# A Tale of Two Tunnels: Economic Effects of Newly Imposed Tolls on Heavily Traveled Tunnel Venues in Virginia

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**Abstract**

Many studies have examined the reaction of drivers either to the opening of new roads, bridges and tunnels that assess tolls upon those who use them, or to driver reactions when existing tolls are increased. This study examines a much less common situation—the imposition of tolls on two existing, heavily traveled tunnel venues. Ordinarily, driver demand is price inelastic in tolled situations, but not so here. Initial driver reactions to the new tolls were strongly negative, though this response did dissipate somewhat over time. Critical issues here include the availability of viable substitute free travel venues; the amount of time lost by drivers when the substitutes are used; and, the disparate impact of the new tolls upon the cities adjacent to the tolled tunnels. These results may discipline policy-makers and investors who regard tolls as enticing solutions to their problems.

## 1 Introduction

Once tolls have been established on roads, bridges and tunnels, increases in those tolls are a regular occurrence. What happens, however, when a government decides to place tolls on vehicles that traverse heavily used, but previously free highway venues? This is an unusual circumstance in the United States.

The tolling situation examined in this paper focuses on the Commonwealth of Virginia, which via a 58-year public-private partnership with the Elizabeth River Company, expanded and improved two existing tunnels that carry traffic between the cities of Norfolk and Portsmouth in the 1.75 million-person Hampton Roads[1] area in Southeast Virginia. Previously, vehicle passage through these two tunnels (known as the Midtown and the Downtown) was free. However, beginning January 1, 2014, tolls were assessed on all vehicles using these tunnels, with the size of these tolls reflecting the time of the day and day of the week when the tunnel was used as well as the number of axles on the vehicle. In 2014, the toll assessed a two-axle vehicle using either tunnel was $1.00 one-way, but by January 1, 2019, the analogous rush hour toll had risen sequentially to $2.20 (Elizabeth River Tunnels, 2019).

When tolled routes are established, the availability of attractive alternative traffic routes always is a crucial consideration. In this case, public transportation substitutes either were minimal or zero, but several alternate (though more time-consuming) routes existed that drivers of vehicles could utilize instead traveling through the tunnels. Initially, they opted to do so in large numbers. Indeed, citizen and driver anger over the newly instituted tolls was substantial and a significant number of vehicles chose to drive the free, but time-consuming alternate routes rather than use the tunnels. Even so, over time, this adverse reaction began to dissipate as drivers compared the (larger) value of their lost time to the size of the tolls.

[1] Hampton Roads formally is the Virginia Beach-Norfolk-Newport News metropolitan region. Many refer to it as the "Tidewater" region or as "Coastal Virginia."

The work we report here estimates: (1) the impact the new tolls had upon vehicle traffic, recognizing that factors other than tolls influence traffic as well; (2) the importance of the alternate traffic venues; (3) the reduction in congestion at the tunnels; (4) the benefit-cost analysis a typical driver implicitly makes concerning the use of tunnels; (5) the price elasticity of demand of vehicle drivers as the tolls have increased since 2014; and, (6) the differential impact the tolls have had on the citizens and cities of the region. We also offer the lessons we believe policy-makers should take from these episodes.

## 2 Background

Highway tolls have existed in the United States since Colonial times. The first major toll road was the Philadelphia and Lancaster Turnpike in Pennsylvania (1792), but smaller, shorter toll roads existed prior to the American Revolution (Lee and Miller, 2015). Some of these were constructed and operated by private individuals, a model that flourished in the next century.

Tolls were necessary to pay for the construction and operation of toll roads, but private owners in particular and some government owners also sought to earn revenues from their tolls beyond their costs. Many toll roads were profitable business propositions.

Still, the economic analysis of vehicle tolls languished until the 1960s when Walters (1961) and Vickrey (1969) analyzed the use of variable vehicle tolls closely attuned to the demand for vehicle travel as one means to reduce road congestion. Since then, variable vehicle tolls and HOT traffic lanes (high occupancy toll roads that manage the traffic flows in specific lanes by means of variable tolls closely attuned to demand) have become increasingly fashionable. Congestion pricing designed to reduce traffic bottlenecks by means of variable tolls has been introduced throughout the world (U.S. Department of Transportation, 2018). Nearly always, however, HOT lanes and congestion pricing have been introduced at the same time free lanes along the same travel path have been preserved. This, along with resulting reductions in congestion, has made these innovations more palatable to the public.

The fiscal constraints faced by governments have stimulated reliance upon tolled roads, bridges and tunnels. The General Accounting Office (2012) counted 41 new tolling projects underway in that year. In 2018, the Whiteface Mountain Memorial Highway in New York State was the most expensive toll road in the nation at $1.25 per mile, while the Chesapeake Bay Bridge Tunnel at $30 for a round trip was the most expensive bridge toll, and the $13 one-way toll on the Lincoln and Holland tunnels entering New York City the most expensive tunnel venue (Cutolo, 2018).

Bridges and tunnels present a distinctive circumstance. Frequently, a bridge or tunnel constitutes the only way for a vehicle to travel from one point to another, or as in Virginia's case, available alternative routes exist, but are inferior. Consider the example of the Rickenbacker Causeway, which is the only means for a vehicle to travel to and from Miami and Key Biscayne in Florida. In late 2018, a two-axle passenger vehicle paid $2.25 to travel to Key Biscayne (there is no toll coming from Key Biscayne) if the vehicle had a Sun Pass that could be electronically scanned as the vehicle traveled through the toll plaza. If, however, the drivers were Key Biscayne residents, then they could obtain a "resident" pass that cost them only $24 annually and would not be assessed tolls (Miami-Dade, 2018). Non-resident commuters could purchase an annual pass for $60.

The Rickenbacker Causeway example illustrates three important realities. First, assuming the demand curve for travel is negatively sloped, tolls depress the volume of vehicle traffic. The question is, how much? This is information that toll operators covet. Second, if no viable alternative routes exist, then the ability of many drivers to avoid paying tolls shrinks, but how much? Third, the imposition of tolls does not affect all citizens equally and whether one is a winner or loser depends upon factors such as where they live and how often they must use the tolled venue.

