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Support for and Behavioral Responses to Tolls: Insights From Hampton Roads, Virginia

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Building a Sustainable Transportation Infrastructure for Long-Term Economic Growth

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Chapter 6
Support for and Behavioral Responses to Tolls:
Insights From Hampton Roads, Virginia

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ABSTRACT

This chapter analyzes the experiences with tolling in the Hampton Roads region of Southeastern Virginia to better understand residents' and drivers' support for tolls and behavioral responses to tolls. The Hampton Roads region, with its population of 1.7 million and extensive network of highways, roads, bridges, and tunnels, has a long history of toll facilities that date back to the 1920s. The most recent tunnel tolls, associated with the Elizabeth River Crossing Project and introduced in February 2014, are the focus of this chapter. This chapter analyzes two sets of survey data to provide insights that have implications for policies regarding tolling: (1) The Life in Hampton Roads Surveys which includes questions about support for tolls and toll avoidance behaviors; and (2) two surveys (pre- and post- toll implementation) commissioned by the regional transportation planning organization.

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INTRODUCTION

"In infrastructure, you get what you pay for and for decades we haven't been paying nearly enough" (American Society of Civil Engineers, 2017, p. 2). According to the 2017 Infrastructure Report Card, $4.59 trillion is the infrastructure investment need over a 10-year period for the nation's infrastructure to earn and maintain a grade of B (good, adequate for now). Every four years since 2001, the American Society of Civil Engineers (ASCE) releases its assessment of the nation's infrastructure, and once again, America's infrastructure received a grade of D+ (poor, at risk). According to the ASCE grading scale, a grade of D indicates that many elements of the infrastructure may be "approaching the end of their service life…exhibits significant deterioration…with strong risk of failure" (p.13). The nation's infrastructure has scored a D or D+ since the advent of the four-year periodic grading. Specifically, bridges have scored a C+ while the roads have scored a D. These bridge and road scores have been consistent during a time of increased use (American Society of Civil Engineers, 2017).

The ASCE's 2017 report explicitly emphasizes that federal and state funding of infrastructure is woefully inadequate for addressing deteriorating infrastructure. They conclude that "the U.S. has only been paying half of its infrastructure bill for some time" (p. 7). Reportedly, there is a $836 billion backlog of highway and bridge needs with about 50% of that needed to repair existing highways and 15% o needed for repairing bridges.

Given this inadequacy, funding mechanisms or revenue raising methods need to be reexamined. The Federal Highway Trust Fund is the primary source for federal highway funding. The federal motor fuels tax serves as the primary source of revenue for the Highway Trust Fund (Yusuf, 2014). However, the tax rate of the federal motor fuels tax has been stagnant at 18.4 cents per gallon of gasoline and 24.4 cents per gallon of diesel fuel since 1993. At the state level, the motor fuels tax has similarly been cited as a source of the crisis in highway finance (O'Connell & Yusuf, 2013; Yusuf & O'Connell, 2013) with roots in three primary issues: (1) the tax is levied on a per gallon basis that does not automatically adjust with inflation; (2) vehicle fuel efficiency has increased, reducing fuel consumption per mile traveled; and (3) the impact of inflation on construction costs. Local governments are not immune to the problem; as Yusuf, O'Connell, and Abutabenjeh (2011) point out, localities in the U.S.A. are also confronting a crisis in highway finance that forces local governments to look for new sources of funding.

The ASCE argues that infrastructure is the "backbone" of the economy and therefore infrastructure investment is an investment in the U.S. economy. In its 2016 economic impact study, Failure to Act: Closing the Infrastructure Investment

Gap for America's Economic Future (2016), the ASCE emphasizes the costs of deteriorating infrastructure to businesses and households. These costs for 2015 are estimated at $147 billion, which include higher operating and repair costs of vehicles, safety costs, environmental costs, and time costs. These costs are expected to increase substantially as the delay of sufficient funding continues. Furthermore, the deficient and deteriorating infrastructure negatively impacts productivity across job sectors. The ASCE estimates a loss of $3400 per year in household disposable income, millions of lost jobs, and a $4 trillion loss in gross domestic product by 2025 (American Society of Civil Engineers, 2016).

