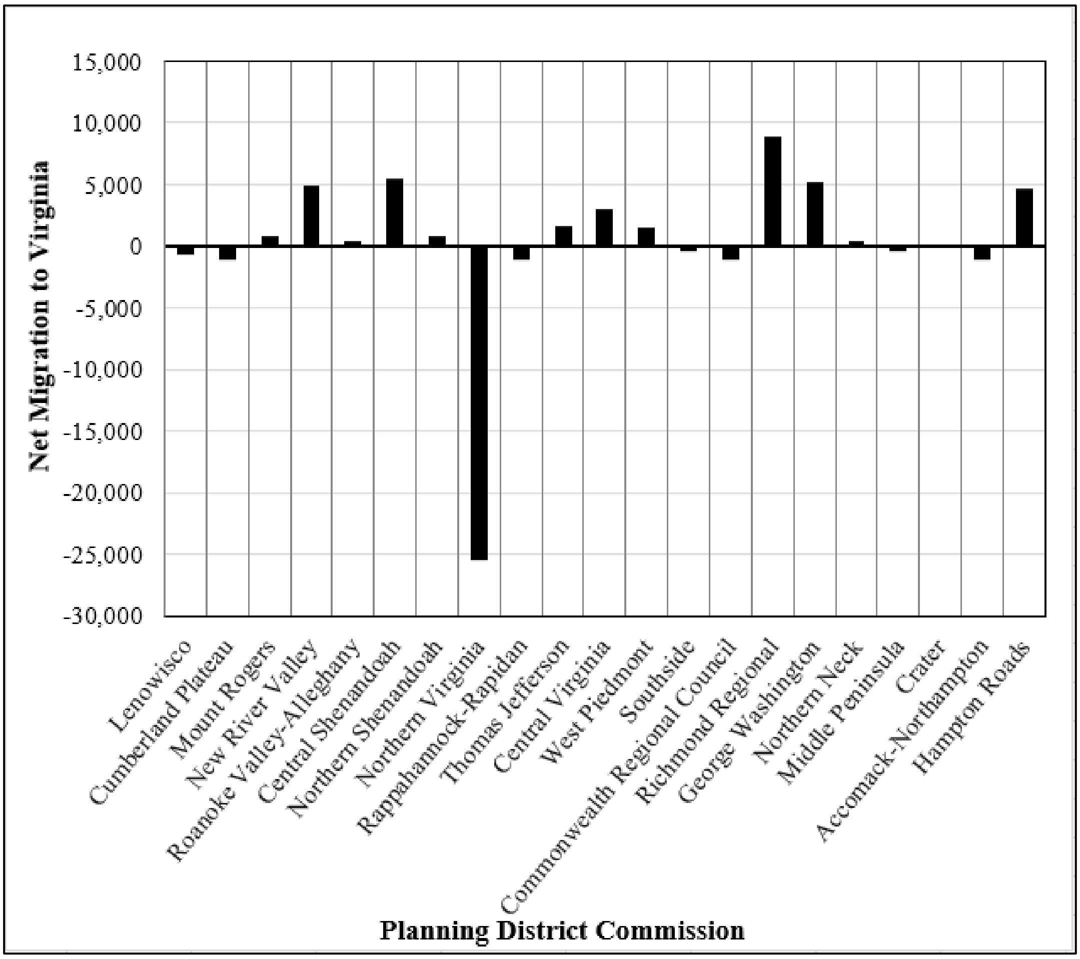


Figure 30. Net Change in Virginia's Population by PDC, 2012-2016. Data provided by the U.S. Census Bureau (2018f). For example, for the period 2012-2016, 25,390 more persons moved from the Northern Virginia PDC than moved to the Northern Virginia PDC. PDC = planning district commission.

These 25,000 "direct" jobs are expected to have ripple effects in the form of 11,225 direct jobs and 22,061 induced jobs, leading to the creation of 58,287 total jobs by 2030, according to Chmura Economics and Analytics (2018). The ripple effect is a result of support services jobs created in the area because of Amazon's HQ2.

Another view of Amazon is from the perspective of the localities in which it is situated and for the 2040, rather than the 2030, forecast year. The 2019-2039 forecasts for one such jurisdiction that will house part of HQ2—Arlington County—will require revision to incorporate Amazon's proposed workforce of up to 50,000 direct jobs (plus the 2,310 indirect and induced jobs that would be created in that county), according to Fuller and Chapman (2018). Arlington County's job growth projections before Amazon's announcement forecast the addition of 34,312 jobs over this period. With Amazon's potential addition of 52,310 jobs (including the indirect and induced job growth), the county's employment base would increase by 44.4% rather than the original estimate of 17.6% by 2039 (Fuller and Chapman, 2018). Fuller and Chapman (2018) assumed that the 52,310 jobs associated with Amazon's arrival did not account for any of these previously projected job gains in the county. It should be noted that Fuller and Chapman (2018) indicate that only 2,310 ripple effect jobs are in Arlington County; another 42,011 indirect jobs are forecast for the remainder of Virginia.

Not surprisingly, Amazon's arrival would have much smaller effects on the employment forecasts for Virginia than for Arlington County alone. From 2019-2039, Virginia's employment was projected to increase by 464,820 jobs by Fuller and Chapman (2018)—representing a total increase of 11.4% for that 20-year period. Amazon's added direct and indirect jobs (assuming all net new jobs) would increase Virginia's projected employment growth by 73,705 to 78,319 additional jobs for a larger 13.7% employment growth rate for this period (Fuller and Chapman, 2018).

Taken in context, however, researchers at the Stephen S. Fuller Institute at George Mason University (hereinafter "Fuller Institute") contend that the Washington MSA region overall has previously had and will continue to have a rate of job growth that exceeds what Amazon alone will cause. They project that the maximum Amazon-related change that will occur represents +6% to 13% of the employment and population growth that has occurred in the Washington MSA region over the last 20 years (Fuller Institute, 2018).

The Northern Virginia region is also expected to see significant increases in the number of graduate and doctoral candidates in the fields of engineering and technology as a result of Amazon's arrival. Virginia Tech will be funding a $1 billion graduate campus with programs focusing on technology in Alexandria, and George Mason University will be building an institute for digital innovation on its Arlington campus for advanced research (O'Connell and McCartney, 2018). Amazon's arrival will position the region's economy to continue to diversify away from its past heavy reliance on federal government employment (Fuller Institute, 2018). Fuller and Chapman (2018) also expect Amazon's arrival to enable Northern Virginia to attract and retain more highly educated and skilled workers, decreasing the outmigration of these workers that has been occurring.

Fuller and Chapman (2018) report a detailed analysis of the potential economic, demographic, and employment effects of Amazon's arrival on Arlington and Virginia from 2019-2039 (defined as full build-out by the authors). In that analysis, the authors estimate the population, income, job growth, and economic/fiscal effects of HQ2 at build-out for both Arlington and Virginia using two different average salary scenarios for Amazon employees ($150,000 and $200,000, in 2017$). Another analysis of the potential economic, fiscal, and employment effects of Amazon on Arlington, Virginia, and the Washington MSA in 2030 is provided by Chmura Economics and Analytics (2018).

Local Population Forecasts

The National Landing area is anticipated to see a gradual increase in population from 2019-2045 as Amazon fills more HQ2 jobs with each passing year. These investments, along with Amazon's arrival, are likely to result in an increase in Northern Virginia's forecast population (Woolsey, 2018). At full build-out (2039), Fuller and Chapman forecast that Arlington's population will show an increase of 24.2% since 2019 versus their growth forecast of 16.2% without Amazon. Similarly, the authors forecast that Virginia's population growth in the 2019-2039 period will be 17.2% versus the population forecast of 14.6% in the absence of Amazon. These estimates include the added Amazon jobs (potentially 52,310) and indirect and induced job growth (Fuller and Chapman, 2018). It should be noted that Fuller and Chapman's analysis uses IHS Markit data.

The addition of households with at least one member holding an HQ2 job is forecast to produce a net gain of between 7,139 and 8,045 households for Arlington in the 2019-2039 period. The additional Virginia (including Arlington) households with at least one member holding an HQ2 job are forecast to produce a net gain of between 34,278 and 34,290 households in the state (depending on the assumed average wage per HQ2 job) (Fuller and Chapman, 2018). The authors estimate that Arlington would gain another 1,000 to 1,100 households with a member holding a job supported by HQ2 spending, and Virginia (including Arlington) is estimated to gain between 39,415 and 44,041 households with a job supported by HQ2 spending (Fuller and Chapman, 2018).

Local Income Forecasts

Of the 25,000 jobs to be created by the Amazon HQ2, one-half are expected to be in information technology and the other one-half in support services such as human resources, custodial, accounting, and marketing. Amazon announced that they would pay an average annual salary of $150,000 (Fleishman, 2018). Thus, National Landing will have an influx of skilled workers with high salaries.

George Mason University researchers highlight household income differentials between Amazon and non-Amazon households as an important aspect of forecast growth in employment and households for the 2019-2039 period. The average HQ2 household salary for Virginia residents is projected to be $228,187 (in 2017 $) by Fuller and Chapman (2018), and the household incomes associated with jobs indirectly created or induced by Amazon is projected to be $115,169. If other high-paying employers are attracted to Virginia, similar effects on income forecasts for the state would be expected. Apple, for example, is said to be exploring the possibility of another campus in Northern Virginia (Jan and Orton, 2018).

Local Transportation Demand

Amazon alone expects to employ 37,850 people by 2034—excluding the jobs from the "ripple effect" (O'Connell and McCartney, 2018). With its population increasing by tens of thousands, the infrastructure of the National Landing area may be strained. The increase in skilled labor with Amazon's arrival and the activity near Amazon HQ2 may put more cars on the already congested roads and may require increased investment in public transit. Existing heavy traffic congestion in the I-395 corridor may worsen with Amazon's arrival and render access to Reagan National Airport even more difficult during rush hours (Shaban, 2018).

Virginia plans an investment of $195 million for transportation improvements to Metro stations and Reagan National Airport and the construction of a pedestrian bridge connecting Amazon's new hub in National Landing to Reagan National Airport. Arlington County and the City of Alexandria have also pledged to invest $570 million in transportation projects (Woolsey, 2018). If Amazon exceeds the 25,000 job benchmark, Virginia will make up to another $100 million in transportation money available (Slatt, 2018).

Local Housing

Although Fuller Institute researchers forecast that Amazon will generate additional demand for housing, they believe that those effects will be dispersed and gradual. Amazon's location decision is likely to increase both rents and housing prices, but that effect might be only marginally greater than what would be expected without Amazon (Fuller Institute, 2018). Areas closest to National Landing may see larger increases in demand and prices (Sullivan, 2018).

The issue of affordable housing is distinct from issues about housing supply. Arlington County has long had housing affordability problems (Sullivan, 2018). A shortage of affordable housing units may drive lower-income residents away from the National Landing area, resulting in longer commutes for them (Jan and Orton, 2018). Changes in the supply of affordable housing are expected to have racially disparate impacts (Bateman et al., 2018) as white families in Arlington and Alexandria currently have significantly higher incomes than other groups. The lack of affordable housing in an urban area can price out the current residents, leading to gentrification. The Crystal City area is already experiencing increased property values since Amazon's November 2018 announcement. Arlington and Alexandria have said that they plan to invest at least $150 million in housing over the next 10 years, including the creation or preservation of 2,000 to 2,400 affordable units in areas near National Landing.

Regional Forecasts

At the time that PDC-level and district-level population and employment forecasts were generated, Amazon was not envisioned. It is also possible that there may be unexpected arrivals or departures of large employers in other parts of Virginia. Thus, examining how Amazon's arrival affects these regional forecasts may allow one to understand how these forecasts may change should such an unexpected event occur.

For the Northern Virginia PDC or VDOT's Northern Virginia District, the forecast population for 2045 (Weldon Cooper, 2018) increases by 96,870 people (representing households with a worker directly employed by Amazon) and by an additional 125,472 people (representing households with a worker whose employment is an indirect impact of the arrival of Amazon), based on the 2040 build-out analysis (Fuller and Chapman, 2018) and presuming that the additional 125,472 people live in Northern Virginia. Assuming this total 222,342 people in 2040 remain in Northern Virginia in 2045, the 2045 population climbs from a baseline of 3,546,256 without Amazon to 3,768,598 with Amazon, for an increase of 6.3%. Similar calculations based on employment (Woods & Poole, 2018b) show a net increase from 2,746,961 jobs in 2045 without Amazon to 2,841,282 jobs in 2045 with Amazon, for an increase of 3.4%. In 2009 dollars, Northern Virginia median household incomes in 2045, all in 2009 dollars, are $124,142 (Moody's Analytics, 2019), but these already reflect the knowledge that Amazon had arrived (Berdanier, 2020); the research team estimates that without Amazon, the household incomes would be about 1.2% lower for the Northern Virginia PDC based on salaries reported by Fuller and Chapman (2018).

Role of Transportation in Attracting Jobs and Population

Investments in transportation infrastructure have been advocated as a mechanism to attract jobs to a particular region. For example, Buchanan County, Virginia, sought to attract economic development in part through an airport expansion (to allow corporate jets) and roadway investments (Hester, 2011). Shearer et al. (2018) indicate that in Central Indiana, jobs tend to be clustered along transportation corridors. Zhao and Leung (2018) concluded that investments in local roads in Minnesota did, in fact, increase the employment rate in the counties where the roads were located.

Transportation investments have also been viewed as a way of halting a decline in population. John (1982) reported that Arlington's population was expected to increase because of a rezoning of land near heavy rail (Metro) stations that would allow condominiums and commercial construction, stating the following: "An influx of young professionals into new housing near Arlington Metro subway stations is expected to increase the number of county residents 14 percent during the 1980s and reverse a decade of declining population, according to county planning officials." In 1980, Arlington had had a population of 152,599 (John, 1982; Weldon Cooper, 1993). The Arlington forecasts appear prescient: John (1982) reported a forecast of 173,799 for 1990 (compared to 170,897 observed) and a forecast of 191,155 for 2000 (compared to 189,453 observed); observed values are from Weldon Cooper (1993, 2003). Adjacent Alexandria also grew by roughly 24% from 1980-2000 (Weldon Cooper, 1993, 2003), although John (1982) indicated a population forecast increase of just 1% from 1980 to 1990 that would then "remain about steady" until year 2000. In this particular case, the presence of a transportation investment (heavy rail) coupled with a supporting land use policy (allowing for intense development near stations) appears to have contributed to a population increase.