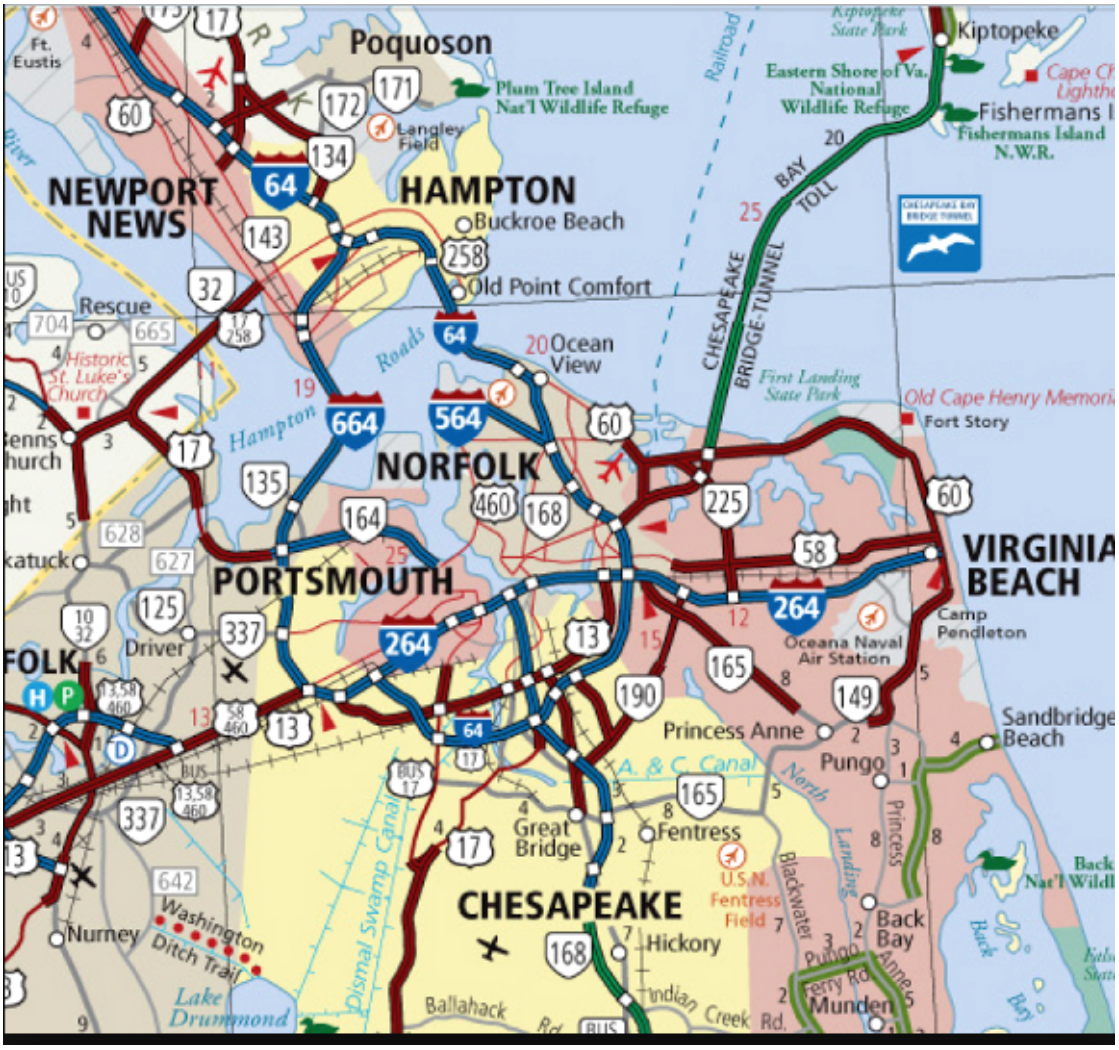
There are two additional realities to consider that are independent of the Rickenbacker paradigm. One is that the reactions of drivers to the imposition of toll are asymmetric. A $1.00 toll on a previously free route will elicit a much stronger and more negative driver reaction than increasing the toll on the same route from $1.00 to $2.00. The other reality is that even drivers who are vehemently opposed to tolls gradually get used to them and many pay them because they eventually decide that the value of their lost time exceeds the

price of the toll they must pay (Ghosh, 2001, is one of many who has explored these choices).

In this paper, we address each of these realities in the context of newly imposed tolls on the Midtown Tunnel (MTT) and Downtown Tunnel (DTT) connecting the cities of Norfolk and Portsmouth in Virginia. The tunnels pass under the Elizabeth River, a branch of the Chesapeake Bay, and were free of tolls until January 1, 2014. The tolls were imposed to pay for the cost of improving and expanding the tunnels at an approximate cost of $2.1 billion (Federal Highway Administration, 2018).

Norfolk and Portsmouth plus cities within the region host more than 700,000 jobs; an estimated 100,000 of these job holders are strong candidates to use the tunnels. The work of many of the job holders within this region is connected to activities of the Department of Defense. The largest naval base in the world is in Norfolk and an estimated 40 percent of the region's economy is dependent upon defense spending (Dragas Center, 2018).

Figure 1 provides a map that highlights the extent to which water courses intersect most of the Hampton Roads region. Route 460 in the map is the MTT and connects Norfolk to Portsmouth. I-264 between Norfolk and Portsmouth is the DTT. A typical driver of a vehicle may incur an additional 30 to 60 minutes of commuting time if she does not choose to use one of the tunnels during rush hours.




Source: Hampton Roads Transportation Planning Organization.

