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FINAL REPORT

A RECONSIDERATION OF VARIABLE USED TO DETERMINE ECONOMIC TURBULENCE IN *A RETROSPECTIVE EVALUATION OF TRAFFIC FORECASTING TECHNIQUES*

for the

VIRGINIA DEPARTMENT OF TRANSPORTATION

RESEARCH CONDUCTED WITH THE RESOURCES PROVIDED BY:

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Introduction

This analysis is a response and re-evaluation of a variable being used in the research report *A Retrospective Evaluation of Traffic Forecasting Techniques (2016)* by John S. Miller, Ph.D., P.E. and Research Assistants. The variable used in accordance with their traffic forecasting technique along 39 Virginia studies between their base year and forecast year is the number of economic recessions, which correlates with the accuracy of forecasted traffic volumes against the observed traffic. Economic recessions were used as a rough indicator of unforeseen economic changes, or "economic turbulence", because of the comprehension and accessibility to economic recession data. But, there is a different tangible and quantitative metric that can measure economic turbulence between the base year and forecast year. In this essay, I give insight and reasoning as to why economic recessions, which are based off of national gross domestic product (GDP) are not the best indicator of economic turbulence and why employment is a better option for this research report.

Economic Recessions

Recessions and GDP are not the best indicators of economic turbulence within a state because the economic prosperity on a state level does not always correlate with the national measurement of recessions in GDP which are determined by the Federal Reserve. **Figure 1** is showing the percent change in real GDP for the state of Virginia and a trend line representing the predicted percent change in real GDP for each year from 1965 to 2015. Data for gross domestic product is provided by the Bureau of Economic Analysis.[1] **Figure 2** is showing the national real GDP growth rates and shaded regions represent classified recessions.[2] During any national recession, the national GDP growth rate may be different than Virginia's GDP growth rate. For example, during the 2007-2009 recession, national real GDP growth dropped to almost 2% while Virginia GDP growth rate was reaching 4%.

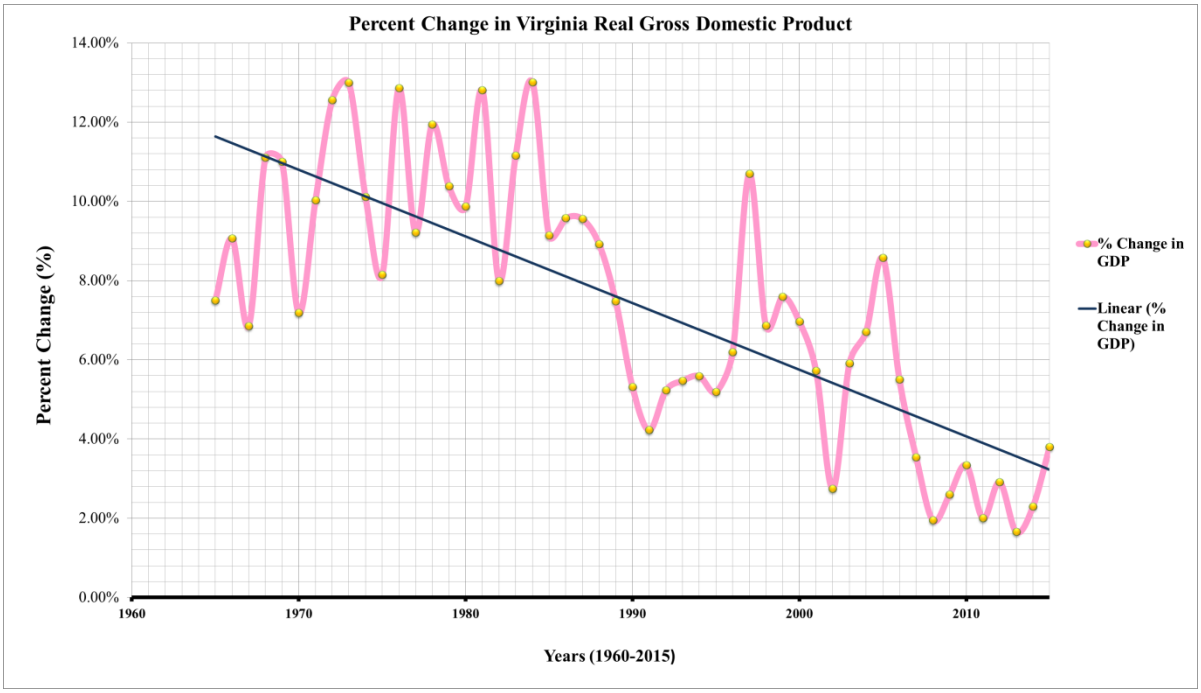

Figure 1. Percent Change in Virginia Real Gross Domestic Product. Data provided by Bureau of Economic Analysis.