The ASCE (2017) recommends dedicated funding for federal, state, and local levels of government to support investment in infrastructure. Specifically, it recommends raising the federal motor fuels tax rates and indexing these rates to the consumer price index. Also, the ASCE argues that "infrastructure owners and operators must charge, and Americans must be willing to pay, rates and fees that reflect the true cost of using, maintaining, and improving infrastructure" (American Society of Civil Engineers, 2017, p. 9).

Essentially, the ASCE argues for funding that is sufficient to cover current needs and the flexibility to adjust to cover future needs. This emphasis on sufficiency and long-term adequacy are consistent with financially sustainable transportation. Leuenberger and Bartle (2009) approach transportation sustainability from the perspective of moving people and goods, economics, and also social, financial, and environmental perspectives. Similarly, Black (2010) defines sustainable transportation as a system that meets the needs of transportation and mobility in a way that is safe and efficient (reduced congestion), but with concerns for the environment (e.g., use of renewable fuels and reduction of emissions).

Many of these sustainability factors play into the fiscal sustainability approach of this chapter, consistent with Chen's (2014) argument that the financial component is a critical foundation for supporting other aspects of sustainability. This chapter focuses on the use of tolls as a means to generate revenues while simultaneously managing congestion. By providing an analysis of the acceptability of tolls and behavioral responses to tolls, the chapter also highlights implications for the long-term adequacy of tolls as a revenue source, and the effectiveness of tolls as congestion pricing mechanisms to change driver behavior.

Tolling is an alternative funding mechanism that seeks to address the lack of long-term sustainability of the primary sources of revenues for roads, highways and bridges – the motor fuels tax. Tolling is a user fee that is imposed on drivers for use of the tolled roadway (or facility). Tolls can also be used as a congestion pricing mechanism, where the price of the tolls can be adjusted to reflect demand for the tolled roadways and therefore be used to manage congestion (Brownstone,

Ghosh, Golob, Kazimi, & Van Amelsfort, 2003; Perez, Giordano, & Stamm, 2011; Schaller, 2010). In the longer term, tolls with congestion pricing built in also have the potential to address environmental sustainability by influencing land use patterns (Urban Land Institute, 2013).

BACKGROUND

"Tolling and road pricing have become part of contemporary transportation planning and policy making" (Zmud & Arce, 2008, p. 49), particularly in the current environment where governments face significant demands for transportation services and infrastructure, while experiencing increasingly limited resources to meet the demands. Many states and localities in the U.S. are experiencing transportation funding shortfalls coupled with growing needs to address congestion and increase mobility.

Tolls, defined as direct user fees charged for use of road capacity and services, have long been used in the U.S. as a supplemental source for transportation revenues. Toll roads of earlier centuries were largely owned by private toll or turnpike companies, while the toll facilities of the twentieth century have largely been associated with quasi-public authorities (Yusuf, O'Connell, & Anuar, 2014). In recent decades, tolling has become increasingly associated with public-private partnerships for specific transportation projects.

Over the years the traditional concept of tolls has changed very little, with the primary rationale for tolling being to obtain needed funding for specific projects, to shift the burden and costs to specific users, and to provide an immediate and direct source of revenue to service bonds and other financing obligations (Rusch, 1984). One additional function of tolling has recently been introduced, with tolls also taking on a congestion pricing function of managing demand (Yusuf et al., 2014).

Evidence in the popular media and in empirical research studies indicate that the public is not particularly supportive of tolls (Cook, 2014; Kimberlin, 2012; King, Manville, & Shoup, 2007; Laing, 2014; Odeck & Bråthen, 1998; Peirce, 2007; Podgorski & Kockelman, 2006; Rasmussen Reports, 2014; Schade & Schlag, 2003; Zmud & Arce, 2008). However, public support and response to tolls is important to consider when pursuing a tolling project (Santos & Fraser, 2006; Yusuf et al., 2014). Furthermore, the effectiveness of tolls as a congestion management tool also hinges on how the public (drivers, particularly) respond to the tolls.