Figure 1: The Hampton Roads, Virginia Region

The experience of Washington State when it placed tolls on previously free SR 520 in very late 2011 is relevant. SR 520 is a floating 1.42-mile bridge that crosses Lake Washington and connects east suburban Redmond to Seattle near the University of Washington. However, two other bridges, one of which is I-90, also cross Lake Washington and are both heavily traveled and free. They constitute more viable substitute routes than any alternates available in the MTT and DTT tolling situation and consequently handle more than three-quarters of the traffic crossing Lake Washington. In the event, traffic over SR 520 plunged by 36 percent in 2012, but by 2017, one-half of that decline had been restored and traffic was climbing annually (Washington State DOT, 2014 and Stantec, 2018). Neither study computed price elasticities, but Stantec did model the probability that a driver would select SR 520 based upon variables such as the size of tolls, the value of a driver's time, and the length of a trip. Drivers dislike tolls, value their time, and are put off by long trips.

The evidence we present here is distinctive because it focuses primarily on the movement from a no toll situation to one involving tolls and does so in the context of a world in which viable alternative travel routes are limited. We find that the shock effect attached to the introduction of tolls in such a world to be considerable and it reflects drivers exploring and utilizing a variety of methods to avoid paying [2]. This reaction was sufficiently large and elastic that it should give pause to officials who harbor notions about imposing tolls on other previously free routes.

We also give considerable attention to the distributive impact of tolls on individuals and cities and show that even when tolled routes are regional in nature, the impact of tolls on individuals and cities is quite uneven. Some bear substantially higher costs than others.

# 3 Review of Related Work

In any situation involving toll roads, those operating vehicles are forced to answer a question—do the benefits derived from using the toll road outweigh the costs of doing so? Critical to this benefit/cost analysis are the quality of toll road, the size of the toll, the value of the time saved, and the availability of alternative routes. These factors can vary substantially from one situation to another and hence so also do some of the conclusions reported in empirical studies relating to tolls.

We focus selectively here on studies that have estimated price elasticities of demand in tolling situations and other studies that have made estimates of the differential impact tolls have on individuals, cities and regions. While these studies are informative (see Khademi and Timmermans (2011) for a capable survey), they are less useful in elucidating the Virginia tunnel situation we have described here because the Virginia situation involves the imposition of tolls on traffic venues that previously were free rather either than the construction of a new venue or (at least initially) increases in already existing tolls.

Several studies, however, have greater relevance to the work presented here. Hirschman et al. (1995) analyzed 12 years of monthly traffic and toll data for New York City's Tri-borough Bridge and Tunnel Authority (TBTA). As expected, they discovered highly inelastic curves for tunnel passage – the typical elasticity was only -.10, while the most elastic circumstance was only -.50. Tolls trebled over the space of 12 years, but traffic on the TBTA facilities going into and out of Manhattan nonetheless grew 15 percent. Meanwhile, traffic over the free East River and Harlem River bridges grew 17 and 26 percent, respectively.

Much depends upon the availability of substitute travel paths and the degree of congestion confronting drivers. Mekky (1999) found toll elasticities as high as -4.0 for Toronto's Highway 407 as time passed. However, this was a situation where drivers could choose alternate, free travel paths and apparent congestion was not deemed overwhelming. These are lessons that those who would implement or increase tolls would be wise to consider.

Holgun-Veras et al. (2005, 2006) examined time-of-day pricing in Port Authority facilities in New York and New Jersey and focused as well on the impact of EZPass availability on drivers. An EZPass is an active transponder unit that emits a radio signal. When placed in one's vehicle, it automatically bills the vehicle for a tunnel toll as the vehicle transits and usually means that drivers need not stop. Vehicles using an

[2]The most obvious alternative is to drive an alternate route; however, public transportation, carpooling, telecommuting, changing one's job, and changing one's residence also are possibilities.

EZPass usually pay sharply reduced tolls. Holgun-Veras et al. found this increased drivers' price elasticity of demand, presumably because it increases their options. As we will see in the Virginia situation we describe, EZPass usage became an important indicator of drivers' resistance to the newly imposed tolls.

More recently, Spears et al. (2010) concluded that the price elasticity of demand for vehicle passage on a tolled facility ranges between -0.1 and -0.45. Thus, a 10 percent increase in a toll will elicit a 1.0 percent to 4.5 percent decline in traffic. In general, their results supported those of Arentze et al. (2004), who found short-run price elasticities for traffic on specific roadways to vary between -.35 and -.49.

Littman (2017), however, argues that in the long-run, the price elasticity of demand for vehicle traffic can be elastic if one accounts for total vehicle operating costs, not simply tolls. It is fair to say, however, that an economic consensus has developed that says that in the short-run, the price elasticity of demand for vehicle travel with respect to tolls is inelastic. This sense of the drivers' demand curves has underpinned numerous tolling decisions around the world and was influential in Virginia as well.

Considerable attention has been paid to the equity implications of congestion pricing on drivers (Ecola and Light, 2009 and General Accounting Office, 2010, provide good examples), but comparatively less focus on the impact that tolls have upon entire cities and regions. Which municipalities benefit and which are injured when tolled venues are introduced? When there have been attempts to assess municipal costs and benefits, the focus usually been on tolled venues as means to stimulate economic development. Boarnet and Chalermpong's (2001) study is exemplary; the duo examined the link between highways and urban development by employing both hedonic analysis and repeat sales techniques to study the impact of the construction of toll roads in Orange County, California, on both house prices and demographics. They found that homebuyers exhibit a willingness to pay for improved access and this impacts residential development patterns and induced traffic. DeCorla-Souza and Kane (1992) and Parasibu (2005) examined regional development and concluded that variable tolls shorten travel times, increase production efficiency, and stimulate regional private investment and socio-economic growth. However, Pesaran et al. (1999) concluded that even though higher road tolls may contribute to financing local road networks, they nevertheless impede inter-regional trade and thus lead to greater market segmentation.

While substantial additional work has been done in this arena since these studies, it is fair to say that there has been little or no attention paid to issues relating to the disparate impact that tolls have on individuals and cities. This is important distinction because as we will see, what is true for the whole (perhaps a state or a region) may not hold true for its individual parts.