That said, although transportation infrastructure can play a supporting role in attracting jobs, reports in the literature suggest that transportation is rarely, if ever, the sole factor that attracts jobs or population; other forces include public subsidies, immigration policies, demographic shifts such as family size, and public amenities such as schools. Shearer et al. (2018) suggest that in Central Indiana, "other factors besides the distribution of jobs" affect the ability of a region to attract employment, such as economic incentives (e.g., more than one-half of all job growth over a 10-year period was attributed to companies that received such incentives); grants for job training; development of certificate programs that are not tethered to a particular technology (and thus likely to be usable as products evolve); and coordination between localities and "anchor institutions" for the hiring of local residents. Paral (2017) suggests that immigration has historically been a crucial determinant of growth: a study of population changes in the 1900s for 13 cities in Michigan (Detroit, Grand Rapids), Illinois (Chicago, Cincinnati), Minnesota (Minneapolis, St. Paul), Missouri (Kansas City, St. Louis), Nebraska (Omaha), Ohio (Akron, Cleveland, Toledo), and Wisconsin (Milwaukee) showed that population more than doubled from 1900 to 1930, with almost one-half of this growth (41%) attributed to immigrants and their children. Paral (2017) connects a dramatically reduced rate of population increase (1% from 1930-1950) and a subsequent 7.5% decrease (1950-1970) to laws restricting immigration that were enacted in the 1920s (while recognizing that higher birth rates helped avoid depopulation). Friedman (2015) suggests that a reduction in family size in general can be expected in locations where "the economic value of children declines." Although of course employment opportunities affect the ability to attract residents, Cromartie et al. (2015) found in a series of interviews of persons who had chosen to return to rural communities that a critical determinant was the availability of schools (and an implication is that the loss of a local school might be a deterrent for potential returnees).

The magnitude of the effect of transportation investments on a region's ability to attract population or jobs also requires careful interpretation. Zhao and Leung (2018) report that in Minnesota counties, a 1% increase in transportation investments was "associated" with a county employment rate increase of 0.007% if the investments were in local streets and a county employment increase rate of 0.008% if the investments were in trunk facilities. Trunk facilities are not defined in the study but appear to be comparable to Virginia's primary system based on a review of Minnesota Department of Transportation (2019). Although Zhao and Leung (2018) conclude this statistically significant impact on employment rate, stating that road investments "contribute significantly to employment in Minnesota counties," they also note that they did not find a relationship between such investments and total employment by county. Chi et al. (2006) note that for rural areas, previous literature suggested that highway investments tend to increase rural population—but that there can be an exception if the investment causes residents to travel to urban jobs. This exception is explained in a literature review by Boarnet and Haughwout (2000) (which, in turn, was cited by Chi et al. [2006]): investments in roadways serving counties that were not employment centers but were near such centers had a "negative cross county spillover" in that the highway investment tended to reduce economic activity in the county that was not the employment center. "Lessons From Hell" (2019) notes that although rural small towns seeking to attract tourism could take some initiatives on their own (e.g., building a "clear civic story," having energetic boosters, and being "open—both to migrants and visitors"), it was also helpful not to be completely remote, citing an example of the town of Hell located within 30 minutes of the University of Michigan, itself a regional employment center.

Meyer and Miller (2013) point out that although initial transportation investments have greatly influenced land development and hence population or employment growth (a Virginia-specific example is the impact of the Monitor-Merrimac Bridge Tunnel on land development in Suffolk [Pascale, 2017]), later investments that incrementally improve transportation access may not "significantly affect metropolitan patterns of urban development," leading the authors to conclude that without other factors that encourage employment or population growth, later investments in transportation may not have a substantial impact.

Lessons Learned From the Interaction of Population and Employment

Given that Virginia has a relatively rich data set of regional population and employment totals, by both PDC and district, a question of interest is the extent to which these values have changed in tandem. At any given point in time, population and employment are highly correlated at the regional level: e.g., at the VDOT district level, population and employment had correlations of 0.97 and above 0.99 for 1975 and 2017, respectively. However, the rate at which population and employment values change over time suggests an additional nuance.

A comparison of historical growth rates of population and employment shows more variance in that of employment. Figure 31 (VDOT districts) and Figure 33 (PDCs) show average annual employment growth rates that are considerably higher than those of population for most geographical units for the period 1975-2000. However, Figures 32 and 34 show the population growth rates of most geographical units surpassing those of employment in 2000-2017. For example, the George Washington PDC dropped from an average employment growth rate of 7.9% during the period 1975-2000 to 2.1% during the period 2000-2017. In addition, 10 of 21 PDCs had negative employment growth rates during 2000-2017, and 6 of these 10 also had a negative average annual population growth rate during this period. Given that districts or modified PDCs are relatively large geographical areas, this association should be expected to the extent that people will tend to move to areas with more job opportunities (or that employers will tend to cluster in locations with larger populations).

The relative changes in population from 1975-2017 follow closely the relative changes in employment during this period. For 1975-2000, VDOT's Fredericksburg District had the highest growth rate in both categories (2.712% for population and 6.177% for employment), followed by Northern Virginia (2.336% and 5.115%), Culpeper (1.761% and 3.628%), and Virginia statewide (1.355% and 3.346%). Hampton Roads, Staunton, and Richmond all remained close to each other in both categories, and Salem, Lynchburg, and Bristol had lower annual growth rates. Although one might expect similar population and employment trends (e.g., Northern Virginia has grown substantially in both categories), the variance in employment growth rates between the two time periods is greater than that of population between the two time periods. For example, the statewide growth rate for population, though higher from 1975-2000 (1.355%), did not drop much during the latter period of 2000-2017 (1.06%). By contrast, the statewide growth rate for employment dropped substantially during the latter period (2000-2017) to 0.623% from 3.346% during the earlier period of 1975-2000.

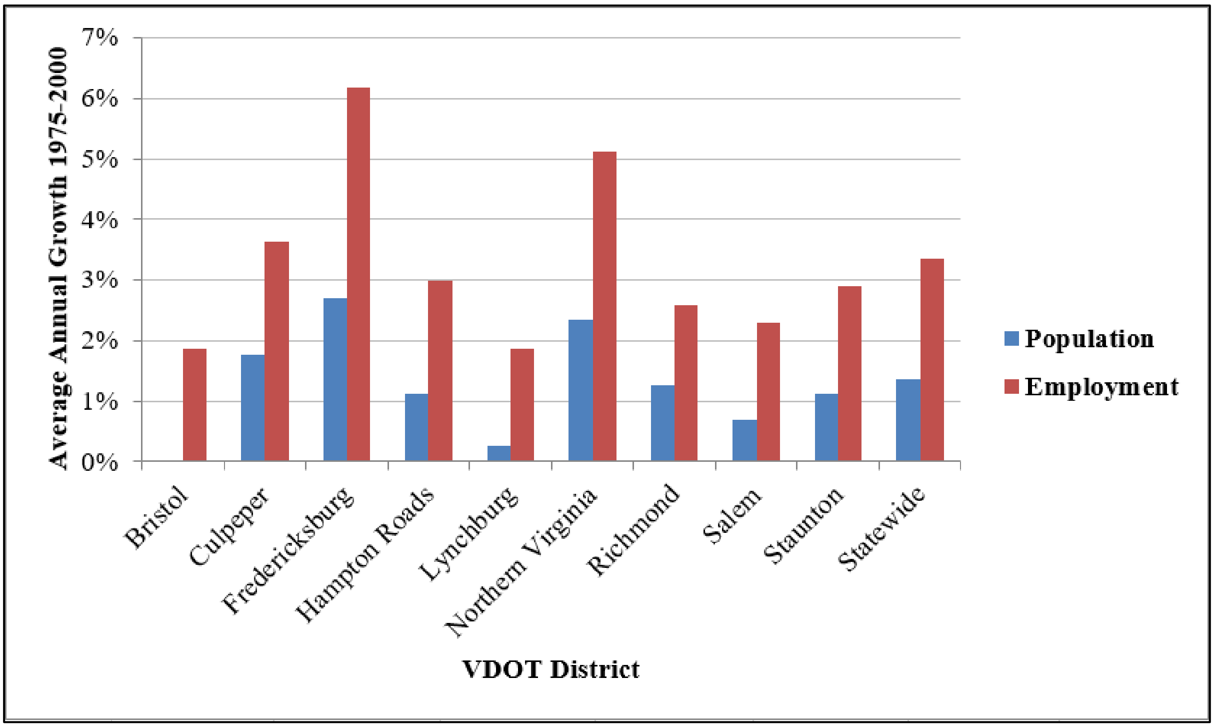


Figure 31. Average Annual Growth Rates, 1975-2000, by VDOT District. For example, in 1975, the population of the Northern Virginia District was 1,019,200. With an average annual growth rate of 2.336%, the population in 2000 was 1,019,200 * $(1.02336)^{25}$ ≈ 1,815,197. The superscript "25" indicates that the 1.02336 is raised to the 25th power, as there are 25 years from 1975-2000.

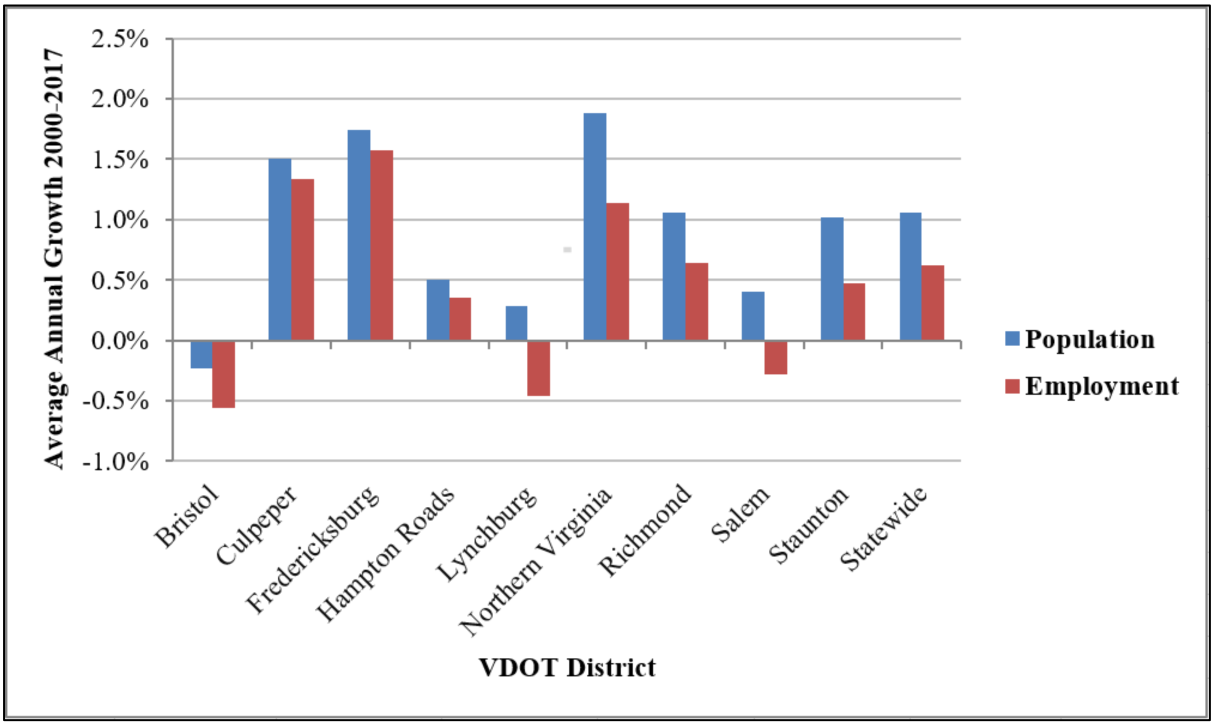


Figure 32. Average Annual Growth Rates, 2000-2017, by VDOT District. For example, in 2000, the population of the Northern Virginia District was 1,815,197. With an average annual growth rate of 1.880%, the population in 2017 was 1,815,197 * $(1.01880)^{17}$ ≈ 2,491,299. The superscript "17" indicates that the 1.01880 is raised to the 17th power, as there are 17 years from 2000-2017.

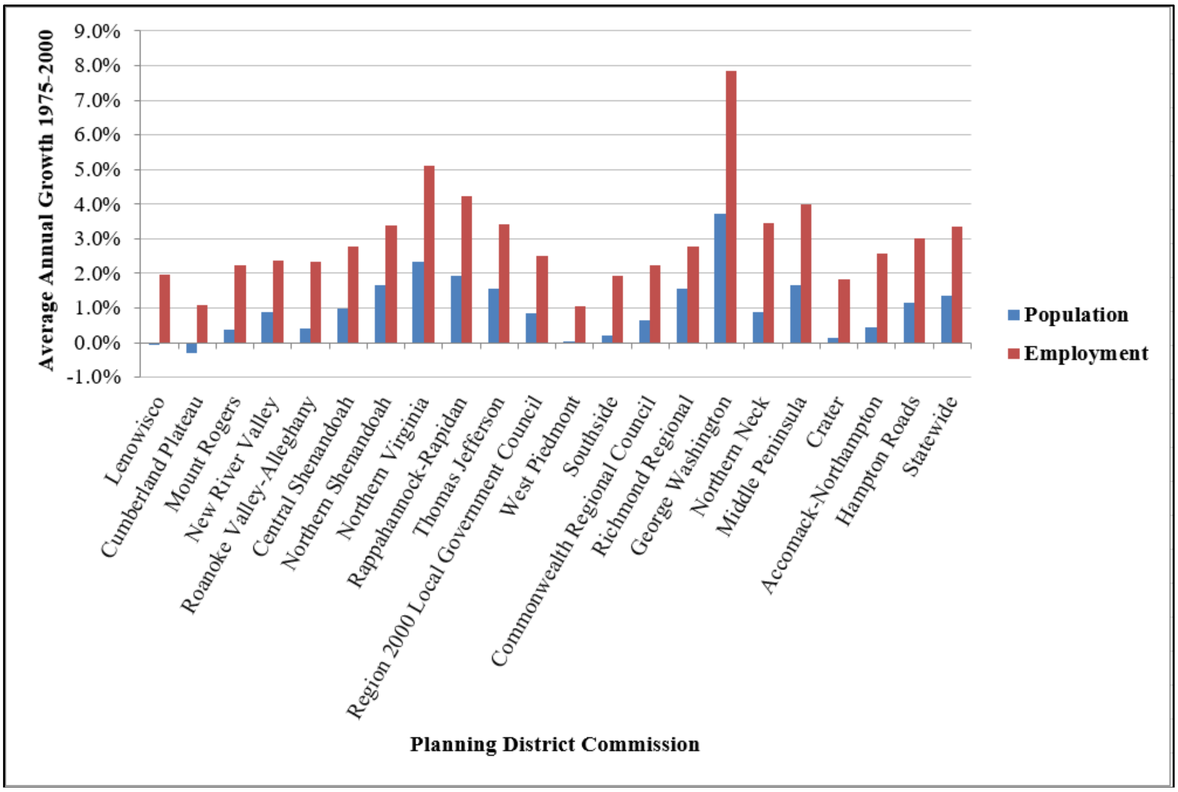


Figure 33. Average Annual Growth Rates, 1975-2000, by PDC. For example, in 1975, employment for the Rappahannock-Rapidan PDC was 15,114. With an average annual growth rate of 4.230%, employment in 2000 was 15,114 * $(1.04230)^{25} \approx 42{,}580$. The superscript "25" indicates that the 1.04230 is raised to the 25th power, as there are 25 years from 1975-2000. PDC = planning district commission.