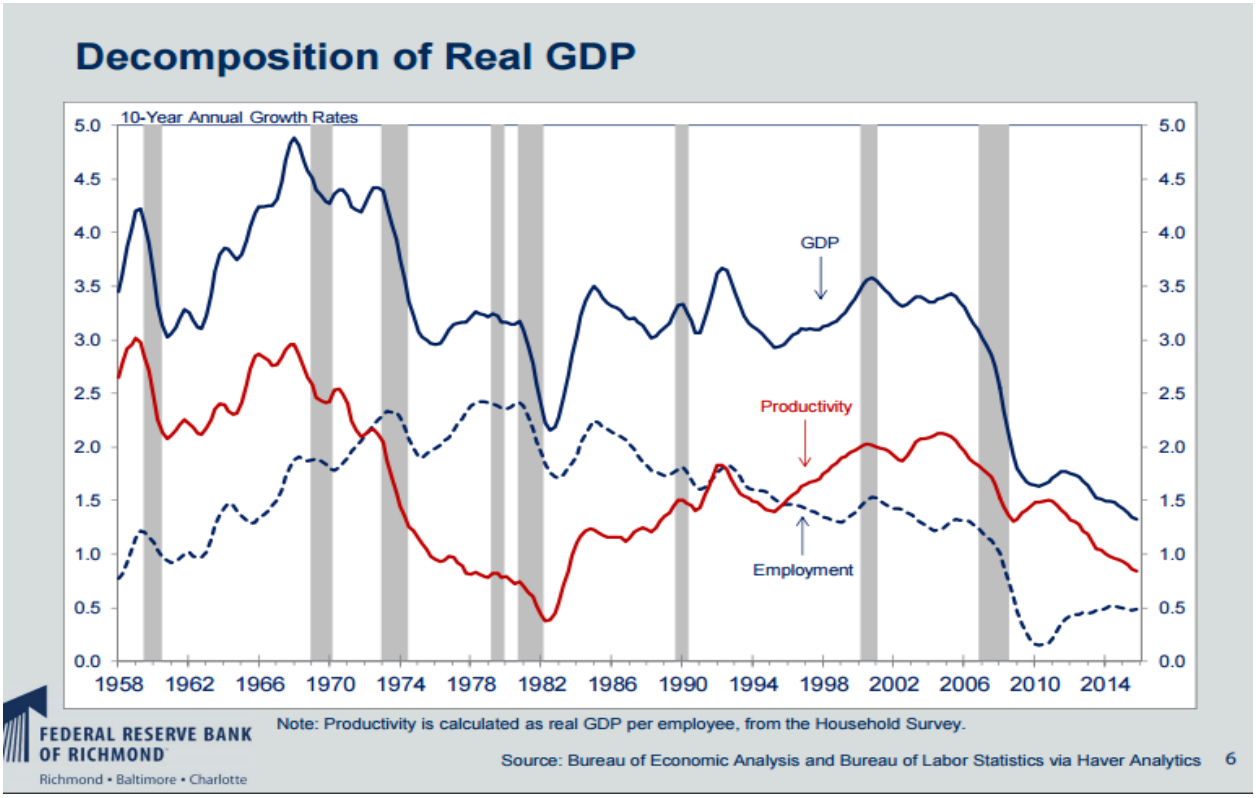

Figure 2. U.S. National Real Gross Domestic Product. Image provided by the Federal Reserve of Richmond.

Between 2000 and 2001, national real GDP growth reached a local maximum of approximately 3.5%, however Virginia was seeing a slowing down of their growth rates to less than 6%, which is still greater than the nation's. The GDP at the state level and GDP at the national level do not always follow the same instances. Along with the change in GDP inconsistency, there are other reasons as to why GDP should not be used to measure economic turbulence in the form of economic recessions for this research report.