# 4 Empirical Results

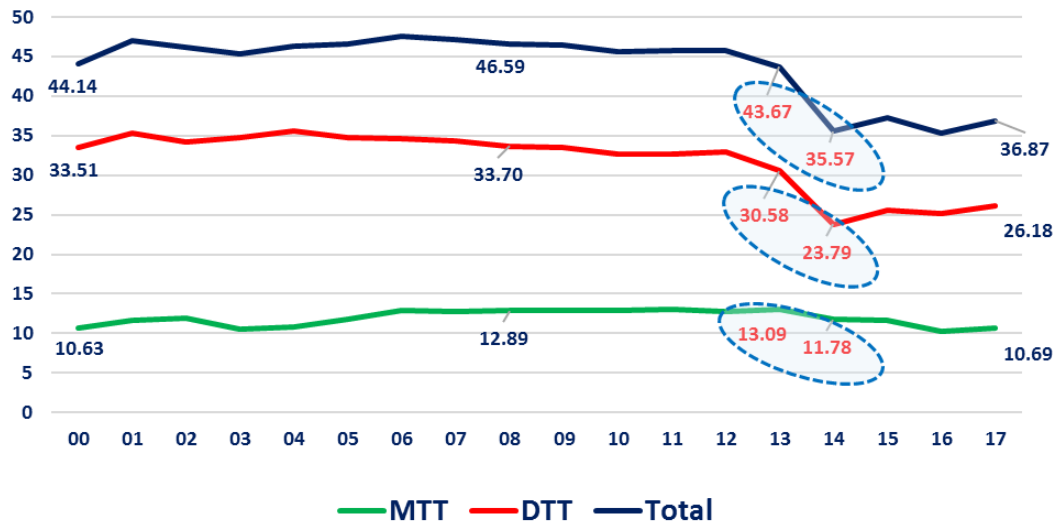
Our empirical results are divided into four parts.

## 4.1 The Tolls Cut into Vehicle Traffic

The tolls went into effect on January 1, 2014 and vehicle traffic through the two tunnels immediately began to diminish. Whereas in January 2013, traffic through the two tunnels totaled 3.627 million, in January 2014 it declined to only 3.013 million (a 14.5 percent decline). Figure 2 provides annual vehicle traffic data for the two tunnels.

One can see in Figure 2 that 8.1 million fewer vehicles (an 18.5 percent decline) used the two tunnels in 2014 as opposed to 2013 and that the drop was particularly severe for the Downtown Tunnel (DTT), where vehicle traffic fell 22.2 percent. The DTT handles heavy commuter traffic, while the Midtown Tunnel (MTT) is a primary outlet of trucks traversing in and out of the Port of Virginia. Arguably, commercial trucks carrying twenty-foot equivalent units (TEUs) are less sensitive to prices than the job commuters and students who dominate the DTT.

One also can perceive in Figure 2, however, that vehicle traffic in the DTT already had been declining gradually for almost a decade prior to the imposition of the tolls. Thus, not all the decline in DTT traffic between 2014 and 2017 can be attributed to the tolls. The Hampton Roads region (formally the Virginia Beach-Norfolk-Newport News metropolitan statistical area) is heavily dependent upon government spending




Source: Virginia Department of Transportation and the City of Portsmouth.

Figure 2: Annual Vehicle Traffic, MTT and DTT, 2000-2017 (millions)

(and especially defense spending). The real value of direct defense spending within the region declined almost 10 percent between 2011 and 2017. This reduction, along with the related negative impact of federal government budget sequestration, was a blow to the region because of its dependence upon defense spending (Dragas Center, 2018)

## 4.2 The Impact of Tolls: A Counterfactual Approach

Figure 2 strongly suggests that the imposition of tolls had a dramatic negative effect on tunnel traffic. But, how much? What would tunnel traffic have been in 2014 had the tolls not been imposed? We undertook a counterfactual multivariate regression analysis to estimate the size of this effect because one cannot attribute the entire slump in tunnel traffic after 2014 to the imposition of tolls.

The centerpiece of the data supporting our counterfactual analysis is daily vehicle traffic counts through the two tunnels, 2000-2017. We have daily 6,575 observations to support the regression analysis we present below.

These are the variables we utilize and their predicted signs in the regression equations:

$MTT_i$ = traffic[3] through the Midtown Tunnel on day "i," as i = 1,...,n, where n = 6,575

$DTT_i$ = traffic[4] through the Downtown Tunnel on day "i," as i = 1,...,n, where n = 6,575

$DAY_i$ = multiple category dummy variable representing the days of the week with 1 = for this day of the week and 0 otherwise (we assume that work day traffic will be larger than traffic on weekends)

$MONTH_i$ = multiple category dummy variable representing the months of the year with 1 = for this month and 0 otherwise (we assume that traffic will be higher in summer months)

$EMP_i$ = $QCEW$[5] estimate of employment within the region on day "i," but the observations are monthly (we assume that increased employment in the region will stimulate travel through the MTT and DTT)

[3]Data obtained from the City of Portsmouth, VA and the Virginia Department of Transportation, www.virginiadot.org, and include both passenger cars and trucks.

[4]Data obtained from the City of Portsmouth, VA and the Virginia Department of Transportation, www.virginiadot.org, and include both passenger cars and trucks.

[5]Quarterly Census of Employment and Wages, Bureau of Labor Statistics, www.bls.gov/cew.

$TEU_i$ = monthly number of twenty-foot equivalent shipping units (TEUs) handled at the Port of Norfolk on day "i," but the observations are monthly (we assume that increased activity at the Port of Norfolk, the third busiest port on the East Coast, stimulates traffic through the MTT, which is the tunnel closest to the Port)[6]

$DOD_i$ = annual direct Department of Defense (DOD) expenditures in the region on day "i," but the observations are annual (we assume that that defense expenditures made in the region stimulate tunnel traffic)[7]

All financial variables are "real" and are expressed in December 2017 prices. The typical estimating equation is of the form:

$MTT_i = a + B_{ij}X_{ii}$ as i = 1,...,n observations and $j = 1, ..., m$, where $m$ is the number of independent variables; and

$DTTi = a + B_{ij}X_{ij}$ as $i = 1, ..., n$ observations and $j = 1, ..., m$, where $m$ is the number of independent variables.