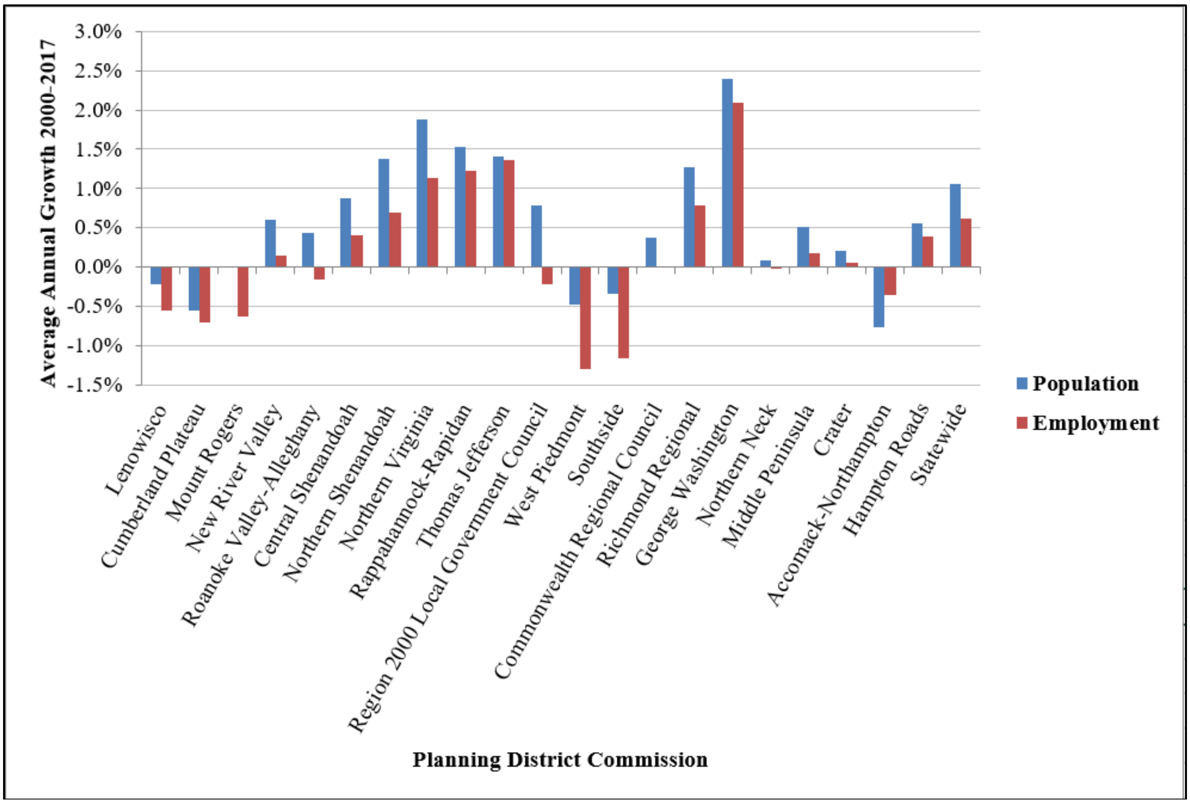


Figure 34. Average Annual Growth Rates, 2000-2017, by PDC. For example, in 2000, employment for the Rappahannock-Rapidan PDC was 42,580. With an average annual growth rate of 1.221%, employment in 2017 was 42,580 * $(1.01221)^{17} \approx 52{,}337$. The superscript "17" indicates that the 1.01221 is raised to the 17th power, as there are 17 years from 2000-2017. PDC = planning district commission.

Lacey et al. (2017) point out that the "labor force participation rate" started to fall after the 2001 recession and then decreased radically after the 2007-2009 economic recession. Such recessions are clear in Figure 35. The average employment growth rate in Figure 35 drops sharply at both of these points as well as during the 1980-1985 period. The individual employment growth rates of Fredericksburg and Northern Virginia are the two highest, both during the 1980-1990 period, which includes a recession in the early 1980s, and during the 2005-2010 period, which includes the 2007-2009 recession. In addition, these two districts are responsible for the highest population growth rates during 1975-2000 and 2000-2017. This population growth is possibly attributable to these two districts having the highest employment growth during this period.

By contrast, Bristol is the only district with a negative population growth rate during 2000-2017, and its employment growth rate dropped from 1.86% during 1975-2000 to -0.56% during 2000-2017. Lynchburg and Salem, which had the next two lowest population growth rates behind Bristol, were the only other two districts that had negative employment growth rates during 2000-2017. These examples show an association between population and employment growth rates.

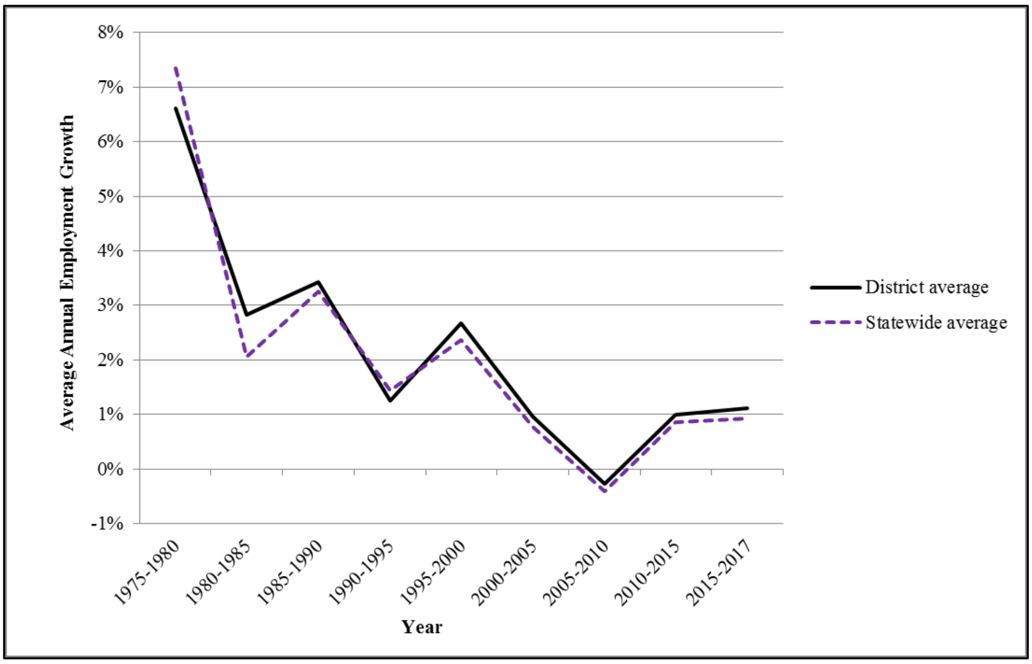


Figure 35. Average Annual Employment Growth in 5-Year Increments by VDOT District. For example, the average annual employment growth from 1975-1980 across all nine VDOT districts was 6.6% (where each district carries equal weight). Because districts have different amounts of employment, however, the statewide growth rate for that period was 7.4%.

Impacts of Population and Employment Trends on Transportation Needs

There are several ways in which population and employment trends can potentially affect the demand for transportation; however, the ultimate impact of these trends is not necessarily straightforward. As just one example, the potential for transit to increase as a result of population changes may be considered. Zmud et al. (2014) suggest that as millennials enter the workforce, they may have different travel patterns than baby boomers, especially if the former are more culturally diverse than the latter. Kim (2009) further suggests that immigrants may initially have higher rates of transit usage, which Blumenberg (2008) notes may be accentuated for some women who come from countries where driving by women is discouraged. Misra

(2017) counters that although immigrants may be predisposed to use transit, those having residences or job locations where transit is not feasible will of course not be able to use transit. Litman (2018) points out that transit becomes more feasible in locations of higher density; however, Sisson (2018) points out that although investments in public transit may offer a solution to congestion, a lack of affordable housing is associated with longer commutes and workers' greater daily time investments in commuting. In short, population changes could increase demand for transit; however, determining if this change will occur can require a more fine-grained analysis than is performed at the regional level.

Accordingly, given the 2045 focus at the regional level, there are at least two trends that appear potentially to influence travel demand:

1. transportation needs of the population age 65+
2. growth in employment types that may be associated with longer-than-average commutes.

Transportation Needs of Population Age 65+

As noted by a member of the OIPI staff, Table 3 underscores a key shift: in two VDOT districts (Bristol and Salem), there will be more persons age 65+ than there will be persons under age 20. Given the sizeable increase in persons age 65+ from 2017-2045 statewide, the transportation needs of the older population merit some discussion. Although public transit may be a viable option for seniors in many urban areas, this may not necessarily be the case in the rural and suburban communities where older people are most likely to live (National Aging and Disability Transportation Center, 2019). A majority of Americans are "aging in place," with only 5% changing their community of residence after age 55, a trend that leads to "naturally occurring retirement communities," which were not necessarily built or designed with services for older people in mind (DeGood, 2011). As a consequence, older residents of these communities may lack the services they need, including transportation options. Many of these areas lack good transit systems: the Center for Neighborhood Technology estimated that the 11.5 million Americans age 65+ living in areas with poor public transit options in 2000 would increase to 15.5 million in 2015 (DeGood, 2011).

With a shortage (or absence) of affordable and convenient travel options, the older population may experience many detrimental effects, including social isolation, reduced quality of life, and possible economic hardship. A 2004 study found that seniors age 65+ who no longer drive make 15% fewer trips to the doctor, 59% fewer trips to eat out, and 65% fewer trips to visit family and friends compared to those who are the same age and continue to drive (DeGood, 2011). Other research, including that done by the American Association for Retired People, shows an increase in seniors using public transit. For example, the National Household Travel Survey data show 328 million additional transit trips by seniors from 2001-2009 (DeGood, 2011). However, the majority of public transit travel by seniors comprises trips taken by those going to and from work; additional travel options are still necessary for those taking trips for other purposes. These options include Dial-a-ride, volunteer transportation programs, and assisted transportation, which is typically funded through a combination of federal, state, and local funds (National Aging and Disability Transportation Center, 2019). In addition, there is no evidence to suggest that the increase in older people riding public transit began when these people retired. Rather, the generation of "baby boomers" who began riding public transit at a younger age is aging, and as that occurs, the number of older people riding public transit is increasing (Rosenbloom, 2009).

Barriers to walking also exist in many communities. Surveys conducted by the American Association for Retired People suggest that seniors often prefer walking rather than public transport or driving as a means to get places, with 70% of respondents age 65+ agreeing that being within walking distance of common amenities is extremely important (DeGood, 2011). National data show that walking is the second most important mode of travel for older people, second only to car travel (Rosenbloom, 2009). However, walking can be severely limited by poorly maintained or nonexistent sidewalks, poorly marked intersections, inadequate time to cross intersections, and various other design flaws making many communities pedestrian unfriendly (DeGood, 2011). In addition, since walking is a difficult task for about 75% of older people, additional care must be taken in the design of communities to meet seniors' travel needs (Rosenbloom, 2009). Older people's ability to use public transit can be limited by several factors, including financial constraints, which is why many older adults resort to walking. For example, although bus fares may not be particularly expensive, many seniors use public transit for leisure travel only and thus the affordability of additional fare costs may be a constraint (Loukaitou-Sideris and Wachs, 2018). Although the lack of convenient public transit in some areas can create travel limitations, it does not have the same safety and mobility impacts as the limitations to walking. For example, unsafe and inappropriate walking infrastructure, such as poor sidewalks, the absence of resting places, and dangerous intersections, create real dangers for seniors, more so than for the younger population (DeGood, 2011).

The total population of Virginia is projected to increase by 16.9% from 2020-2040 (Weldon Cooper, 2017b). Much of this increase is expected to be due to the growth in Virginia's older population. For example, the population of adults age 75+ is projected to increase by 82.0% in this time period, as shown in Figure 36. However, the population of adults age 65-74 is projected to increase by only 9.1% in that period. By 2040, the population of older seniors (75+) is projected to surpass that of youthful seniors (age 65-74) (Weldon Cooper, 2017b). The change in age distribution may also have impacts for how Virginia improves safety for motorists. For example, Getzmann et al. (2018) suggest that a reduction in distracted driving has greater benefit for younger drivers whereas older drivers benefit more from steps that prepare them for the cognitive workload of driving, such as getting more rest. Although both of these initiatives—reduce distractions and be well rested—are logically beneficial to all drivers, Getzmann et al. (2018) suggest that the relative value differs by age group.