Tolls and congestion pricing may prompt changes in drivers' use of a tolled roadway, as drivers may undertake specific behaviors to avoid tolls or reduce the financial impacts of tolls (Keuleers, Chow, Thorpe, Timmermans, & Wets, 2006). Examples of behavioral responses to tolls include changes in route, departure time, or

destination; shift to using public transit; and telecommuting or working from home (Arentze, Hofman, & Timmermans, 2004; Francsics & Ingrey, 2000; Keuleers et al., 2006; Nielsen, 2004; Olszewski & Xie, 2005).

These behavioral responses to tolling exemplify desirable outcomes for transportation demand management (TDM). TDM represents a set of strategies with the goal of influencing travel behavior by providing alternative mobility options, including road pricing, ridesharing and HOV lanes (Meyer, 1997). By influencing drivers' use of a roadway or bridge, the implementation of tolls can play a role as TDM tools to manage and/or reduce congestion.

THE HAMPTON ROADS TOLLING EXPERIENCE

This chapter uses the recent tolling experience in Hampton Roads, Virginia to focus on two important aspects of tolling: perceptions of and support for tolls, and behavioral responses to tolls. The discussion begins with some background information about the transportation system in Hampton Roads and the region's experience with tolling, including the recent tolling experience – the Elizabeth River Crossing Project – that introduced tolls on two key tunnels serving the region. This is followed by an overview of the surveys that provide data for analysis. Survey results are analyzed and discussed to provide in-depth understanding of public support for tolls and behavioral responses to tolls. Suggestions for future research are offered and the Conclusion section summarizes key points and discusses implications for transportation finance.

Transportation and Tolling in Hampton Roads

The Hampton Roads Transportation System

Bridges and tunnels are distinctive characteristics of the Hampton Roads transportation system. Located on the southeastern coast of Virginia, the Hampton Roads region is one of the world's largest natural harbors. It encompasses several rivers, including the Elizabeth River and the James River, that empty into the Chesapeake Bay and then into the Atlantic Ocean.

Thus, the region's economy relies on the transport of goods and people over or under spans of waterways. The region is home to the Port of Virginia, which is ranked third highest in volume of containerized cargo on the East coast of the U.S. and sixth highest ranked in the country (Nichols, 2017). In 2016, a record setting 21 million tons of general cargo came through the port, of which 61% arrived or departed on the roadways. Additionally, Hampton Roads has well over a dozen

military facilities, including the world's largest naval base and facilities for the Army, Marines, Air Force, and Coast Guard.

The region requires a multifaceted transportation system that supports and connects its many communities. Tunnels and bridges are the most widely used methods for transporting goods and people. There are five tunnels that submerge the waters and two drawbridges that allow for passage of maritime vessels during nonpeak periods. The most commonly used bridges are the Hampton Roads Bridge Tunnel and the Monitor-Merrimac Memorial Bridge Tunnel, followed by the Coleman Bridge, James River Bridge, and High-Rise Bridge. The two major sub-regions of Hampton Roads, the Southside (south of the Chesapeake Bay) and the Peninsula, are connected by bridges and tunnels. Figure 1 shows a map of the Southside of Hampton Roads and the major bridges and tunnels in the area.