In the best of all worlds, all the data we utilize for all of these variables would be daily, but this is not possible here. Utilizing available monthly data (for $EMP$ and $TEUs$) is less a matter of concern than relying upon annual data for direct defense spending in the region ($DOD$). However, it is vitally important to have some measure of defense spending because approximately $40 billion of the $100 billion gross regional product is related to defense spending (Dragas Center, 2018).

One might suppose that the $EMP$ variable would pick up the impact of defense spending, but the $EMP$ and $DOD$ variables exhibit only a +.051 Pearson correlation over the eighteen-year period. There are three plausible reasons for this. First, as just noted, employment observations are monthly, but defense spending observations are annual. Second, the relationships between the two may be lagged. Third, significant proportions of defense spending in the region no longer relate to employees, but instead to equipment, fuel, ships, airplanes, technology, and the like. Reflecting this trend, the number of active duty, full-time military stationed in the region has shrunk by more than 20,000 over the past twenty years as the United States Navy progressively has substituted capital for labor (Dragas Center, 2018).

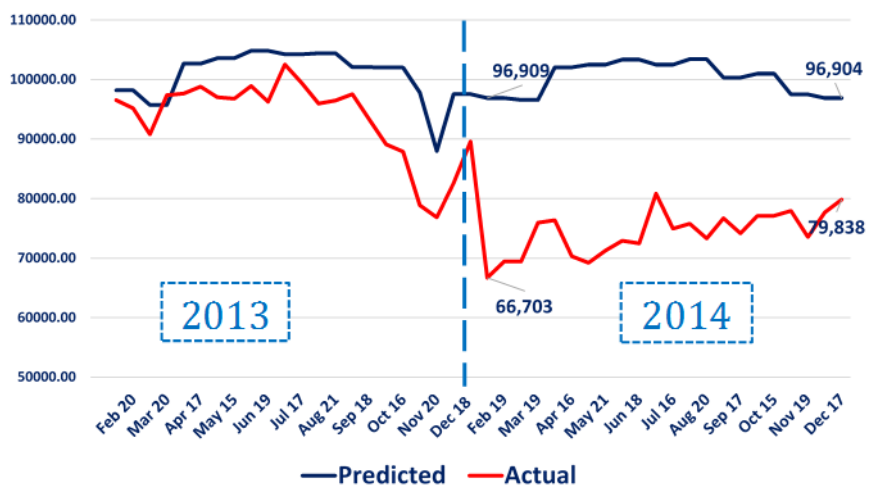



Figure 3: Predicted vs. Actual DTT Vehicle Traffic: 1st and 3rd Wednesdays, 2013 and 2014

Figure 3 compares predicted DTT traffic to actual traffic on the 1st and 3rd Wednesdays of the months February through December for the years 2013 and 2014.[8] The estimates are based upon a regression

[6]TEU data: the Virginia Port Authority, www.portofvirginia.com.
[7]DOD data: the Dragas Center (2018).
[8]January is not included because it is the excluded category in the monthly dummy variables.

utilizing 4,745 daily observations of vehicle traffic, 2000-2012. The coefficients from this estimating equation were used to generate the predicted traffic volumes reported in Figure 3. The model predicts actual traffic reasonably well until January 2014, when the tolls took were implemented although it does appear that drivers began to adjust their driving habits several months prior to the tolls.

The parameters for the predicted values are reported in Table 1.

Table 1: Regression Results for 2000-2013 That Generate Counterfactual Tunnel Travel Estimates

| Independent Variables | Estimated Coefficient | Absolute Value, t-Statistic | Standardized Coefficient |
|---|---|---|---|
| Monday Dummy | 26,251.86 | 61.7 | 0.64 |
| Tuesday Dummy | 30,407.60 | 71.36 | 0.74 |
| Wednesday Dummy | 31,229.22 | 73.29 | 0.76 |
| Thursday Dummy | 31,265.62 | 73.38 | 0.76 |
| Friday Dummy | 35,779.59 | 84.08 | 0.87 |
| Saturday Dummy | 15,351.83 | 36.08 | 0.38 |
| February Dummy | 4,075.13 | 7.89 | 0.01 |
| March Dummy | 6,705.59 | 7.17 | 0.08 |
| April Dummy | 6,435.88 | 11.57 | 0.08 |
| May Dummy | 6,651.48 | 11.03 | 0.13 |
| June Dummy | 8,136.93 | 13.35 | 0.12 |
| July Dummy | 6,209.50 | 10.04 | 0.12 |
| August Dummy | 6,987.11 | 11.67 | 0.14 |
| September Dummy | 3,162.60 | 5.38 | 0.06 |
| October Dummy | 3,292.42 | 5.88 | 0.07 |
| November Dummy | 1,449.16 | 2.48 | 0.03 |
| December Dummy | 545.02 | 0.97 | 0.01 |
| Regional Employment Index | 44.29 | 0.50 | 0.01 |
| TEU Port Index | 94.44 | 5.33 | 0.10 |
| DOD Spending Index | -189.00 | -14.03 | -0.10 |

Adjusted $R^2$ =0.703.

There are several important takeaways implied in Figures 2 and 3 and Table 1:

1. Actual tunnel traffic badly trailed predicted non-tolled traffic in every month (31 percent in February 2014), but the monthly gap diminished by the end of the year to only 17.6 percent. By contrast, there was a 36 percent reduction in vehicle traffic in Seattle in 2012 when tolls were placed on the previously free SR 520 Bridge crossing Lake Washington (Washington State Department of Transportation, 2014).