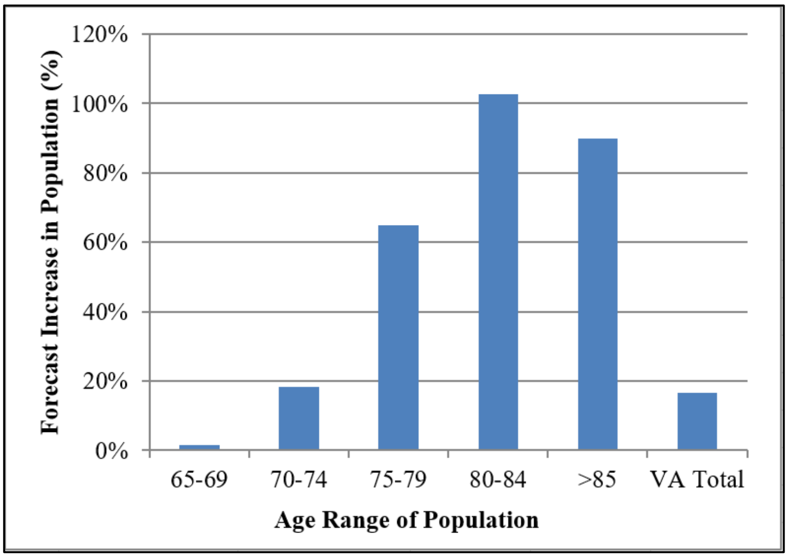


Figure 36. Forecast Increase in Virginia Population by Age, 2020-2040. Data from the Weldon Cooper Center for Public Service (2017b). VA = Virginia.

The impacts of an increasing population of seniors on vehicle miles of travel may be difficult to forecast. Although 88% of older adults continue to drive at age 65, only 69% continue to drive at age 75 (DeGood, 2011). Thus, if driving rates by age for seniors in 2045 are similar to current rates, the aging of the population may result in fewer drivers on the road by 2045, resulting in decreased traffic and a need for more pedestrian facilities, as the population age 75+ uses walking as one of their main modes of transportation (DeGood, 2011). Conversely, technological advances—e.g., fully automated or "driverless" vehicles—could increase travel in personal vehicles by people age 75+ by 2040. Miller and Kang (2019) discuss a number of scenarios that are possible in an era of driverless vehicles.

Impact of Changes in Employment Category on Commute Time

Kopf (2016) reports the average commute time for 24 categories of workers based on data extracted from the ACS. For example, Kopf (2016) notes that workers in the two categories of "computer science and math" and "construction and mining" each have the longest commute times (35.9 minutes) and workers in the category of "military specific" have the shortest commute times (22.7 minutes) (which the author attributes to the ability of some military employees to live on a base). Kopf (2016) also notes that certain professions are more likely to take certain modes of transport to work: for example, employees in the category of "lawyers and legal support" are 6 times more likely to use transit than employees in the category of "installation, maintenance, and repair," and employees classified as "physical and social science" are 6 times more likely to use a bicycle than employees classified as "finance."

There does not appear to be a perfect relationship between the 24 employment categories cited by Kopf (2016) and those shown in Tables 22 and 23. For instance, Table 22 lists two separate categories of "farm employment" and "forestry, fishing, related activities and other employment," which are combined by Kopf (2016) as "farming, fishing, and forestry." Similarly, Table 22 lists a single category of "professional and technical services employment," which, based on a review of Woods & Poole (2018a), should correspond to three categories listed by Kopf (2016): "architecture and engineering," "lawyers and legal support," and "physical and social science."

Accordingly, the research team devised a rough correspondence between the employment categories reported by Kopf (2016) and those in Table 22 by aggregating the corresponding commute times where feasible. For example, for the Table 22 category of "professional and technical services" employment, the research team averaged the three commute times reported by Kopf (2016) for the categories of "architecture and engineering" (30.2 minutes), "lawyers and legal support" (28.9 minutes), and "physical and social science" (28.8 minutes) to obtain an average time of 29.3 minutes. The resultant commute times are shown in Table 38.

Table 38 shows that if commute times from 2017-2045 were to remain constant such that the only change was the proportion of workers in each profession, the average commute time would decrease slightly from 27.4 minutes to 27.1 minutes for 2017-2045. Table 38 of course should not be used to infer that commute times will not change. Other factors (e.g., a net increase in employment, possibly increased congestion because of increased travel demand, or possibly decreased congestion because of improvements in technology) may alter commute time. Rather, the data in Table 38 simply suggest that changes in the type of employment alone may not necessarily alter commute times.

Table 38. Forecast Percent of Employment by Category (Virginia) and Commute Time (National Average)

Employment Category	2017[a]	2045[a]	Commute Time[b]
Farm employment	1%	1%	24.6
Forestry, fishing, related activities and other employment	0.30%	0.30%	24.6
Mining employment	0.20%	0.20%	33.4
Utilities employment	0.20%	0.20%	27.2
Construction employment	5%	5%	33.4
Manufacturing employment	5%	3%	25.8
Wholesale trade employment	3%	2%	25.4
Retail trade employment	10%	10%	[c]
Transportation and warehousing employment	3%	3%	27.2
Information employment	2%	1%	31.8
Finance and insurance employment	4%	4%	29.4
Real estate and rental and lease employment	5%	5%	29.4
Professional and technical services employment	11%	12%	29.3
Management of companies and enterprises employment	1%	1%	28.0
Administrative and waste services employment	6%	6%	26.0
Educational services employment	2%	2%	23.1
Health care and social assistance employment	10%	13%	25.5
Arts, entertainment, and recreation employment	2%	2%	28.6
Accommodation and food services employment	7%	7%	22.0
Other services, except public administration employment	6%	7%	27.7
Federal civilian government employment	4%	3%	26.0
Federal military employment	3%	2%	21.0
State and local government employment	10%	10%	28.4
Expected average commute time	27.4[d]	27.1[d]	

[a] Percentages based on Woods & Poole (2018b). For example, in both 2017 and 2045, 1% of Virginia's employment falls in the category of farm employment.
[b] Commute times based on Kopf (2016).
[c] The employment categories reported by Woods & Poole (2018b) and Kopf (2016) do not align perfectly and thus were related by the research team. The research team could not determine which commuting time from Kopf (2016) applied to this category.
[d] Computed by multiplying the percentage employment from 2017 or 2045 by the corresponding commute time, summing these products for all categories, and dividing by 0.9 because of the exclusion of retail trade employment.

As is the case with population, potential impacts are uneven by geography. For instance, the category of professional and technical services, which tends to have longer commute times than is the norm based on the research team's examination of the results of Kopf (2016), may be considered. Although this category of employment is forecast to grow between 31% and 61% statewide, the growth by PDC is both more uneven and more uncertain. For some PDCs, such as Richmond and Crater, Figure 37 clearly shows that this category of employment is forecast to increase (although the percentage increase is uncertain). For other PDCs, such as Central Virginia and Mount Rogers, there is considerably more variability, with one source forecasting an increase and the other forecasting a decrease. Figure 37 generally suggests that this particular category of employment is forecast to grow in some urban or urbanizing areas (e.g., George Washington) but also in some more rural locations (e.g., West Piedmont).

Using an earlier data set, Crane and Chatman (2003) raised the possibility that "decentralization"—that is, the movement of jobs from an urban setting to a more dispersed suburban setting—had the potential both to raise and lower commute times, depending on the job type. The authors suggested that moving "construction and wholesale" employment to the suburbs reduced commuting distance but that the opposite effect occurred when moving "manufacturing" jobs to the suburbs, leading the authors to suggest that at least two different forces merit consideration: (1) the mixing of land uses, and (2) the alignment of job patterns with population patterns. Crane and Chatman (2003) explained that suburbanizing construction jobs, for instance, led residents to be able to choose jobs closer to home (thereby shortening commute distances) whereas suburbanizing manufacturing jobs, especially for certain high-tech industries, led residents to have to travel to (presumably suburban) locations farther from home. The latter condition is noted by Kopf (2016) in his explanation of why some technical services jobs might have longer commutes, owing to some individuals working at employment centers in "remote locations." An implication for Virginia, given the growth of jobs in the professional and technical services category, is that the impact of these jobs on commute times will depend to some extent on if they are located near population centers and, as noted in the Amazon case study, whether there is a supply of housing that these workers can afford.

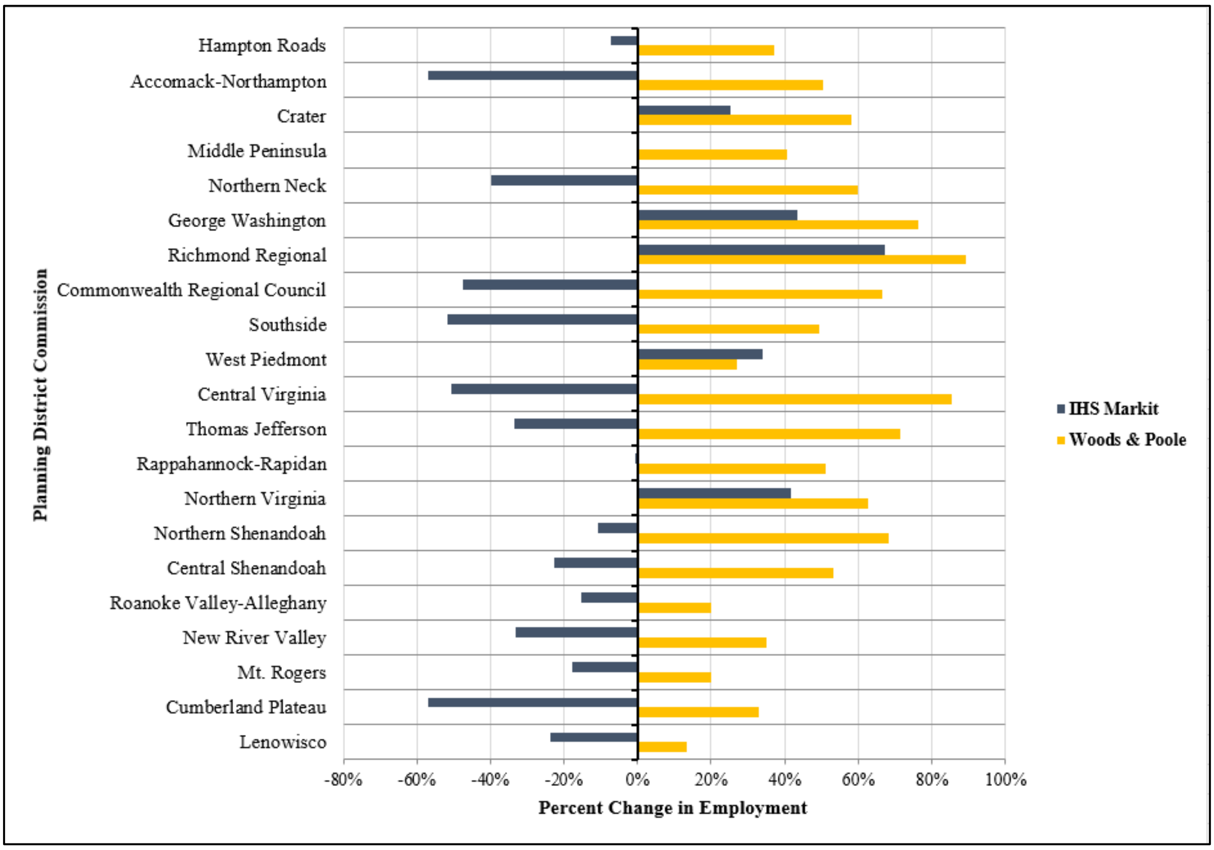


Figure 37. Forecast Percent Change in Employment in the Professional and Technical Services Category by Planning District Commission Based on IHS Markit (Jeafarqomi, 2018b) and Woods & Poole (2018b)

Forecasts as a Range

Table 39 presents the population forecasts for 2045 by modified PDC. On a percentage basis, there is some uncertainty at the state level, with growth rates of between 24% and 33%, for a difference of about 9%. There is greater uncertainty for individual PDCs; for example, the corresponding differences between the minimum and maximum values for Accomack-Northampton, George Washington, and Cumberland Plateau are 25%, 21%, and 18%, respectively.

Table 40 presents the employment forecasts for 2045 but in a slightly different manner. The two left columns show the year 2017 employment from two different sources. Because of differences in how employment is tabulated, the Woods & Poole total is about 31% higher than the IHS Markit statewide total.

Table 39. Summary of Population Forecast Ranges for 2045 by Planning District Commission

PDC	Population 2000[a]	Population 2017[a]	2045 Population		Percent Growth (2017-2045)	
			Low Forecast	High Forecast	Low Forecast	High Forecast
Lenowisco	93,105	88,145	87,000	94,000	-1%	6%
Cumberland Plateau	117,229	104,439	90,000	109,000	-14%	4%
Mount Rogers	188,984	189,063	182,000	205,000	-3%	8%
New River Valley	165,146	182,993	202,000	209,000	11%	11%
Roanoke Valley-Alleghany	311,827	334,781	365,000	387,000	9%	15%
Central Shenandoah	258,763	299,042	358,000	373,000	20%	25%
Northern Shenandoah	185,282	235,443	297,000	308,000	26%	31%
Northern Virginia	1,815,197	2,501,308	3,546,000	3,871,000	42%	55%
Rappahannock-Rapidan	134,785	177,418	228,000	252,000	29%	42%
Thomas Jefferson	199,648	252,588	323,000	331,000	28%	28%
Central Virginia	222,317	261,254	306,000	326,000	18%	25%
West Piedmont	202,909	184,422	160,000	193,000	-13%	4%
Southside	88,149	81,493	72,000	79,000	-11%	-4%
Commonwealth Regional Council	97,102	102,387	111,000	113,000	9%	9%
Richmond Regional	865,941	1,084,424	1,366,000	1,504,000	26%	39%
George Washington	241,044	364,840	535,000	614,000	47%	68%
Northern Neck	49,353	49,782	49,000	56,000	0%	11%
Middle Peninsula	*83,684	91,489	100,000	110,000	10%	19%
Crater	167,129	173,092	174,000	182,000	1%	1%
Accomack-Northampton	51,398	44,391	34,000	46,000	-22%	3%
Hampton Roads	1,533,739	1,667,226	1,910,000	1,954,000	15%	17%
Virginia (total)	7,079,030	8,470,020	10,528,000	11,284,000	24%	33%

[a] Tabulated based on data from the Weldon Cooper Center for Public Service (2011, 2017a, 2018).
[b] Tabulated based on data from Woods & Poole (2018b) and Weldon Cooper Center for Public Service (2018).