Gross domestic product is a poor indicator of economic turbulence because it does not capture all production of good and services in the economy and neglects to measure the welfare of those who consume and/or produce the goods and services that are accounted for in GDP which makes it hard to aggregate all of them.[3] For example, common household services like the unpaid job of a stay-at-home parent or an under-the-table babysitter are not accounted for in GDP. And in terms of automobiles, the value of tasks such as servicing your own car, filling up the tank and cleaning are not counted for in GDP.

GDP does not adjust to fluctuations in pollution. For example, if people changed their primary mode of transportation from less cars to more bikes and walking – but kept their same job and same income, there would be less highway traffic and air pollution, but that change in transportation value would not be captured by GDP.

GDP does not distinguish between factors that are increasing or decreasing welfare.[4] According to the Victoria Transport Policy Institute, an increase in traffic density can lead to an

increase in car crash rates.[5] And increased crash rates can lead to an increase in GDP because victims of a car crash will spend more money on hospital and medical expenses, but human welfare and safety has surely decreased. Regardless of if a car crash even occurs, research shows that an increase in traffic density can lead to increased spending on transportation in general.[6]

In conclusion, I consider GDP to be a poor indicator of economic turbulence for this research report because of the inconsistencies of national GDP compared to the Virginia GDP, and the missing important factors that GDP does not measure.

Employment

As a solution, I propose the use of employment as an alternative measure of economic turbulence. **Figure 3** shows the average percent change in employment in the state of Virginia. Data for total non-farm employment is provided by the Bureau of Labor Statistics (BLS) on a monthly basis for 1965 to 2011.[7] Non-farm statistics are distinguished from other employment because other government agencies (e.g. Department of Agriculture) record statistics on agricultural based employment. The equation used to calculate the average percent change of employment is given below.

$$\text{Average Percent Change} = \frac{100\%}{n}\frac{\sum(E_{y2}-E_{y1})}{E_{y1}} \qquad \textbf{Equation 1}$$

Where

E_{y2} = Employment in current year
E_{y1} = Employment in previous year
n = 12; for each month employment is recorded by BLS per year

Equation 1 is used because it is identical to the equation used to calculate mean percent error in the original research report. The two variables, mean percent error, and average percent change in employment, are now both measuring marginal relativity rather than economic recessions which only counted total incidents.

The data collected from **Equation 1** is plotted in **Figure 3** and is fitted with a trend line in purple, which represents the predicted measure of the average percent change in employment for any given year. In **Figure 3**, there are instances of distinct *troughs*, or drastic decreasing changes overtime. These troughs are what I am using to measure economic turbulence according to the guidelines set by the Bureau of Labor Statistics[8]:

Peaks and troughs are designated according to the following criteria:

- Periods between peaks and troughs – known as phases—must be at least 6 months in duration.

- Periods between one peak and the next, or between one trough and the next –known as cycles – must be at least 15 months in length.
- Neither a peak nor a trough can be designated in the table's first or last 5 months.
- Any irregular (not seasonal) and quantifiable changes are removed prior to calculating peaks and troughs.
- The trough must be lower than any other point in the cycle, excluding irregular quantifiable and temporary changes (such as strikes).
- Peaks and troughs must occur in alternating order.
- It is important to note that the peaks and troughs identified in a CES time series are specific to that particular time series. Although turning points in CES data frequently coincide with or occur near cyclical turning points in the overall economy, this is not always the case. (Note: Economy-wide turning points are identified by the National Bureau of Economic Research (NBER). For more information, including a complete list of business cycle dates, consult the NBER webpage at http://www.nber.org/cycles/main.html