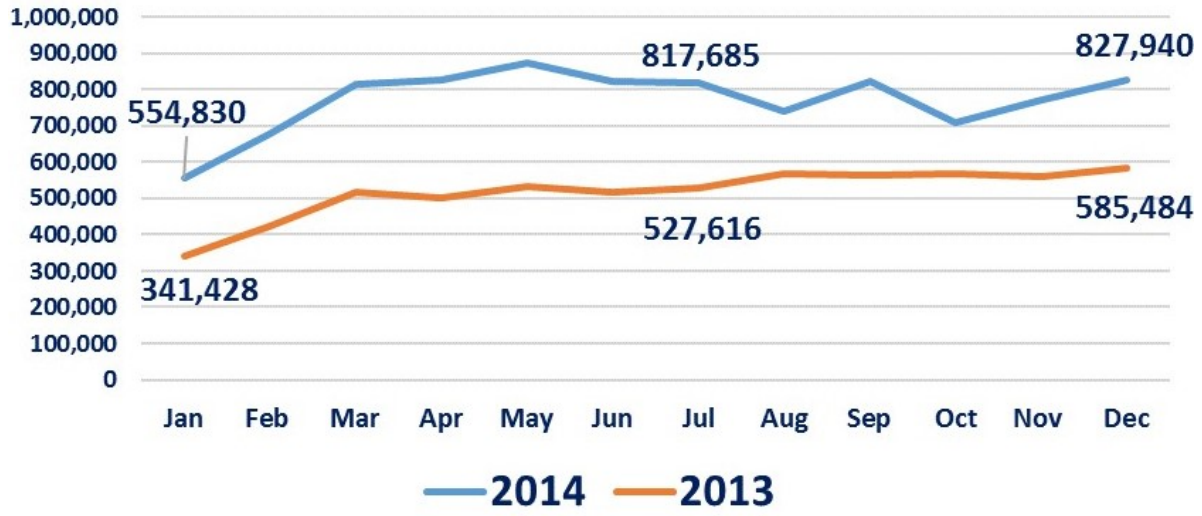
2. Quantitatively, days of the week, followed by months of the year, were the most important determinants of the volume of tunnel traffic.

3. Other variables (employment and $TEU$ activity at the Port of Virginia) were statistically significant, but quantitatively less important determinants of the daily volume in vehicles in the tunnels.

4. The negative sign on the defense spending variable may seem puzzling, but much of the region's growth in defense spending has come in Newport News, where Huntington Ingalls constructs massive $13 billion aircraft carriers. Only a very small minority of the shipyard's 20,000+ employees have a need to use the MTT and DTT to go to work. Indeed, their employment at Huntington Ingalls likely influences where they live and reduces MTT and DTT traffic.

5. The .703 adjusted $R^2$ suggests that there are other factors not specified in this equation that also influence tunnel travel. Plausibly, these include local tax structures (including especially those that apply to restaurants and businesses), the availability of parking, perceived safety, the increasing attractiveness of competing cities such as Virginia Beach, traffic congestion, and traffic conditions on the alternate routes that avoid the MTT and DTT.

6. With respect to alternate routes of travel that avoid the MTT and DTT, Figure 4 demonstrates that significant numbers of drivers chose alternate, non-tolled routes when the tunnel tolls were imposed on January 1, 2014. Traffic over the Gilmerton Bridge, a popular, but time-consuming alternative, rose 242,000 in December 2014 over the comparable December 2013 number. This was approximately eight percent of the December 2013 traffic volume through the two tunnels. The moral to this story is that at only at their peril do toll authorities ignore the importance of alternate travel routes when they consider imposing or raising tolls.




Source: Hampton Roads Transportation Planning Organization.

Figure 4: Gilmerton Bridge Vehicle Traffic: 2013 vs. 2014

## 4.3 Drivers Value Their Time

An important reason why some drivers of vehicles drifted back to using the tunnels is the value they place on their time. Thus, when drivers decide whether they will use either of the tunnels, implicitly or explicitly they balance the value of the time they will save by using the tunnels against the toll they must pay.

We can elucidate this tradeoff. The Bureau of Labor Statistics (2018) reported that the average hourly wage in the Hampton Roads region was $22.79 in May 2017, meaning that a 30-minute delay to avoid paying tunnel tolls had a value of $11.40 for a typical regional worker for a one-way trip. This is more than five times as high as the lowest peak-time toll a two-axle vehicle driver now can pay ($2.09) to use either of the tunnels and is 37 percent higher than the lowest peak-time toll ($8.33) a three-or-more axle truck can pay.[9] (Elizabeth River Tunnels, 2018).

Thus, drivers may grumble, but the value a typical driver attaches to her time suggests that over time increasing numbers of drivers will decide to pay the tolls. The gradually declining gap between predicted and actual vehicle traffic presumably reflects some of this calculus. Table 2 provides additional evidence in the form of increased EZ Pass use by those using either tunnel. This reflects not only the increased convenience of EZ Pass, but also the reality that those drivers who do not use EZ Pass pay tolls that are at least 50 percent higher.[10]

There are other benefits that MTT and DTT users have realized since the onset of tolls including reduced congestion and more predictable, reliable trips. The Hampton Roads Transportation Planning Organization

[9] Elizabeth River Tunnels, "Toll Rates Information," www.driveert.com/toll-info/toll-rates.

[10] A "Good to Go" pass is Seattle's counterpart to Virginia's EZ Pass. Good to Go usage rose in Seattle and generally has been higher than that in Virginia (Washington State Department of Transportation, 2014).

(2015) reported that traffic flowing east through the DTT flowed thirteen minutes faster during the morning rush hour, while the time saving was nineteen minutes for those going west using the MTT during the evening rush hour. Against this, those drivers who used a major alternate, non-tolled routes (the Gilmerton Bridge and another venue known as the High Rise Bridge) now experienced longer drive times (for example, four minutes in the evening).[11] There are no free lunches when drivers decide upon different paths.