Table 40. Summary of Employment Forecast Ranges for 2045

Planning District Commission	Employment 2017[a]	Employment 2017[b]	% Growth (2017-2045)[c]	
			Low Forecast	High Forecast
Lenowisco	34,745	30,099	2%	23%
Cumberland Plateau	43,153	37,344	-15%	19%
Mount Rogers	100,303	83,033	5%	19%
New River Valley	96,630	81,129	10%	26%
Roanoke Valley-Alleghany	214,525	169,783	2%	31%
Central Shenandoah	177,971	136,473	10%	37%
Northern Shenandoah	129,823	101,843	9%	39%
Northern Virginia	1,756,035	1,293,486	31%	56%
Rappahannock-Rapidan	86,185	61,922	13%	47%
Thomas Jefferson	166,318	125,463	27%	34%
Central Virginia	140,329	108,254	7%	41%
West Piedmont	93,747	75,811	11%	24%
Southside	39,058	32,858	-19%	19%
Commonwealth Regional Council	41,709	33,539	-3%	24%
Richmond Regional	759,909	598,022	18%	51%
George Washington	170,468	126,033	31%	67%
Northern Neck	22,331	15,975	-8%	25%
Middle Peninsula	36,740	25,641	4%	27%
Crater	98,383	75,717	16%	25%
Accomack-Northampton	25,877	22,934	-26%	27%
Hampton Roads	1,041,008	782,271	12%	34%
Virginia (Total)	5,275,247	4,017,630	18%	44%

[a] Employment based on Woods & Poole (2018b).
[b] Employment based on IHS Markit (Jeafarqomi, 2018).
[c] Range is based on the percent change from 2017-2045. The low forecast indicates the smaller percentage from Jeafarqomi (2018) and Woods & Poole (2018b); the high forecast indicates the larger percentage.

Accordingly, the ranges on the right side of Table 40 show the percent changes in these employment types. For instance, Woods & Poole (2018b) suggests that Rappahannock-Rapidan will grow from its baseline value of 86,185 to 126,907 (a growth rate of 47%). IHS Markit forecasts a percentage increase of 13% using a different baseline value (61,922) and forecast value (69,782).

Comparison of Forecast Growth in Virginia and Forecast Growth in Adjacent States

Stakeholders asked how Virginia's forecast growth compares with that of its border states (Kentucky, Maryland, North Carolina, Tennessee, and West Virginia) and the District of Columbia. Table 41 summarizes previous population growth rates, and population and employment forecasts, for the states bordering Virginia and the District of Columbia. Because the forecast growth periods of these regions differ somewhat, Table 41 presents the average annual growth rate, calculated by the research team based on Equation 1. For example, Ruther et al. (2016) forecast that Kentucky's population will increase from 4,425,092 in 2015 to 4,886,381 in 2040, which corresponds to an increase of 0.40% each year over a 25-year period as shown in Equation 2. The forecast rate for Virginia is provided in Table 41 for comparison purposes.

$$\text{Annual growth} = (\text{Forecast value} / \text{Current value})^{(1/\text{number of years})} - 1 \qquad \text{[Eq. 1]}$$

$$0.40\% = (4{,}886{,}381 \text{ people in 2040} / 4{,}425{,}092 \text{ people in 2015})^{(1/25 \text{ years})} - 1 \qquad \text{[Eq. 2]}$$

Table 41 shows the historical population growth rates over the 10-year period of 2008-2018. Except for the District of Columbia, these historical rates were not calculated by the research team but rather were provided directly by Rosewicz et al. (2019). Using Virginia data, the research team confirmed that these rates were computed in a manner similar to that of Equation 1. At a state level, Virginia has shown population growth near the middle of that of its border states (and the District of Columbia): with an annual growth rate of 0.84%, Virginia is similar to Tennessee (0.81%). Virginia has grown much faster than Kentucky and Maryland (and unlike West Virginia has not lost population over the past 10 years) but not nearly so fast as North Carolina. The urban location of the District of Columbia has more than doubled Virginia's annual growth rate for the past decade, and the District of Columbia has generally grown faster than the United States as a whole.

Rosewicz et al. (2019) observed that for the 50 U.S. states (not just those shown in Table 41 and excluding the District of Columbia), several factors heavily influence population growth: migration from other states, migration from other counties, birth rates (which have been generally dropping), death rates (which could increase as the population ages), and economic conditions. For these reasons, they expect the U.S. population as a whole to increase, but not as quickly as in the past. Although a change in population from one year to the next can be misleading, as a number of factors affect population growth (District of Columbia, 2015), they suggest that looking at series of year-by-year changes can be informative. In this regard, Virginia's annual population changes have (like Maryland's) decreased since their 2008-2009 levels, in contrast to North Carolina's growth rates, which have remained strong (see Figure 38).

It should be noted that for the 5 years of 2010-2014, the populations according to the District of Columbia Office of Planning (2017) and the District Department of Transportation (2015) differ slightly. Had the latter numbers been used in Figure 38, the annual growth rates for the District of Columbia would have changed slightly for the years 2010-2016: 2.16% to 2.19%, 2.53% to 2.51%, 2.47% to 2.36%, 1.64% to 1.51%, and 1.81% to 2.10%. These changes would not materially alter Figure 38: The District of Columbia would still show the highest growth rates for the period 2008-2018 compared to the states that border Virginia.

Table 41. Forecast Annual Population and Employment Growth by the District of Columbia and States Bordering Virginia

Location	Previous Growth (Population, 2008-2018)	Forecast Growth		
		Period	Population	Employment
District of Columbia[a]	1.93%[a]	2010-2040	0.83%[b] or 1.34%[b]	0.76%[b] or 0.82%[b]
Kentucky	0.41%[c]	2015-2040	0.40%[d]	N/A
Maryland	0.61%[c]	2016-2040	0.57%[e], 0.80%[f]	1.28%[f]
North Carolina	1.10%[c]	2010-2040	1.18%[g]	1.29%[g]
Tennessee	0.81%[c]	2010-2040	0.98%[h]	1.46%[h]
West Virginia	-0.19%[c]	2000-2030	0.004%[i]	N/A
Virginia[h]	0.84%[c]	2017-2045	0.78%[j] or 1.03%[j]	0.60%[j] or 1.31%[j]

[a] Calculated by the research team based on 2008 population data from the District of Columbia (2015) and 2018 population data from the U.S. Census Bureau (2017).
[b] District Department of Transportation (2014).
[c] Not calculated by the research team but provided directly by Rosewicz et al. (2019). Using Virginia data, the research team confirmed that the calculations by Rosewicz et al. (2019) followed Equation 1.
[d] Ruther et al. (2016).
[e] Maryland Department of Transportation (2019).
[f] Woods & Poole (2018b).
[g] Atkins (2011).
[h] Tennessee Department of Transportation (2015).
[i] Wilbur Smith Associates (2010).
[j] Estimated by using the forecasts in Tables 35 and 36.

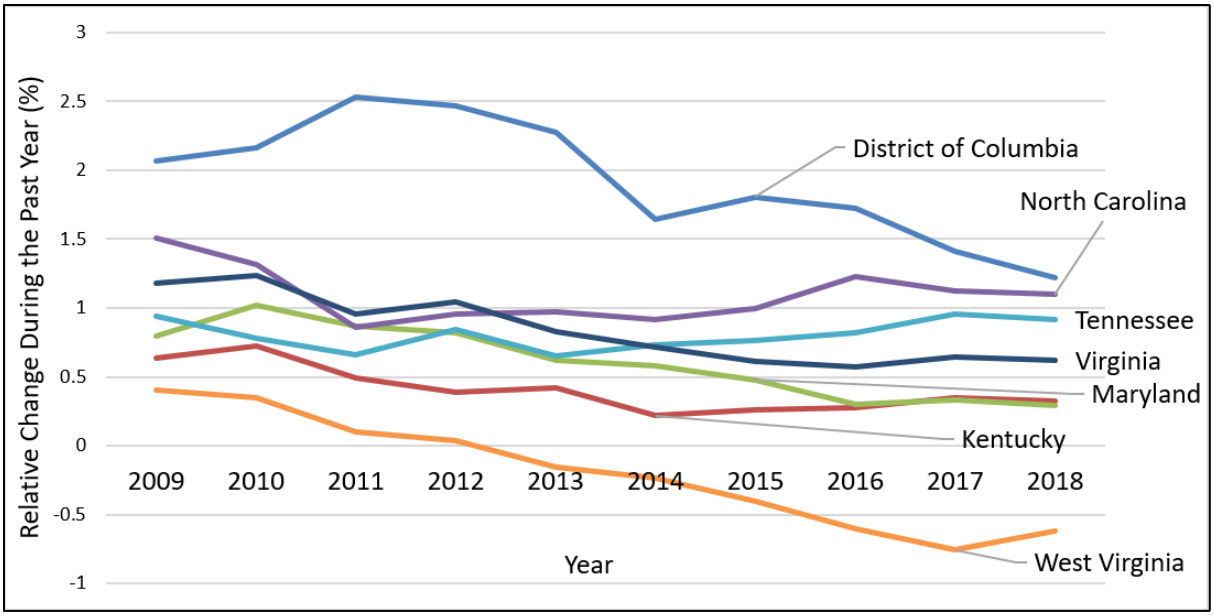


Figure 38. Percent Change in Population Relative to Previous Year for Virginia Border States and the District of Columbia. Data for all states were provided by Rosewicz et al. (2019) except as follows for the District of Columbia: 2008-2009 population (District Department of Transportation, 2014); 2010-2017 population (District of Columbia Office of Planning, 2017); and 2018 population (U.S. Census Bureau, 2018). For example, in 2013 the population of the District of Columbia was 650,114 and in 2014 was 660,797 (District of Columbia Office of Planning, 2017), which is an increase of 1.64%.

Virginia's forecast annual population growth (0.78% or 1.03%) is perhaps characterized as being near the upper middle of this group (border states plus the District of Columbia) being surpassed by that of North Carolina (1.18%) and possibly Tennessee (0.98%) yet being larger than that of West Virginia, Kentucky, and Maryland (with forecast growth annual rates of less than 0.01%, 0.40%, and 0.57%, respectively). There is naturally some variation in these forecasts; for example, although the Maryland Department of Transportation (2019) provides data that enable one to compute a 0.57% forecast population growth rate, the use of data from Woods & Poole (2018b) supports a 0.80% population growth rate. This difference (0.23%) is comparable to the difference in growth rates for Virginia from two different sources (0.25%). The District Department of Transportation (2014), in fact, provides two forecasts, attributing the lower to MWCOG and the higher to the District of Columbia Office of Planning; the difference in rates is about 0.51%. Although this is large, it should be noted that that the District of Columbia has been growing relatively quickly over the previous 10 years, and for a faster growing region one might expect some additional uncertainty.

Virginia's forecast population growth rate clearly differs from that of West Virginia and Kentucky. West Virginia's population is forecast to grow slightly over a 30-year period (2000-2030) according to the most recent statewide transportation plan available (Wilbur Smith Associates, 2010) by less than one-tenth of 1% (from 1.808 million to 1.810 million). In contrast to Virginia, some rural areas are forecast to grow more (on a relative basis) than urban areas: the most "remote rural counties" have a 7% forecast growth in population for 2000-2030, compared to a 10% decrease in the West Virginia county with the largest population as of 2005. In addition, in Kentucky, almost two-thirds of counties (66%) are forecast to see their population drop from 2015-2040 (Ruther et al., 2016). By contrast, in Virginia, less than one-third of PDCs are forecast to have a decline in population based on Weldon Cooper (2017a), and only 1 of Virginia's 21 PDCs is forecast to have a decline in population based on Woods & Poole (2018b).

Most of the areas bordering Virginia pay explicit attention to the aging population: Virginians age 65+ represent 15% of Virginia's population in 2017 but are forecast to be 19% or 20% by year 2045. North Carolina indicates that persons age 65+ may constitute 18% of the state's population in 2040, compared to 13% at present (Atkins, 2011). Coupled with the population increase, the state's plan suggests an increase in travel demand; however, because of this population, which may include baby boomers who work part-time rather than full-time, travel patterns may be changing from what has been observed in the past (Atkins, 2011). Tennessee shows a similar change for the same period, with persons age 65+ increasing from 13.5% of the state's population in 2010 to 19.2% in 2040, leading to an emphasis on roadway design elements that appeal to this population, such as better signage (Tennessee Department of Transportation, 2015). The proportion of persons age 65+ in West Virginia is forecast to grow, although West Virginia's current and forecast percentages for 2005 and 2030 are higher than the current and forecast percentages for Virginia for 2017 and 2045. In West Virginia, the percentage of persons age 65+ is forecast to grow from 15.5% in 2005 to 22.9% in 2030 (Wilbur Smith Associates, 2010). In Kentucky, slightly earlier data used by the state for planning purposes indicated that the fastest growing age group on a percentage basis is persons age 65-84 (Kentucky Transportation Cabinet, 2014). Maryland does not report explicit forecasts for persons age 65+ in its transportation plan but does note that the state is growing older (Maryland Department of Transportation, 2019), with an observed 24% increase in the population age 65+ in a 6-year interval (2010-2016). The Maryland Department of Transportation includes an acknowledgment that persons age 65+ tend to be in rural areas, which may explain why a border region that is urban only and that has no rural areas—the District of Columbia—is the only border region that does not discuss an aging population (District Department of Transportation, 2014).

In terms of employment growth on a percentage basis, Virginia's forecast employment growth rate is probably surpassed by Tennessee and somewhat comparable to that of Maryland, North Carolina, and the District of Columbia. There is substantial variation in employment forecasts even for a single state, so it is possible that differences in employment growth by state reflect differences in methodologies. That said, a theme that emerges in terms of employment in some of Virginia's border regions is the relative change in the importance of service employment. North Carolina (Atkins, 2011) suggests that service employment may increase from 84% to 87% of jobs from 2010-2040, with manufacturing employment dropping by 15% (in 2040) relative to its 2010 value. Tennessee (2015) also explicitly acknowledges a shift from manufacturing to service employment between the present and 2040.

Virginia's population and employment growth is also affected by changes in other states. One example is that employment centers can attract residents across state lines. Because 75% of persons who work in Washington, D.C., live elsewhere, the availability of jobs in that city and the relative attractiveness of Virginia compared to other potential residential locations will also affect Virginia population and employment forecasts. Another example is cited in West Virginia's multimodal plan (Wilbur Smith Associates, 2010): the Virginia Inland Port. As of 2010, several companies, such as SYSCO, have moved to Front Royal, Virginia, specifically to take advantage of the inland port; although the number of jobs created therein is not given, it was noted that such facilities bring "jobs to local economies." Wilbur Smith Associates (2010) examined the extent to which various types of intermodal facilities could be implemented in West Virginia, including one at Prichard located in the western part of West Virginia. In 2015, the first intermodal facility for West Virginia opened at Prichard (Hutchins, 2015), with one of its key benefits being cited as being within 1 mile of the Heartland Corridor Rail Line, which runs from Norfolk, at the Port of Virginia, to Chicago, a major rail hub (Creasy, 2019).