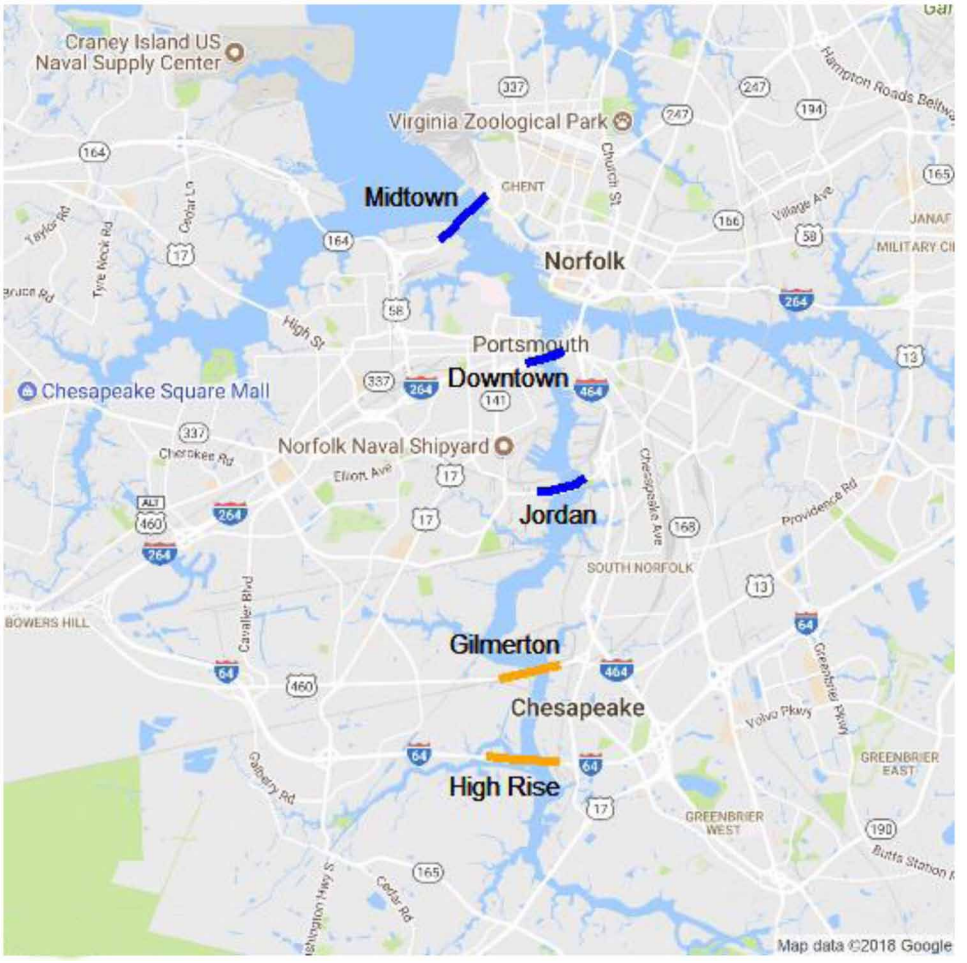
After years of decreasing roadway usage that began around the Great Recession, roadway usage is on the rise as measured by vehicle-miles of travel and traffic volume (Nichols, 2017). Congestion tells a clearer story of the Hampton Roads travel experience, with a 1.23 travel time index, indicating that it takes 23% longer to travel during peak travel periods than during uncongested periods (Nichols, 2017). This travel time index places Hampton Roads in ninth place among the 35 large metropolitan areas with populations of 1 million to 3 million. Hampton Roads is ranked fifth among the 35 largest metropolitan areas, experiencing almost six hours of congested conditions during the work week in 2016 (Nichols, 2017).

Therefore, roadway conditions, especially the bridges and tunnels that are so vital for mobility around the region, are critical for Hampton Roads' viability. Yet, like much of the rest of the country, the region's infrastructure needs are vast. The aging infrastructure of the bridges and tunnels and increase in urbanization create unique challenges for the Hampton Roads area. The average age of bridges in Hampton Roads is 41 years old, while more than 400 bridges are over 50 years old (Nichols, 2017). As of 2017, 64 bridges were designated as structurally deficient and 248 bridges were designated as functionally obsolete (Nichols, 2017). Therefore, Hampton Roads is faced with the necessity to repair and/or expand its aging infrastructure in order to effectively and safely meet the persistent and growing demands of the users.