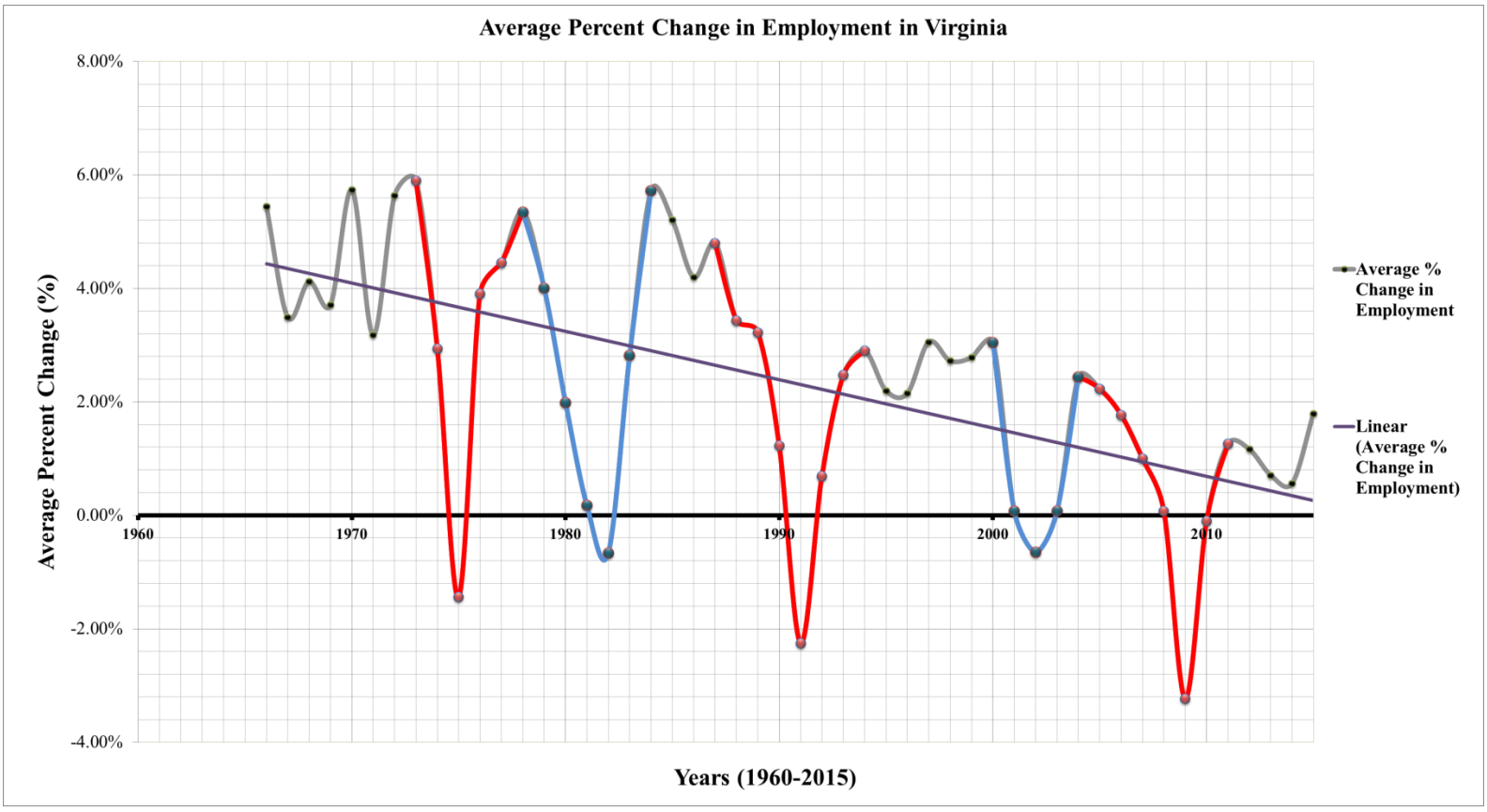

Figure 3. Average Percent Change in Employment in Virginia. Data Provided by the Bureau of Labor Statistics.

In **Figure 3**, the alternating red and blue daggers represent different troughs in the average percent change in employment overtime and have no other signification. One criterion that I have added to BLS's trough definition is that the trough's lowest point must be a negative value.

A negative average percent change in employment is a defined signification that there were less people employed in the current year relative to the year before ($E_{y2} < E_{y1}$), but growth recovered all within 2-3 years of a trough's lowest point. This precarious growth can be seen as a representation of economic turbulence.