Promotional literature for the Port of Virginia (Port of Virginia, 2019), in turn, cites as a benefit the connection by rail from Norfolk to Prichard (and via this route, to Chicago and the West Coast). If this intermodal connector (in West Virginia) expands the Port of Virginia's market, it appears that this other-state initiative would serve to have economic benefits, and potentially employment impacts, for Virginia.

CONCLUSIONS

Population

- *Population growth rates in Virginia have decreased since 2000, with 1975-2000 showing greater average annual growth rates for most (eight of nine) VDOT districts and most (19 of 21) PDCs than 2000-2017.* Figure 5 shows a greater average annual increase from 1975-2000 in all but one VDOT district (Lynchburg). Similarly, nearly all PDCs in Figure 6 have greater average annual growth rates during the same time period, with the exceptions being the Crater PDC and the Roanoke Valley-Alleghany Regional Commission.

- *The Northern Virginia District is accounting for an increasing percentage of Virginia's total population.* Both VDOT's Northern Virginia District and the Northern Virginia PDC have the second greatest ratio of 2017 population / 1975 population compared to the other districts and PDCs. The Northern Virginia area has continued to grow in size since the 1970s, which has resulted in Virginia's center of population shifting north (Sen, 2017b). Although other districts continue to increase in population, the Northern Virginia PDC, which includes the same jurisdictions as VDOT's Northern Virginia District, went from 20.2% of Virginia's population in 1975 to 29.4% in 2017.

- *With the growth of Northern Virginia's population being much greater than the decline in the population of other PDCs, Virginia's population increased 68% from 1975-2017.* Northern Virginia's 144% increase in population during this period was much greater than the increase in Virginia's statewide population.

- *Virginia's current population is unevenly distributed by PDC, by jurisdictions within PDCs, and by VDOT district.* Three of Virginia's 21 PDCs and three of Virginia's districts account for almost two-thirds (63%) of Virginia's 2017 population, and 10 of Virginia's 133 cities and counties account for almost one-half (48%) of Virginia's 2017 population.

- *Virginia's population is forecast to grow between 24% and 33% from 2017-2045.* On an annual basis, this forecast growth rate (0.78% to 1.03%) is near the upper middle of the forecast growth rates of border states, surpassed by North Carolina (1.18%), inclusive of Tennessee (0.98%), and larger than the forecast rates of West Virginia (<0.01%), Kentucky (0.40%), and Maryland (0.57%).

- *Four of Virginia's 21 PDCs, clustered along the I-95 corridor (Northern Virginia, George Washington, and Richmond Regional) and the eastern portion of the I-64 corridor (Hampton Roads), are expected to account for 83% to 85% of the growth during the period 2017-2045.* For one data source, 4 PDCs (Cumberland Plateau, Southside, West Piedmont, and Accomack-Northampton) are forecast to have double-digit population declines of 10% to 22% from 2017-2045; for another data source, just 1 of these PDCs (Southside) will see a decline (of about 4%).

- *Virginia's population age 65+ is forecast to increase from 1.27 million to between 1.99 million and 2.26 million from 2017-2045.* Much of this increase is expected to occur in PDCs that presently have comparatively lower proportions of persons age 65+, such as the Northern Virginia and George Washington PDCs.

- *Although persons age 75+ are a relatively small percentage of the state's population at present (6%), this group is expected to grow by 104% to 150%, becoming between 10% and 11% of Virginia's total population.* A doubling (e.g., 100% increase or more) of this age cohort is expected in several PDCs, including some urban PDCs that presently have comparatively lower percentages of persons age 75+: George Washington, Northern Virginia, Richmond Regional, Rappahannock-Rapidan, and Hampton Roads.

- *There can be differences between population forecasts performed by two different entities.* MWCOG (2018) produces their own forecast for individual jurisdictions. The average percent difference between this source and Weldon Cooper (2017a) for the 2045 populations of 13 different jurisdictions is 19.66%, with differences between forecasts for individual jurisdictions ranging from 2% (Fairfax County) to almost 38% (City of Fairfax).

Employment

- *Since 1975, employment has become more concentrated in fewer PDCs.* Every PDC has had employment growth for the period 1975-2017; however, the share of statewide employment for the largest PDC (Northern Virginia) and the PDC adjacent to it (George Washington) has grown from 21% (in 1975) to 36% (in 2017). Only 3 other PDCs increased their share of statewide employment over that period, all by less than one-half percent; all other PDCs lost employment share.

- *Statewide employment growth slowed since 2000, with almost one-half of Virginia's PDCs showing declining employment for 2000-2017.* For the period 1975-2000, average annual employment growth rates ranged from 1.04% (West Piedmont) to 7.87% (George Washington); statewide employment increased at a rate of 3.35%. For the period 2000-2017, however, employment growth rates dropped in all PDCs and 10 saw a drop in their employment numbers. Average annual percent employment growth for that period ranged from a decrease of 1.30% (West Piedmont) to an increase of 2.10% (George Washington).

- *Virginia's employment in 2017 is concentrated in 3 PDCs with the highest populations: Northern Virginia (33%), Hampton Roads (20%), and Richmond Regional (14%).* Woods & Poole (2018b) also show that the remaining PDCs have a relatively low proportion of the state's employment; the fourth highest share (in 2017) is Roanoke Valley-Alleghany Regional Commission (with 4.1%); the fourth highest share in 2045 is forecast to be George Washington (with 3.8%). It should be noted that at the relatively large PDC level, jobs and population are highly correlated (correlation coefficients of 0.99 for both 2017 and 2045).

- *Virginia's employment is forecast to grow between 18.2% and 44.1% from 2017-2045.* On an annual basis, this range of forecast growth rates (0.60% to 1.31%) encompasses the forecast growth rates for the District of Columbia (0.76% to 0.82%), Maryland (1.28%), and North Carolina (1.29%) and is surpassed by the forecast growth rate for Tennessee (1.46%).

- *Employment concentration in the largest PDCs is forecast to grow slightly*. The share of employment captured by the 3 most populous PDCs is forecast to increase slightly from 67% at present to 70% in 2045 (Woods & Poole, 2018b). The same source suggests these 3 PDCs (Northern Virginia, Hampton Roads, and Richmond Regional) account for 75% of the new jobs expected from 2017-2045, with the percentage increasing to 80% (if George Washington is added to the list); the addition of Roanoke Valley-Alleghany and Central Shenandoah means that those 6 PDCs account for 85% of new jobs by 2045. IHS Markit (Jeafarqomi, 2018) also suggests an increase in concentration, with the same top 4 PDCs (Northern Virginia, Hampton Roads, Richmond Regional, and George Washington) accounting for 87% of new jobs from 2017-2045 and the top 6 PDCs (these 4 plus Thomas Jefferson and Crater) accounting for 94% of new jobs over that same period.

- *Forecasts of employment growth are magnified at the PDC level*. Whereas Woods & Poole (2018b) suggests that all 21 PDCs will see employment growth over this period (from a 16.3% increase in Crater to a 67.5% increase in George Washington), IHS Markit (Jeafarqomi, 2018) suggests that only 16 PDCs will see an employment increase, with 5 seeing an employment drop (from a 25.8% drop in Accomack-Northampton to a 3.2% drop in Commonwealth Regional). Not surprisingly, jurisdiction level variation is greater: Woods & Poole (2018b) shows employment growth rates ranging from 6% to 100% whereas IHS Markit (Jeafarqomi, 2018) shows growth rates ranging from a 45% drop to a 52% increase (although the manner in which these two sources categorize jurisdictions is not identical).

- *As with population forecasts, there may be greater variation in forecasts for smaller entities than for larger ones.* The forecast employment growth rate for the state as a whole for the period 2015-2045 (50.15%) is more similar to that of the United States as a whole (45.34%), although there is greater variation at the PDC level (Woods & Poole, 2018b).

Household Income

- *Mean household income (in 2017) varies by almost a factor of 3 among PDCs, from $60,582 (Lenowisco) to $172,388 (Northern Virginia).* Although it is just 1 of 21 PDCs, the large population in Northern Virginia, coupled with the large household income therein, increases the value of a statewide weighted mean household income where each household carries the same weight. That is, the mean Virginia household income in 2017 was $120,910, but only 2 PDCs—George Washington and Northern Virginia—have incomes in excess of this statewide average.

- *Mean household income (in constant 2009 dollars) is forecast to grow between 25% and 40% from 2017-2045.* Although the statewide average growth is slightly less than 38%, from $120,910 (2017) to $166,467 (2045), only 2 PDCs exceed this increase on a percentage basis: Accomack-Northampton (forecast to see an increase of almost 38.5% from $80,544 to $111,527) and Southside (forecast to see an increase of 39% from $69,878 to $97,414).

Retrospective Forecast Accuracy

- *Longer term forecasts usually have a considerably higher margin of error than shorter term forecasts.* Lombard (2017a) points out that 30-year county-level population projections are expected to have a margin of error of more than 30%; reducing this horizon to 10 years reduces the expected error to 12%. Lombard (2017a) notes that given an observed 2000 Virginia state-level population of 7.1 million, it is not surprising that a 7-year forecast (made in 1993) of 6.9 million was more accurate than a 23-year forecast (made in 1977) of 6.5 million. The more recent forecast took advantage of an understanding of recent demographic trends (Lombard, 2017a).

- *Volatility adversely affects projections.* In some cases, size is a good predictor of volatility; in one case, total county population forecasts were more accurate than forecasts of county population by age group (Albemarle County Department of Community Development, 2011; Albemarle County Department of Planning and Community Development, 1994). But volatility is not always correlated with the size of the unit of analysis: unexpected rapid growth in a larger jurisdiction may produce a larger forecast error than for a smaller jurisdiction (MWCOG, 2018).

- *Unexpected economic or societal events may lead to increased uncertainty in population projections.* The City of Williamsburg (2013) made projections in 1998 and 2006 for the population of the city in 2010. Although one would expect the latter projection to be more accurate than the former, the unanticipated recession of 2007-2009 led to an 18% error in the 2006 forecast—higher than the 2% error of the 1998 forecast (City of Williamsburg, 2013). By extension, other unforeseen impacts would affect forecast accuracy.

- *A shift in Virginia's geographic population center that initially began in the 1970s may cause more uncertainty in the projected populations of the affected cities.* During the 1970s, population growth in the Hampton Roads and Richmond areas began to slow and that of Northern Virginia grew (Sen, 2017b). Although forecasts show continued population growth therein, the rate of this increase may be difficult to forecast accurately because of the lack of knowledge regarding other factors that may influence this trend.

Stakeholder Areas of Interest

- *Migration between Virginia and other states has reduced Virginia's population growth.* The most recent data set available (the 2017 ACS [U.S. Census Bureau 2018g]) suggests that Virginia lost more residents than it gained (a net change of 12,073 people) based on movements in 2016, or about 0.14% of Virginia's population at the time the survey was performed. Earlier migration patterns from the 2012-2016 ACS (U.S. Census Bureau, 2018f) and literature published by Lombard (2017b) that used a separate data set from the Internal Revenue Service showed that there was net migration out of the Northern Virginia PDC for that earlier period. These migration patterns reflect only the movement of Virginians between U.S. states and the District of Columbia; they do not reflect net change between Virginia and other countries or births and deaths.

- *Transportation investments have the potential to support population growth and economic development but only if other conditions that also support such growth are present.* The literature shows instances where investments in transportation led to an increase in employment rate (but not total employment) (Zhao and Leung, 2018) and population (John, 1982). However, because other factors such as immigration (Paral, 2017), economic incentives (Shearer et al., 2018), school availability (Cromartie et al., 2015), and the presence of proximate competing employment centers (Boarnet and Haughwout, 2000) also affect location choice, a given investment in transportation may not necessarily affect a region's development pattern. The likelihood of an investment having an impact on growth decreases if the proposed investment only marginally improves travel conditions, as opposed to an investment that renders a formerly inaccessible area accessible (Meyer and Miller, 2013).

- *Although population and employment are highly correlated at the district or PDC level, regional employment values are more volatile than regional population values*. For the period 1975-2017, the changes in annual population growth rates by VDOT district tended to be substantially smaller than the corresponding changes in annual employment growth rates.

- *Although changes in transportation needs appear to vary by region, a common theme is that the population of Virginians age 65+ is increasing faster than that of other age groups*. Related investments that support mobility for this group may be of interest, such as pedestrian facilities (DeGood, 2011), assistance for persons who have trouble driving (National Aging and Disability Transportation Center, 2019), fare policies for public transportation (Loukaitou-Sideris and Wachs, 2018), and safety measures that specifically target older drivers (Getzmann et al., 2018).

- *A case study suggests that 2045 regional forecasts can be altered by a few percentage points by the unanticipated arrival of a large employer*. Based on the Northern Virginia PDC, the location of Amazon's forthcoming HQ2, the research team estimates that the population and employment for the Northern Virginia PDC (which is the same as VDOT's Northern Virginia District) would be higher by amounts of 6.3% or 3.4% than would be the case without Amazon. This estimate assumes that the 94,321 direct and induced jobs are in place in 2045 (Fuller and Chapman, 2018) and are all located in Northern Virginia.

- *The same case study illustrates the magnifying impacts of changes in employment and population.* The arrival of Amazon shows that each additional job can beget a series of impacts that include further employment growth (depending on the salaries provided by the original jobs), changes in demand for certain occupations, and changes in housing demand, all of which are magnified at the local level:

  — *The arrival of Amazon may add approximately 59,000 jobs by 2030 (Chmura Economics and Analytics, 2018) and 94,000 jobs by 2040 (Fuller and Chapman, 2018).* These jobs include those for persons directly employed by Amazon (cited as 25,000 by the former source and 50,000 by the latter source) and those created by ripple effects because of its presence.