Table 2: Percent of MTT and DTT Tunnel Vehicles Using EZ Pass

| Year | Percent Using EZ Pass |
|---|---|
| 2015 | 72.2% |
| 2016 | 73.5% |
| 2017 | 78.5% |
| 2018 | 82.0% |

Source: Hampton Roads Transportation Planning Organization.

Nevertheless, approximately 100,000 vehicles per day use the two tunnels. After netting out the gains and losses of the time of the drivers, assuming that there are no gains or losses on Saturdays, Sundays and holidays, and that that the average vehicle contains 1.25 drivers, then the value of the saved time of the individuals in the vehicles using the tunnels is slightly less than $76 million annually.[12] While this dollar sum certainly is not the only measure of the economic benefits flowing from the expansion and improvement of the two tunnels, it is an important measure. It falls far short of justifying the $2.3 billion expenditure required to expand and improve the tunnels.

## 4.4 Price Elasticity of Demand

Drivers of vehicles responded visibly to the imposition of tolls in 2014. In that year, vehicle traffic in the two tunnels declined 18.5 percent. However, circumstances such as this are not conducive to computing price elasticities because of the nature of the original toll increase. With respect to the imposition of tolls in 2014, if price elasticity = (% $\Delta$ in Q/% $\Delta$ in P), then % in P is infinitely large because the base price is zero.

Hence, one must settle for computing an arc elasticity between two price points (not including zero) rather than a point elasticity on the demand curve. However, the resulting arc elasticity estimates turn out to be positive rather than negative. Since January 1, 2015, the ERC has increased its tolls four times and these tolls have more than doubled. Despite these increases, the quantity of vehicle tunnel passages gradually has increased, not decreased, as drivers gradually have returned to driving through the tunnels.

Thus, in situations involving the imposition of tolls where none previously existed, computed price elasticities are not informative. Instead, one can observe that the initial reaction of drivers to the newly instituted tolls was hostile and negative, indicating some considerable elasticity in drivers' demand curves for tunnel passage. Subsequently, however, drivers' reactions have been muted at best. Most have not been deterred by significant increases in the tolls they must pay.

Public policy makers and entrepreneurs should take note. The reaction of drivers to newly instituted tolls on previously free traffic venues likely will be large and negative, especially if alternate, free routes exist. Revenue estimates must take this into account. Once tolls have been introduced, however, drivers react only modestly to increases in those tolls.

## 4.5 Differential Impact of the Tolls on Citizens and Cities

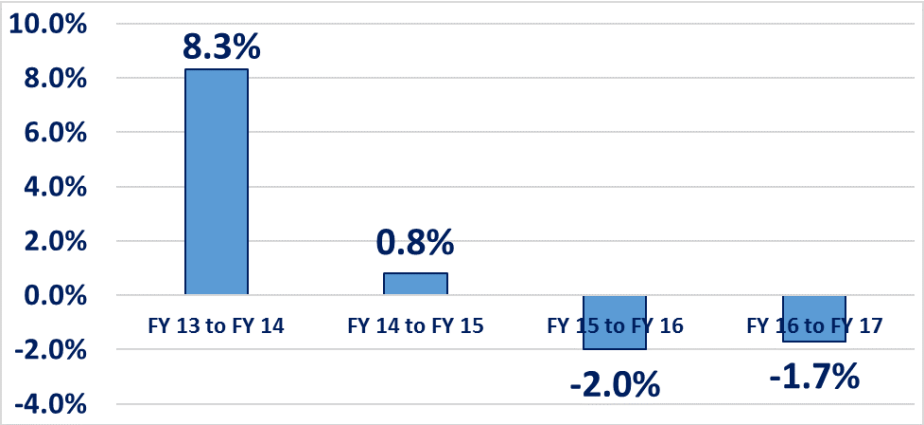
In any tolling arrangement, there are winners and losers. Some citizens and some cities and districts benefit, while others are injured. The identity of the winners and losers depends upon a variety of factors – who must

[11] When Seattle initiated tolls on previously free SR 520 in 2011, its experience was similar. The time spent in a vehicle on a one-way, west bound passage into the heart of Seattle via SR 520 declined by a bit more than three minutes in the morning rush hour, while the time spent on free alternate routes rose by about 2.5 minutes.

[12] Here is the computation, which is a rough estimate. (100,000 vehicles x 200 work days x 8-minute average time gain x 1.25 adjustment for passengers) / 60 minutes = 3,333,333 hours x $22.79 per hour = $75.97 million

pay the tolls, their ability to pay the tolls, the availability of free alternatives, and the like. These factors often are downplayed or even ignored when new tolling regimes are introduced. It is not that policy-makers deny that there are distributional effects associated with tolls. Instead, it is that analyses of such are not easy to conduct and potentially yield uncomfortable results that might complicate support for the projects.

Prior to the introduction of tolls, representatives of the City of Portsmouth, into which both tunnels feed, were divided as to whether they supported the use of tolls in order to finance the expansion and improvement of the MTT and DTT. After tolls were introduced, and the reactions of drivers became visible, the city's government reassessed its situation and concluded that the impact of the tolls was especially harsh upon its residents. Consider Figure 5, which reports annual changes in meal and beverage tax revenues in the Olde Town section of Portsmouth, which is the historic city's waterside restaurant district. The City's leaders and citizens took this as evidence that Portsmouth was especially burdened by the tolls.




Source: City of Portsmouth. Data from zip code 23704.

Figure 5: Percent Changes in Meal and Beverage Tax Revenues in Olde Town Portsmouth, FY 2013 through FY 2017

Additional evidence spotlights the relative burden that the tolls have placed upon Portsmouth. Table 3 supplies U.S. Census data that estimate the number of individuals who likely must use either the MTT or DTT in order to travel to and from their jobs. In this metropolitan region, more than 60 percent of all workers cross a city or county line in order get to work. Numerous watercourses divide the region and limit the pathways individuals might take to travel to their jobs. In the cases of the MTT and DTT, there are four cities (Norfolk, Portsmouth, Suffolk, Virginia Beach) whose workers realistically either must use one of the tunnels to go to and from work, or instead decide to use one of the free, but time-consuming alternatives.