Employment is a good indicator of economic turbulence for a few reasons. With readily compiled data, the Current Employment Statistic (CES) is one of the first available monthly economic indicators for evaluating the health of the economy for well over 50 years.[9] It is a stable variable in timeliness and definition. Researchers are able to see month to month changes on employment for all the time series along the 39 studies used in the original research report. And the jobs and descriptions used to calculate employment follow a standard provided by the North American Industry Classification System, which is also used by Mexico and Canada. While GDP also follows a standard for what's being used to calculate it, the goods and services used are often outdated and fail to keep up with the quickly evolving technology and newer products over the past century.[10]

Employment is indicative of the current state of the economy.[9] The peaks and troughs of employment tend to move in synch with the peaks and troughs of the U.S. business cycle. The BLS provides a data table showing turning points in the U.S. business cycle in terms of the peaks and troughs identified by the National Bureau of Economic Research (NBER) and the CES. From 1970 to 2010, the indicated trough years match similarly with trough years that I've indicated with data only from **Figure 3**. A comparison of trough dates can be seen below in **Table 1**.

Table 1. Comparison of indicated trough months. Data provided by the Bureau of Labor Statistics.

NBER	CES	Figure 3
March 1975	April 1975	1975
November 1982	December 1982	1982
March 1991	May 1991	1991
November 2001	August 2003	2002
June 2009	February 2010	2009

Lastly, employment is used among many economic data users such as policy makers, financial markets, and other government agencies including transportation. In the Wisconsin Department of Transportation's Transportation Planning Manual, chapter 9 details their Traffic Impact Analysis.[10] On page 18 they state that socioeconomic controlling factors such as employment can be used to compare their standard traffic forecasts to their extended traffic forecasts. They also often use employment as a control total in their travel demand process (page 34).

In conclusion, employment is a tangible and quantitative metric that can measure economic turbulence due to the same reasons why economic recessions were chosen. Employment is comprehensible; the breadth of data is easily accessible, and is used by an array of institutions -- including transportation agencies -- in analyzing the stability or fluctuations in the economy. And for these reasons, I am confident that employment is a variable that can be implemented into *A Retrospective Evaluation of Traffic Forecasting Techniques.*

Calculations

In this section, I will be presenting:

- an example of calculating the average percent change in employment using **Equation 1** and data from **Table 2** below,
- how to calculate the new variable *number of troughs*
- and added material per request on the averaged average percent change in employment over the duration of each study.

The previous economic turbulence variable, number of economic recessions, number of troughs, and the averaged average percent change in employment are recorded in **Table 3**.

Average Percent Change in Employment

Average percent change in employment is calculated by using **Equation 1** which can be found either on page 3 or here below:

$$\text{Average Percent Change} = \frac{100\%}{n}\frac{\sum(E_{y2}-E_{y1})}{E_{y1}} \qquad \textbf{Equation 1}$$

Where

E_{y2} = Employment in current year
E_{y1} = Employment in previous year
n = 12; for each month employment is recorded by BLS per year

First, the yearly average of employment is calculated (e.g. yearly average for 1960 was 1,017.51 employees in thousands) for each year and then the percent change between the current year and previous year were calculated.

For example, the yearly average for 1960 was 1017.51 and 1961 was 1034.86.

$$\frac{E_{y1}}{n} = 1017.51 \qquad \frac{E_{y2}}{n} = 1034.86$$

$$\frac{(1034.86 - 1017.51)}{1017.51} = .01705 \approx \mathbf{1.71}\%$$

The average percent change in employment for current year 1961 is 1.71%.

Table 2. Average Percent Change in Employment in Virginia. Original data provided by the Bureau of Labor Statistics.

Year	Yearly Avg. Employment in VA	Avg. % Change in Employment	Year	Yearly Avg. Employment in VA	Avg. % Change in Employment
1960	1017.51	-	**1988**	2772.48	3.43%
1961	1034.86	1.71%	**1989**	2861.94	3.23%
1962	1081.77	4.53%	**1990**	2897.08	1.23%
1963	1123.67	3.87%	**1991**	2831.70	-2.26%
1964	1162.98	3.50%	**1992**	2851.24	0.69%
1965	1218.93	4.81%	**1993**	2921.74	2.47%
1966	1285.31	5.45%	**1994**	3006.45	2.90%
1967	1330.23	3.49%	**1995**	3072.50	2.20%
1968	1385.04	4.12%	**1996**	3138.71	2.15%
1969	1436.43	3.71%	**1997**	3234.70	3.06%
1970	1518.85	5.74%	**1998**	3322.78	2.72%
1971	1567.11	3.18%	**1999**	3415.26	2.78%
1972	1655.45	5.64%	**2000**	3519.43	3.05%
1973	1753.11	5.90%	**2001**	3522.06	0.07%
1974	1804.60	2.94%	**2002**	3499.15	-0.65%
1975	1778.61	-1.44%	**2003**	3501.78	0.08%
1976	1848.06	3.90%	**2004**	3587.36	2.44%
1977	1930.35	4.45%	**2005**	3667.30	2.23%
1978	2033.54	5.35%	**2006**	3732.22	1.77%
1979	2115.00	4.01%	**2007**	3769.48	1.00%
1980	2157.03	1.99%	**2008**	3772.37	0.08%
1981	2160.79	0.17%	**2009**	3650.41	-3.23%
1982	2146.42	-0.67%	**2010**	3646.78	-0.10%
1983	2206.92	2.82%	**2011**	3692.79	1.26%
1984	2333.28	5.73%	**2012**	3735.83	1.17%
1985	2454.73	5.21%	**2013**	3762.29	0.71%
1986	2557.73	4.20%	**2014**	3783.44	0.56%
1987	2680.42	4.80%	**2015**	3851.19	1.79%