  — *For the specific localities affected by Amazon, economists expect Amazon to generate substantial additional employment and population growth from induced, indirect, and spinoff effects (Chmura Economics and Analytics, 2018; Fuller Institute, 2018). These effects are affected by the Amazon salaries; for example, Fuller and Chapman (2018) suggested that with Amazon salaries of $150,000, there would be 44,321 induced jobs—a number that rises by 5,177 to 49,498 induced jobs if the Amazon salaries are $200,000.*

  — Economists say that *although Amazon's arrival will intensify job growth and housing demand (particularly in Arlington), the net impact may be a 6% to 13% increase compared to the population and growth rates for the Washington, D.C., region over the last 20 years* (Fuller Institute, 2018).

— *Amazon could enable Northern Virginia and Virginia to retain more highly educated and skilled employees, countering recent patterns of outmigration* (Fuller and Chapman, 2018).

— *Investments in higher education in Northern Virginia will increase the number of graduates and doctoral candidates in information technology and related fields to provide the employees needed by Amazon and related companies* (Woolsey, 2018).

— *The arrival of Amazon will allow Arlington and Virginia to continue further diversifying their economies toward less reliance on federal employment* (Fuller Institute, 2018).

— *With Amazon employees' expected average annual income of $150,000, average household incomes of National Landing residents may rise over the next 5 to 10 years* (Fleishman, 2018).

— *An existing lack of affordable housing in Arlington may be exacerbated by Amazon's HQ2 (Jan and Orton, 2018). A shortage of affordable housing may cause lower income households to move farther out and face longer commutes to their jobs.*

RECOMMENDATIONS

1. *OIPI should share the socioeconomic forecasts presented in this report, when needed, as ranges*. By showing the forecasts in population, employment, and income as ranges (as done in Figures ES1, ES2, ES3, and ES4), one can convey an expected amount of uncertainty for each demographic variable.

IMPLEMENTATION AND BENEFITS

Implementation

Publication of this report and sharing of these forecasts as ranges rather than solely as point estimates are two ways to implement the study recommendation. Examples of such forecasts are those presented in Figures ES1 through ES4.

Benefits

All forecasts have uncertainty, and until the forecast year has passed, one cannot know how accurate, or inaccurate, the forecast will prove to be. The use of ranges, however, enables one to estimate the amount of uncertainty expected for each variable. For example, the uncertainty associated with population is expected to be less than that with employment. By acknowledging this uncertainty in forecasts, one can potentially increase confidence in the development of forecasts. This sentiment is also related to a comment made by an attendee at a public presentation of some of these forecasts on March 13, 2019: it is important to convey a realistic level of the expected accuracy. A similar comment was made when this work was presented at the Commonwealth Transportation Board Meeting on June 18, 2019, in that ranges would be helpful, especially given that there are multiple sources of these data.

ACKNOWLEDGMENTS

The research team acknowledges several individuals who provided assistance with this effort: Jitender Ramchandani, Kathryn Schwing, and Chris Wichman of OIPI and Lukas Camby and Linda Evans of the Virginia Transportation Research Council.

REFERENCES

Albemarle County Department of Community Development. *CPA 2013-00001 Comprehensive Plan Revision.* October 11, 2011. http://www.albemarle.org/upload/images/forms_center/departments/community_development/forms/PC_Reports/COMP_PLAN_UPDATED2.pdf. Accessed November 19, 2018.

Albemarle County Department of Planning and Community Development. *Albemarle County Information Sheet.* Charlottesville, VA, 1994.

Atkins. *Challenges and Opportunities: North Carolina Statewide Transportation Plan.* 2011. https://www.ncdot.gov/initiatives-policies/Transportation/plan/Documents/2040_ChallengeOpp.pdf. Accessed May 16, 2019.

Bateman, N., Schuetz, J., and Ross, M. Amazon's Northern Virginia Headquarters Could Exacerbate Existing Economic Disparities. The Brookings Institution, November 29, 2018. https://www.brookings.edu/blog/the-avenue/2018/11/29/amazon-headquarters-could-exacerbate-existing-economic-disparities-in-northern-virginia/. Accessed April 15, 2019.

Bentley, J. Email to John S. Miller, March 21, 2019.

Berdanier, A. Email to John S. Miller, January 28, 2020.

Blumenberg, E. Moving In and Moving Around: Immigrants, Travel Behavior and Implications for Transport Policy. *University of California Transportation Letters*, Vol. 1, No. 2, December 22, 2008.

Boarnet, M.G., and Haughwout, A.F. *Do Highways Matter? Evidence and Policy Implications of Highways' Influence on Metropolitan Development.* The Brookings Institution Center on Urban and Metropolitan Policy, 2000. https://www.brookings.edu/wp-content/uploads/2016/06/boarnet.pdf. Accessed April 12, 2019.

Bureau of Economic Analysis. *Local Area Personal Income and Employment Methodology.* 2017. https://apps.bea.gov/regional/pdf/lapi2016.pdf. Accessed December 12, 2018.

Bureau of Labor Statistics. Quarterly Census of Employment and Wages. Undated. https://www.bls.gov/cew/. Accessed January 25, 2019.

Bureau of Labor Statistics. Quarterly Census of Employment and Wages: QCEW Data Files. 2018a. https://www.bls.gov/cew/datatoc.htm. Accessed December 19, 2018.

Bureau of Labor Statistics. Quarterly Census of Employment and Wages: Employment and Wages Online Annual Averages, 2017. 2018b. https://www.bls.gov/cew/cewbultncur.htm. Accessed January 25, 2019.

Bureau of Labor Statistics. Employment Projections: Projections Methodology. 2018c. https://www.bls.gov/emp/documentation/projections-methods.htm. Accessed January 23, 2019.

Cai, Q. Email to Haritha Bhairavabhatla, December 6, 2018.

Center on Budget and Policy Priorities. Policy Basics: An Introduction to TANF. 2018. https://www.cbpp.org/research/policy-basics-an-introduction-to-tanf. Accessed February 1, 2019.

Chi, G., Voss, P.R., and Deller, S.C. Rethinking Highway Effects on Population Change. *Public Works Management & Policy,* Vol. 11, No. 1, July, 2006, pp. 18-32.

Chmura Economics and Analytics. *Economic Impact of Amazon's Major Corporate Headquarters in Virginia and the Washington MSA.* December 7, 2018. https://www.vachamber.com/wp-content/uploads/2018/12/Final-Amazon-Study-120718.pdf. Accessed April 23, 2019.

City of Charlottesville. 2007 Comprehensive Plan Chapter Three: Community Characteristics. 2007. http://www.charlottesville.org/home/showdocument?id=8175. Accessed December 11, 2018.

City of Williamsburg. Williamsburg Comprehensive Plan: Appendix A1—Past Comprehensive Plans. 2013. https://www.williamsburgva.gov/home/showdocument?id=7944. Accessed December 11, 2018.

Crane, R., and Chatman, D.G. As Jobs Sprawl, Whither the Commute? *Access*, No. 23, Fall 2003, pp. 14-19.

Creasy, L. Intermodal Gateway Still Holds Untapped Potential for Region. The Herald Dispatch.com. March 24, 2019. https://www.apnews.com/27f52fb261e747a7b96f072a5797b260. Accessed May 30, 2019.

Cromartie, J., von Reichter, C., and Arthun, A. *Factors Affecting Former Residents' Returning to Rural Communities.* ERR-185. U.S. Department of Agriculture, Economic Research Service, Washington, DC, 2015.

DeGood, K. *Aging in Place, Stuck Without Options: Fixing the Mobility Crisis Threatening the Baby Boom Generation.* Transportation for America, 2011. http://t4america.org/docs/SeniorsMobilityCrisis.pdf. Accessed March 26, 2019.

District Department of Transportation. Move DC: The District of Columbia's Multimodal Long-Range Transportation Plan: Chapter 2, Growth, Travel Patterns, and Needs, Washington, D.C., 2014. http://www.wemovedc.org/. Accessed May 16, 2019.

District of Columbia. *D.C. Office of Revenue Analysis Briefing Document Number 2015-1*. 2015. https://cfo.dc.gov/sites/default/files/dc/sites/ocfo/publication/attachments/2015-01_DC%20Population.pdf. Accessed May 31, 2019.

District of Columbia Office of Planning. 2017 Annual Estimates of Populations. 2017. https://planning.dc.gov/node/1296421. Accessed May 31, 2019.

Fleishman, G. Only Half of Jobs at Amazon's HQ2 in Tech, Report Says, With the Balance in Support Positions. *Fortune*, November 21, 2018.

Friedman, G. Population Decline and the Great Economic Reversal. *Forbes*, February 17, 2015.

Fuller, S.S., and Chapman, J. *The Economic and Fiscal Impacts of Locating Amazon's HQ2 in Arlington County, Virginia*. November 8, 2018. https://sfullerinstitute.gmu.edu/wp-content/uploads/2018/11/SFI_-Economic_-Fiscal_Impacts_of_Amazon-HQ2_110818.pdf/. Accessed April 23, 2019.

Getzmann, S., Arnau, S., Karthaus, M., Reiser, J.R., and Wascher, E. Age-Related Differences in Pro-Active Driving Behavior Revealed by EEG Measures. *Frontiers in Human Neuroscience,* Vol. 12, 2018.

Henderson, R. Industry Employment and Output Projections to 2024. Monthly Labor Review, U.S. Bureau of Labor Statistics, December 2015. https://www.bls.gov/opub/mlr/2015/article/industry-employment-and-output-projections-to-2024.htm. Accessed January 28, 2019.

Hester, W.P. Va.'s Declining Communities: Southwest Fights Population Losses. *Richmond Times-Dispatch,* August 14, 2011.

Hutchins, R. West Virginia Opens First Intermodal Terminal. *The Journal of Commerce,* December 28, 2015.

Jan, T., and Orton, K. Northern Virginia Property Owners Are Delighted Amazon HQ2 Is Moving In. Renters, First Time Buyers and Low-Income Residents Aren't. *The Washington Post*, November 13, 2018.

Jeafarqomi, K. Email to John S. Miller, December 13, 2018.

John, K.E. Subway Expected to Reverse Arlington Population Decline. *The Washington Post,* August 27, 1982.

Kamins, A. Email to John S. Miller, January 10, 2019.

Kentucky Transportation Cabinet. *2014-2035 Kentucky Long-Range Statewide Transportation Plan (LRSTP).* 2014. https://transportation.ky.gov/Planning/Documents/2014-2035%20LRSTP.pdf. Accessed May 16, 2019.

Kim, S. Immigrants and Transportation: An Analysis of Immigrant Worker's Work Trips. *Cityscape: A Journal of Policy Development and Research*, Vol. 11, No. 3, 2009.

Kopf, D. Which Professions Have the Longest Commutes? *Priceonomics*, February 23, 2016. https://priceonomics.com/which-professions-have-the-longest-commutes/. Accessed March 10, 2019.

Lacey, T., Toossi, M., Dubina, K., and Gensler, A. Projections Overview and Highlights, 2016-26. Monthly Labor Review, U.S. Bureau of Labor Statistics, October 2017. https://www.bls.gov/opub/mlr/2017/article/projections-overview-and-highlights-2016-26.htm. Accessed January 23, 2019.

Lessons From Hell. *The Economist*, Vol. 431, No. 9138, April 13, 2019, p. 31.

Litman, T. *Land Use Impact on Transports, How Land Use Factors Affect Travel Behavior.* Victoria Transport Policy Institute, July 24, 2018. http://vtpi.org/landtravel.pdf. Accessed March 2, 2019.

Lombard, H. *How Accurate Are Population Projections?* Weldon Cooper Center for Public Service, June 21, 2017a. http://statchatva.org/2017/06/21/how-accurate-are-population-projections/. Accessed November 1, 2018.

Lombard, H. Out-migration From Virginia Continues for a Fourth Consecutive Year. StatChat, December 7, 2017b. http://statchatva.org/2017/12/07/out-migration-from-virginia-continues-for-a-fourth-consecutive-year/. Accessed April 17, 2019.

Loukaitou-Sideris, A., and Wachs, M. *Transportation for an Aging Population: Promoting Mobility and Equity for Low-Income Seniors*. Mineta Transportation Institute, 2018. http://transweb.sjsu.edu/sites/default/files/1704-Sideris-Transportation-Aging-Population-Equity-Mobility.pdf. Accessed April 8, 2019.

Maryland Department of Transportation. *2040 Maryland Transportation Plan: Connecting You to Life's Opportunities.* 2019. http://www.mdot.maryland.gov/newMDOT/Planning/Maryland_Transportation_Plan/Documents/2040_MTP_Document_2019-01-31_WebSinglePages.pdf. Accessed May 16, 2019.

Metropolitan Washington Council of Governments. Round 7.0 Cooperative Forecasting: Population and Household Forecasts to 2030 by Traffic Analysis Zone. 2005. https://www.mwcog.org/documents/2018/10/17/cooperative-forecasts-employment-population-and-household-forecasts-by-transportation-analysis-zone-cooperative-forecast-demographics-housing-population/. Accessed December 5, 2018.

Metropolitan Washington Council of Governments. Final Round 9.1 Cooperative Forecasts. 2018. https://www.mwcog.org/documents/2018/10/17/cooperative-forecasts-employment-population-and-household-forecasts-by-transportation-analysis-zone-cooperative-forecast-demographics-housing-population/. Accessed December 6, 2018.

Meyer, M.D., and Miller, E.J. *Transportation Planning: A Decision-Oriented Approach*, 3rd ed. Modern Transport Solutions, Atlanta, GA, 2013.

Miller, J.S., and Kang, D. *Ways to Consider Driverless Vehicles in the Long-Range Planning Process.* VTRC 19-R11. Virginia Transportation Research Council, Charlottesville, 2019.

Minnesota Department of Transportation. Fun Facts. 2019. https://www.dot.state.mn.us/roadway/data/fun-facts.html. Accessed April 12, 2019.

Misra, T. The Newest Americans, Getting Off the Bus. Citylab, January 5, 2017. https://www.citylab.com/transportation/2017/01/the-newest-americans-getting-off-the-bus/512048/. Accessed March 12, 2019.

Moody's Analytics. *U.S. County Forecast Database*. New York, 2019.

National Aging and Disability Transportation Center. Older Adults & Transportation: Unique Issues Related to Older Adults and Transportation. 2019. https://www.nadtc.org/about/transportation-aging-diability/unique-issues-related-to-older-adults-and-transportation/. Accessed March 26, 2019.