Table 3: Number of Workers Who Likely Use the MTT and DTT on a Daily Basis

| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
|---|---|---|---|---|---|---|
| Live in this City | Commute to Norfolk | Commute to Virginia Beach | Commute to Portsmouth | Commute to Suffolk | Daily Total Using Tunnel for Work | Percent of City Population |
| Portsmouth | 10,300 | 7,000 | | | 31,800 | 33.6% |
| Suffolk | 7,000 | 4,800 | | | 16,400 | 25.7% |
| Norfolk | | | 6,000 | 1,700 | 25,000 | 6.7% |
| Virginia Beach | | | 8,500 | 2,900 | 23,200 | 5.6% |

Source: U.S. Census Bureau, www.census.gov/topics/employment/commuting/data.html.

One can see in Table 3 that an estimated 10,300 workers daily commute from Portsmouth to Norfolk,

while an estimated 6,000 commute from Norfolk to Portsmouth. Column (6) adds those workers coming and going via the tunnels for each city. Thus, 31,800 workers come from, or go to, Portsmouth. Column (7) reports that this is 33.6 percent of Portsmouth's 94,600 population. This percentage provides a rough measure of the relative participation impact of the tolling arrangement on that city. By this measure, that impact is more than six times larger than that of nearby Virginia Beach, a much larger city with 450,000 residents.

An additional way to estimate the burden the tolls place on the various cities is to focus on the ability of each city's residents to pay the tolls. Table 4 assumes that habitual commuters acquire an EZPass, which means in 2019 they paid $2.20 per peak-time passage. Drivers who work 250 days per year will pay $1,100 annually for their passages. One can see in Table 4 that this expenditure constituted 2.81 percent of Portsmouth's per capita income in 2017. Only Norfolk's percentage was higher, while the largest city in the region, Virginia Beach, recorded a much lower 2.06 percent due to its much higher per capita income. Not so coincidentally, Norfolk and Portsmouth have the largest minority populations of any of the listed cities.

Table 4: Annual Peak-Time Tolls as a Percent of Per Capita Income in Four Cities and the Virginia Beach-Norfolk-Newport News Region, 2016

| City | City Per Capita Income 2016 | Peak-Time Toll as a Percent of Per Capita Income |
|---|---|---|
| Norfolk | $38,484 | 2.86% |
| Portsmouth | $39,170 | 2.81% |
| Suffolk | $48,467 | 2.27% |
| Virginia Beach | $53,432 | 2.06% |
| Metropolitan Region | $47,109 | 2.34% |

Source: Federal Reserve Bank of St. Louis, https://fred.stlouisfed.org.

The two measures of toll burden we have introduced – one based upon usage, the other based upon financial consequences to individuals – are rough and ready indicators of how the weight of the tolls is not uniform across either individuals or cities. This is a lesson that policy-makers should not ignore. Where one lives makes a difference and so do one's financial circumstances. It is fallacious to assume uniformity of toll impact across geographic boundaries and demographic groups.

# 5 Lessons Learned

The impact of tolls upon the citizenry is a more complicated subject than it might first appear. Placing tolls on a heretofore toll-free travel path is quite likely to elicit significant complaints. If alternate free routes are available, then substantial rerouting of vehicles will occur as drivers seek to avoid the tolls. This negative reaction diminishes over time, but by no means disappears.

Tolls often reduce traffic congestion and there is a value attached to the time saved by drivers. Nevertheless, if free alternatives are available, congestion likely will increase on those venues.

It is difficult to estimate sensible price elasticities of demand for the use of tolled facilities when previously there were no tolls. In any case, the evidence presented here reveals that drivers are insensitive to increases in already existing tolls.

Where one lives and works and the size of one's income are vitally important factors that determine one is burdened (or helped) by tolls. It is palpably unwise for decision-makers blandly to assume away the distributional consequences of tolls.

There is one final complication to our analysis that cannot be ignored. When Virginia decided to expand and improve the MTT and DTT, it entered into a 58-year public-private partnership with the Elizabeth River Company (ERC), a creature of two very large construction/development companies, Skanska Infrastructure Development and Macquarie Infrastructure and Real Assets (Green, 2017 and Federal Highway Administration, 2018). The Commonwealth's deal with Elizabeth River ultimately saw the ERC receive approximately $580 million in financial support from the Commonwealth of Virginia, plus subsequent additions of more

than $660 million from the Virginia Small Business Financing Authority, and an injection of more than $420 million from the U.S. Department of Transportation, for a total of more than $1.66 billion in public support for the estimated $2.1 billion project (Green, 2017 and Federal Highway Administration, 2018). Thus, the ERC has contributed only about one-quarter of the capital for this public-private partnership.

The agreement with the ERC (DriveERT, 2018) also committed Virginia to reimbursing the ERC if the rate of return on the ERC's invested capital fell below 13.5 percent. This could come into play if, for example, the Commonwealth were to develop or improve alternate travel paths that lower the ERC's income. This possibility euphemistically was labeled a "revenue risk" in the agreement. The ERC additionally was given the right to increase its tolls by 3.5 percent annually, but permission to do more than this in years when the annual increase in the Consumer Price Index exceeds 3.5 percent.[13] These were among the provisions that produced an exceedingly attractive contract for the ERC. The Virginia Governor who inherited this agreement, Terry McAuliffe, labeled it the worst transportation deal in Virginia history (Green, 2017).

We mention the details of this agreement because they accentuate what have been painful experiences for the City of Portsmouth, the Virginia Beach-Norfolk-Newport News region, and the Commonwealth of Virginia. Because of the toll increase provision noted above, this pain likely will increase over time and will not disappear until 2070 when the peak load toll might well exceed $20, one-way.

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[13] An escalation index, (CPIt+1/CPIt), enables the ERC to exceed 3.5 percent when the growth Consumer Price Index (CPI) exceeds 3.5 percent.

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