Number of Troughs

In order to calculate the new variable *number of troughs*, the base year and forecast year for each study are needed. Count how many troughs occur between or during the base and forecast year.

Note: For studies that have a base year or forecast year occurring the same time as a trough year, count it as 1 trough year.

For example, Study No. 2's base year is 1982 and forecast year is 2010. The number of troughs for Study No. 2 will be 4, because the first trough occurs on the base year.

Averaged Average Percent Change in Employment

The averaged average percent change in employment is calculated by summing the average percent change in employment for all years between and including the base and forecast year, and then divided by the number of instances, *n*.

Note: The value found in the fifth column, **Fiscal Year – Base Year** is not the same as *n.*

For example, Study No. 10's base year is 1996 and forecast year is 2014. The sum of the average percent change in employment from 1996 to 2014 is 21.15%. (**Table 2**)

$$\frac{21.15\%}{19\ instances} = 1.11315\ \approx \mathbf{1.11}\%$$

The averaged average percent change in employment from 1996 to 2014 is 1.11%.

Table 3. Virginia Studies & Comparison of Economic Recessions & Average Percent Change in Employment

Study No.	Title	Base Year	Forecast Year	F-B	# of Economic Recessions	# of Troughs in Avg. % Change in Employment	Average of Avg. % Change in Employment
1	Route 3 Corridor Study: Northern Neck and Middle Peninsula (VDOT, 1988a)	1986	2010	24	3	3	1.61%
2	George P. Coleman Bridge Financial Alternatives Study (VDOT, 1989a)	1982	2010	28	4	4	1.84%
3	U.S. 15 James Madison Highway Passing Lane Study (UMA Engineering, Inc., 1997)	1996	2014	18	2	2	1.11%
4	Colonial Heights Thoroughfare Plan (VDH, 1970)	1966	1985	19	4	5	3.58%
5	York River Crossing Travel Demand Study (TransCore and Buchart-Horn, Inc., 2000)	1990	2014	24	3	3	1.14%
6	Interstate 66 HOV Feasibility Study: Fairfax and Prince William Counties (Post et al., 1986)	1985	2010	25	3	3	1.75%
7	I-95/Clermont Avenue Interchange & Connector to Duke Street, Alexandria, Virginia (Louis Berger & Associates, Inc., 1990)	1988	2010	22	3	3	1.36%
8	Route 13 Corridor Study: Northampton County and Accomack County (VDOT, 1988b)	1987	2010	23	3	3	1.51%
9	Routes 17 and 360 Corridor Study: Town of Tappahannock (VDOT, 1989b)	1988	2010	22	3	3	1.36%
10	Route 40 Needs Assessment Study: Campbell County, Charlotte County, Lunenburg County, and Nottoway County (VDOT, 1999a)	1996	2014	18	2	2	1.11%
11	Routes 20/240 Corridor Study: Albemarle County (VDOT, 1990a)	1987	2010	23	3	3	1.51%
12	Route 608 Corridor Study: Augusta County, Fishersville, Stuarts Draft (VDOT, 1996)	1994	2014	20	2	2	1.25%
13	Botetourt County Route 220 Study (VDOT, 1999b)	1994	2014	20	2	2	1.27%
14	Capital Beltway Study: I-95/I-495 Northern Virginia: Short-Term and Mid-Term Recommendations Report (JHK & Associates et al., 1989)	1988	2010	22	3	3	1.36%
15	Route 221/460 Corridor Study: Roanoke and Botetourt Counties (VDOT, 2002)	2000	2015	15	2	2	0.76%
16	Route 360 Corridor Study: Town of Warsaw (VDOT, 1993)	1991	2010	19	3	3	1.17%
17	Dulles Toll Road Extension Route 267: Draft Environmental Document (VDOT, undated b)	1986	2010	24	3	3	1.61%