O'Connell, J., and McCartney, R. Amazon HQ2 Decision: Amazon Splits Price Between Crystal City and New York. *The Washington Post*, November 13, 2018. Accessed April 15, 2019.

Office of Intermodal Policy and Investment. Detailed Scope of VTrans Task 5.2.2. Richmond, 2018. https://docs.google.com/document/d/18hIuecmEqmIDTTWcpggBMvVrEpxFkV95BDIV4ozup94/edit. Accessed November 2, 2018.

Paral, R. *Looking Back to Look Forward: Lessons From the Immigration Histories of Midwestern Cities.* Chicago Council on Global Affairs, 2017. https://www.thechicagocouncil.org/sites/default/files/report_lessons_immigration_history_midwestern_cities_170915.pdf. Accessed December 18, 2018.

Pascale, J. The Monitor-Merrimac Bridge-Tunnel Turns 25 Sunday. Here's How It's Changed Hampton Roads. *The Virginian-Pilot,* April 28, 2017.

Port of Virginia. *Heartland Intermodal Gateway.* 2019. http://www.portofvirginia.com/pdfs/Quick%20Links/Prichard_Heartland_2018.pdf. Accessed May 16, 2019.

Rifkin, J. Everything You Need To Know About Amazon Coming to Northern Virginia. *Northern Virginia Magazine*, December 20, 2018.

Rosenbloom, S. Meeting Transportation Needs in an Aging-Friendly Community. *Journal of American Society on Aging*, Vol. 33, No. 2, 2009, pp. 33-43.

Rosewicz, B., Biernacka-Lievestro, J., and Newman, D. Western, Southern States Gain Residents the Fastest. The Pew Charitable Trusts, 2019. https://www.pewtrusts.org/en/research-and-analysis/articles/2019/02/27/western-southern-states-gain-residents-the-fastest. Accessed May 31, 2019.

Ruther, M., Sawyer, T., and Ehresman, S. *Projections of Population and Households: State of Kentucky, Kentucky Counties, and Area Development Districts, 2015-2040.* Kentucky State Data Center, 2016. http://www.ksdc.louisville.edu/wp-content/uploads/2016/10/projection-report-v16.pdf. Accessed May 28, 2019.

Sen, S. *Understanding Population Projections.* Weldon Cooper Center for Public Service, 2017a. https://demographics.coopercenter.org/sites/demographics/files/PopProjections_Understanding_2017.pdf. Accessed October 13, 2018.

Sen, S. *Despite Slowing Growth Rate, Virginia Is Projected to Be the 10th Largest State by 2040.* Weldon Cooper Center for Public Service, June 26, 2017b. http://statchatva.org/2017/06/26/despite-slowing-growth-rate-virginia-is-projected-to-be-the-10th-largest-state-by-2040/. Accessed November 30, 2018.

Sen, S. Population Projections Show That Virginia Is Aging and Growing More Slowly. Weldon Cooper Center for Public Service, 2019. http://statchatva.org/2019/07/01/population-projections-show-that-virginia-is-aging-and-growing-more-slowly/. Accessed July 9, 2019.

Shaban, H. Winners and Losers From Amazon's HQ2 Decision. *The Washington Post*, November 13, 2018.

Shearer, C., Shah, I., and Muro, M. *Advancing Opportunity in Central Indiana.* Brookings Institution, 2018. https://www.brookings.edu/wp-content/uploads/2018/12/2018.15_BrookingsMetro_Indy-Opportunity-Industries_Report_Shearer-Shah-Muro.pdf. Accessed December 18, 2018.

Sisson, P. High Housing Costs and Long Commutes Drive More Workers to Sleep in Cars, It's a Symptom of a Bigger, Nationwide Problem, Lack of Affordable Housing Near Jobs. Curbed, March 6, 2018. https://www.curbed.com/2018/3/6/17082570/affordable-housing-commute-rent-apartmen. Accessed March 1, 2019.

Slatt, C. Here Are 5 New Infrastructure Projects We'll Likely Get With Amazon. Greater Greater Washington, November, 14, 2018. https://ggwash.org/view/69866/crystal-city-national-landing-virginia-new-infrastructure-get-amazon. Accessed April 30, 3019.

Social Security Administration. Benefits for People with Disabilities. 2017. https://www.ssa.gov/disability/. Accessed February 5, 2019.

Stafford County Planning Commission. Stafford County Virginia Comprehensive Plan, 2010. https://staffordcountyva.gov/DocumentCenter/View/5557/Entire-Comprehensive-Plan-09-15-15?bidId. Accessed December 5, 2018.

Stephen S. Fuller Institute for Research on the Washington Region's Economic Future, George Mason University. *What Does Amazon's HQ2 Mean for the Washington Region?* November 18, 2018. https://sfullerinstitute.gmu.edu/wpcontent/uploads/2018/11/SFI_Amazon_FAQs_1118.pdf. Accessed April 18, 2019.

Sullivan, P. GMU Panel: Don't Expect Amazon to Change the Region All at Once. *The Washington Post*, December 14, 2018.

Tennessee Department of Transportation. *TDOT 25-Year Long-Range Transportation Policy Plan: Demographic & Employment Changes & Trends Policy Paper*. 2015. https://www.tn.gov/content/dam/tn/tdot/documents/Demographic_022316.pdf. Accessed May 16, 2019.

Toossi, M. *Labor Force Projections to 2024: The Labor Force Is Growing, But Slowly*. Monthly Labor Review, U.S. Bureau of Labor Statistics, December 2015. https://www.bls.gov/opub/mlr/2015/article/labor-force-projections-to-2024.htm. Accessed January 28, 2019.

Tribbitt, T. *Spotsylvania County, Virginia; Appropriations; General Obligation.* S&P Global Ratings, 2018. http://www.spotsylvania.va.us/filestorage/21027/21029/23134/28870/40614/RatingsDirect_SummarySpotsylvaniaCountyVirginiaAppropriationsGeneralObligation_39548411_Aug-06-2018.PDF. Accessed April 26, 2019.

U.S. Census Bureau. QuickFacts: Alexandria City, Virginia; Arlington County, Virginia; Loudoun County, Virginia. 2010a. https://www.census.gov/quickfacts/fact/table/alexandriacityvirginia,arlingtoncountyvirginia,loudouncountyvirginia/POP010210. Accessed December 5, 2018.

U.S. Census Bureau. QuickFacts: Manassas Park City, Virginia; Manassas City, Virginia; Prince William County, Virginia; Falls Church City, Virginia; Fairfax City, Virginia; Fairfax County, Virginia. 2010b. https://www.census.gov/quickfacts/fact/table/manassasparkcityvirginia,manassascityvirginia,princewilliamcountyvirginia,fallschurchcityvirginia,fairfaxcityvirginia,fairfaxcountyvirginia/POP010210. Accessed December 5, 2018.

U.S. Census Bureau. QuickFacts: Stafford County, Virginia; Fredericksburg City, Virginia; Prince William County, Virginia; Spotsylvania County, Virginia; King George County, Virginia; Fauquier County, Virginia. 2010c. https://www.census.gov/quickfacts/fact/table/staffordcountyvirginia,fredericksburgcityvirginia,princewilliamcountyvirginia,spotsylvaniacountyvirginia,kinggeorgecountyvirginia,fauquiercountyvirginia/POP010210. Accessed December 5, 2018.

U.S. Census Bureau. QuickFacts: Virginia; Albemarle County, Virginia; Charlottesville City, Virginia (County). 2010d. https://www.census.gov/quickfacts/fact/table/va,albemarlecountyvirginia,charlottesvillecityvirginiacounty/POP010210. Accessed December 12, 2018.

U.S. Census Bureau. QuickFacts: District of Columbia. 2017. https://www.census.gov/quickfacts/fact/table/DC/PST045218. Accessed May 31, 2019.

U.S. Census Bureau. 2017 Population Estimates: Age and Sex (Virginia Localities). 2018a. https://demographics.coopercenter.org/sites/demographics/files/2018-09/Census_2017_AgeSexEstimates_forVA.xls. Accessed October 13, 2018.

U.S. Census Bureau. Quick Facts: Virginia. 2018b. https://www.census.gov/quickfacts/fact/table/va/PST045217. Accessed December 14, 2018.

U.S. Census Bureau. *American Community Survey and Puerto Rico Community Survey 2017 Subject Definitions*. 2018c. https://www2.census.gov/programs-surveys/acs/tech_docs/subject_definitions/2017_ACSSubjectDefinitions.pdf?#. Accessed January 17, 2019.

U.S. Census Bureau. QuickFacts: Appomattox County, Virginia. 2018d. https://www.census.gov/quickfacts/appomattoxcountyvirginia. Accessed January 17, 2019.

U.S. Census Bureau. *Understanding and Using American Community Survey Data: What All Data Users Need to Know*. 2018e. https://www.census.gov/content/dam/Census/library/publications/2018/acs/acs_general_handbook_2018.pdf. Accessed April 17, 2019.

U.S. Census Bureau. County-to-County Migration Flows: 2012-2016 ACS. 2018f. https://www.census.gov/data/tables/2016/demo/geographic-mobility/county-to-county-migration-2012-2016.html. Accessed April 17, 2019.

U.S. Census Bureau. State-to-State Migration Flows 2017. 2018g. https://www.census.gov/data/tables/time-series/demo/geographic-mobility/state-to-state-migration.html. Accessed April 16, 2019.

U.S. Census Bureau. American National Standards Institute/Federal Information Processing Standards (ANSI/FIPS), Washington, D.C., undated. https://www.census.gov/quickfacts/fact/note/US/fips. Accessed March 31, 2020.

Virginia Association of Planning District Commissions. *PDC Directory*. 2018. https://vapdc.site-ym.com/page/EDRoster. Accessed September 6, 2018.

Virginia Department of Transportation. VDOT District Offices. 2018. http://www.virginiadot.org/about/districts.asp. Accessed November 7, 2018.

Virginia Employment Commission. *Virginia Community Profile: Charlottesville MSA.* 2018. http://virginialmi.com/report_center/community_profiles/5121016820.pdf. Accessed December 12, 2018.

Weldon Cooper Center for Public Service. Intercensal Estimates for Virginia, Counties, and Cities: 1970-1980. Undated. https://demographics.coopercenter.org/sites/demographics/files/VA-Intercensal-Estimates_1970-1980_UVA-CooperCenter.xls. Accessed February 11, 2019.

Weldon Cooper Center for Public Service. Intercensal Estimates for Virginia, Counties, and Cities: 1980-1990. 1993. https://demographics.coopercenter.org/sites/demographics/files/VA-Intercensal-Estimates_1980-1990_UVA-CooperCenter.xls. Accessed February 11, 2019.

Weldon Cooper Center for Public Service. Intercensal Estimates for Virginia, Counties, and Cities: 1990-2000. 2003. https://demographics.coopercenter.org/sites/demographics/files/VA-Intercensal-Estimates_1990-2000_UVA-CooperCenter.xls. Accessed February 11, 2019.

Weldon Cooper Center for Public Service. Intercensal Estimates for Virginia, Counties, and Cities: 2000-2009. 2011. https://demographics.coopercenter.org/sites/demographics/files/VA-Intercensal-Estimates_2000-2010.xls. Accessed October 13, 2018.

Weldon Cooper Center for Public Service. *Locality Population Estimates Methodology*. 2015. https://demographics.coopercenter.org/sites/demographics/files/VA_PopEstimates_LocalityMethodology_Jan2015.pdf. Accessed October 13, 2018.

Weldon Cooper Center for Public Service. Population Projections for Virginia and Its Localities, 2025, 2035, 2045, Interpolated From the 2020-2040 Projections. 2017a. https://demographics.coopercenter.org/sites/demographics/files/VAPopProjections_Total_2020-2040_final.xls. Accessed October 13, 2018.

Weldon Cooper Center for Public Service. Population Projections by Age and Sex for Virginia and Its Localities, 2020-2040. 2017b. https://demographics.coopercenter.org/sites/demographics/files/VAPopProjections_AgeSex_2020-2040.xls. Accessed October 13, 2018.

Weldon Cooper Center for Public Service. July 1, 2017 Population Estimates for Virginia and Its Counties and Cities. 2018. https://demographics.coopercenter.org/sites/demographics/files/2018-01/PopEstimates_July2017_UVACooperCenter.xls. Accessed October 13, 2018.

Weldon Cooper Center for Public Service. Intercensal Estimates for Virginia, Counties, and Cities: 2010-2018. 2019a. https://demographics.coopercenter.org/sites/demographics/files/2019-01/VA-Intercensal-Estimates_2010-2018_UVA-CooperCenter_0.xls. Accessed February 11, 2019.

Weldon Cooper Center for Public Service. Population Projections for Virginia and Its Localities, 2020-2040. 2019b. https://demographics.coopercenter.org/sites/demographics/files/2019-06/VAPopProjections_Total_2020-2040_final_0.xls. Accessed July 9, 2019.

Weldon Cooper Center for Public Service. *Virginia Population Projections Methodology.* 2019c. https://demographics.coopercenter.org/sites/demographics/files/2019-08/VAPopProj%20Methodology_2019_Updated.pdf. Accessed January 29, 2020.

Wilbur Smith Associates. *West Virginia Multi-Modal Statewide Transportation Plan*. 2010. http://transportation.wv.gov/highways/programplanning/planning/statewide/Documents/West_Virginia_Long_Range_Multi-modal_Transportation_Plan.pdf. Accessed May 16, 2019.

Woods & Poole Economics, Inc. *2018 State Profile, District of Columbia, Maryland, and Virginia, CD-ROM Technical Documentation*. Washington, DC, 2018a.

Woods & Poole Economics, Inc. *Virginia, Maryland, and the District of Columbia, 2018 State Profile, State and County Projections to 2050*. Washington, DC, 2018b.

Woolsey, A. Prepare for Impact: Amazon HQ2 Officially Coming to Northern Virginia. *Fairfax County Times*, November 13, 2018.

Zhao, Z.J., and Leung, W. *Transportation Investment and Job Creation in Minnesota Counties.* University of Minnesota, Minneapolis, 2018.

Zmud, J.P., Barabba, V.P., Bradley, M., Kuzmyak, R.J., Zmud, M., and Orrell, D. *NCHRP Report 750: Strategic Issues Facing Transportation, Volume 6: The Effects of Socio-Demographics on Future Travel Demand*. Transportation Research Board, Washington, DC, 2014.