Tolling in Hampton Roads

Roadway infrastructure is a massive capital expense that requires specific capital planning and financing. The state of Virginia was one of the first in the modern U.S. highway era to use tolls to pay for roadway projects (Nichols & Belfield, 2016). The Norfolk-Portsmouth Bridge (later called the Jordan Bridge) first opened as a toll bridge in 1928. When traveling the southern branch of the Elizabeth River, this

Figure 1. Map of major bridges and tunnels in the southside of Hampton roads
Note: The Midtown Tunnel, Downton Tunnel and Jordan Bridge are tolled facilities. The Gilmerton and High Rise Bridges are not tolled.
Source: Created by authors from Google Maps



toll bridge was the first road between Norfolk and Portsmouth, creating the first continuous connection roadway from Richmond to the oceanfront (South Norfolk Jordan Bridge, n.d.). Also in 1928, the privately owned but state chartered James River Bridge created the first roadway connecting the Peninsula and the Southside and also created the system of roads and tolled bridges that approached the James River Bridge. The state bought the James River Bridge system in 1949 and implemented tolls from 1955 to 1975. Other tolled roads in the region included the Coleman Bridge and the Hampton Roads Bridge-Tunnel which became tolled facilities in

the 1950s, and the Chesapeake Bay Bridge-Tunnel and the Norfolk-Virginia Beach Expressway which saw tolls introduced in the 1960s. The Coleman Bridge and the Chesapeake Bay Bridge-Tunnel remain tolled facilities today (Virginia Department of Transportation, 2018). Despite the varied popularity of tolls, Hampton Roads drivers have experienced tolling as an aspect of roadway financing for decades, and that experience has increased with the expansion of the Downtown and Midtown Tunnels via the Elizabeth River Crossing Project.

Elizabeth River Crossing Project

The Midtown Tunnel and the Downtown Tunnel are tunnels that serve among the most congested areas in Virginia (Nichols & Belfield, 2016). Frequently, these two tunnels had travel queues of more than four miles during high travel periods. Congestion and a drastic need for infrastructure improvement prompted a project to add travel tubes to the Midtown Tunnel (Nichols & Belfield, 2016). The Midtown Tunnel was constructed as a one tube tunnel with travel lanes in both directions. Travel safety would likely improve with the elimination of the bi-directional tube where instead each tube's traffic will flow in only one direction. Additional travel lanes would decrease travel back-ups and reduce traffic congestion.

This project to improve traffic conditions added a two-lane tunnel under the Elizabeth River as well as an extension to the Martin Luther King Extension to I-264. Because of government constraints, a public-private partnership would likely be adequate to successfully fund and enable a higher project quality (Daito, Chen, Gifford, Porter, & Gudgel, 2013). The total project was financed at $2 billion with a state contribution of $503 million combined with private sector investment. In addition to the benefits of improved traffic conditions, this project would also increase accessibility to jobs, educational facilities, medical services, shopping and tourism (Virginia Department of Transportation Office of Public-Private Partnership, 2014).

Through a public-private partnership, tolls were introduced to finance infrastructure and traffic condition improvements. According to Lee and Miller (2016), tolls have been an approach to manage rather than control highway congestion. Currently, both the Midtown Tunnel and Downtown Tunnel have implemented the use of all electronic tolling. With electronic tolling, the traditional toll collection plaza is replaced by an all-electronic video system that captures vehicle license plates and an E-ZPass system that relies on a transponder that allows drivers to pay for tolls automatically. Drivers that do not have an E-ZPass are mailed an invoice for their toll fees.

The public-private partnership project was financed and administered between the Virginia Department of Transportation and the Elizabeth River Crossings OpCo, LLC (Nichols & Belfield, 2016). Tolling began in 2014. As of this writing, tolls

are generally unpopular (Pascale, 2017) and vary from $1.73 to $2.09 for E-ZPass passenger vehicles to as much as $3.81 for registered "pay by plate" passenger vehicles and $5.53 for unregistered "pay by plate" passenger vehicles (Elizabeth River Tunnels, 2018).