Study No.	Title	Base Year	Forecast Year	F-B	# of Economic Recessions	# of Troughs in Avg. % Change in Employment	Average of Avg. % Change in Employment
18	Route 240 Corridor Study: Albemarle County (VDOT, 1990c)	1987	2010	23	3	3	1.51%
19	Pulaski Area—Year 2000 Transportation Plan (VDH&T, 1981)	1980	2000	20	3	2	2.47%
20	Route 29 Corridor Study: City of Charlottesville and Albemarle County (U.S. DOT et al., 1990)	1987	2010	23	3	3	1.51%
21	Peninsula Area Transportation Study, Recommended Transportation Plan, Vol. II (Deleuw, Cather & Associates, 1967)	1967	1985	18	4	2	3.49%
22	Hampton Roads TDM Study (Michael Baker Jr., Inc., 2004)	2000	2011	11	2	2	0.67%
23	2010 Statewide Highway Plan: Culpeper District (VDOT, 1989c)	1987	2010	23	3	3	1.51%
24a	Statewide Highway Plan: Thomas Jefferson Planning District (VDH&T, 1984a)	1981	2005	24	3	3	2.16%
24b	Statewide Highway Plan: Richmond Regional Planning District (VDH&T, 1984b)	1981	2005	24	3	3	2.16%
24c	Statewide Highway Plan: 5th Planning District (VDH&T, 1984c)	1981	2005	24	3	3	2.16%
25	Statewide Highway Planning System (SHiPS) (a VDOT database)	1994	2013	19	2	2	1.28%
26	University of Virginia Research Park Study (Cox Company, 2008)	2006	2014	8	1	1	0.50%
27	Rivanna Village at Glenmore TIA Study (Cox Company, 2001)	2001	2006	5	1	1	0.99%
28	Stonefield at Route 29 (Strohhacker, 2010)	2010	2012	2	0	0	0.78%
29	Town of Orange 2020 Transportation Plan Technical Report (Michael Baker, Jr., Inc., 2002)	2000	2010	10	2	2	0.61%
30	Route 360 Corridor Study: Hanover County, From Chickahominy River Bridge (Henrico County) to Pamukey River Bridge (King William County) (VDOT, 1990b)	1990	2005	15	2	2	1.57%
31	Route 10 in Chesterfield County Study (Johnson, 2001)	2001	2014	13	2	2	0.53%
33	Trip Generation and Distribution Study, Phase 1, West Creek, West Creek Parkway, Goochland County, Virginia (Frank Coleman & Associates, 1988)	1997	2007	10	1	1	1.69%
34	Route 1 Appomattox River Bridge and Approaches Location Study: Petersburg to Colonial Heights (Hayes, Seay, Mattern & Mattern, 1989)	1987	2010	23	3	3	1.51%
35	Route 1 Corridor Study: Fairfax and Prince William Counties (TransCore et al., 1997)	1995	2014	19	2	2	1.17%

36	Richmond International Airport Corridor Feasibility Study (LPA Group and David Volkert & Associates, 1999)	1998	2014	16	2	2	0.94%
38	BJ's Wholesale Club Traffic Impact Assessment (Vanasse Hangen Brustlin, Inc., 2007)	2007	2014	7	1	1	0.18%
39	Bell Creek Road Intersection Study (Johnson, 2002)	2000	2014	14	2	2	0.70%

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How to find Employment Data (Not Seasonally Adjusted)
Source: Bureau of Labor Statistics http://www.bls.gov/
Go to http://www.bls.gov/sae/data.htm > Multi-Screen (yellow icon) > Check: Not Seasonally Adjusted > All Employees, In Thousands** > State: Virginia > Area: Statewide > Total Nonfarm > Select: Total Nonfarm > Retrieve Data > Upper Middle of the Page Click - From: 1960 To: 2016 > Go