Data and Surveys for Tolling in Hampton Roads

This chapter uses two sets of survey data to understand residents' and drivers' support for tolls and behavioral responses to tolls in Hampton Roads. The first set of survey data comes from the Life in Hampton Roads (LIHR) Survey, conducted annually by the Old Dominion University Social Science Research Center. The analysis includes data from the 2012 survey (following the announcement of the tolls on the Downtown and Midtown Tunnels) through the 2016 survey and focuses on receptiveness and responses to tolls more broadly. The second set of data comes from the regional transportation planning organization, the Hampton Roads Transportation Planning Organization (HRTPO). The HRTPO commissioned two pre- and post-toll surveys that were conducted in early January 2014 (before the tolls went into effect) and in November 2014 (after toll implementation).

The Life in Hampton Roads Survey

The Social Science Research Center at Old Dominion University conducts an annual (every summer) Life in Hampton Roads (LIHR) survey, beginning in 2010. The principal goal of the survey is to gauge the quality of life in the Hampton Roads area. Residents from the cities of Chesapeake, Hampton, Newport News, Norfolk, Portsmouth, Suffolk, and Virginia Beach are surveyed about their perceptions of life in the region. Additional goals of the survey include determining the attitudes and perceptions of citizens regarding local topics such as transportation and traffic, local and state government, education, and crime, as well as providing a source of data to local decision and policy-makers. The analysis in this chapter utilizes data from the 2012 through 2016 surveys (Luetke, Gibbs, Pronier, Vandecar-Burdin, & Richman, 2012; Parker, Bush, Richman, & Vandecar-Burdin, 2014; Parker, Close, Gainey, & Vandecar-Burdin, 2015, 2016; Resnick et al., 2013).

The survey utilizes a computer-assisted telephone interviewing (CATI) system. Starting in 2011, both landline and cellphone numbers were utilized for the survey. A random digit dial telephone sample is utilized comprised of landline telephone numbers with Hampton Roads exchanges. A cellphone sample is also utilized based on switch points within the Hampton Roads area. The sample size for the LIHR surveys vary between 762 and 962 (see Table 1).

Table 1. Life in Hampton Roads survey sample sizes and margins of error

Year	Sample Size	Margin of Error
2012	762	5.3%
2013	812	5.3%
2014	853	3.7%
2015	883	3.9%
2016	962	3.6%
2017	908	3.3%

The Life in Hampton Roads survey also includes several questions useful for describing the travel characteristics of Hampton Roads residents. First, the average one-way commute to work or school, summarized in Table 2, ranges from about 22 minutes to 24 minutes across the years of analysis. Hampton Roads residents also indicated that congestion is a major concern for drivers in the region. For example, over time, there has been an increasing percentage of residents who avoided a business in a neighboring city due to traffic congestion from about 40% in 2012 to over 52% in 2017 (see Figure 2).

Life in Hampton Roads survey respondents also highlight the reliance of Hampton Roads residents on bridges and tunnels. As shown in Table 3, in 2012 just over ten percent of respondents traveled through a bridge or tunnel five to six times a month and almost 40% of respondents traveled through bridge or tunnel more than once a week. From 2014 to 2017, the survey asked respondents if they use a bridge or tunnel to commute to work or school (see Table 4). Between 13% and 18% of respondents indicated regular use of a bridge or tunnel for travel to work or school.

Table 2. Average one-way commute (in minutes) to work or school

2012	23.4
2013	23.7
2014	23.8
2015	23.6
2016	22.2
2017	24.0

Note: This includes people whose commute was greater than zero minutes or whose commute was zero minutes, but they were not retired or unemployed.

Figure 2. Percent of respondents who avoided visiting a business in a neighboring city due to concerns about traffic congestions

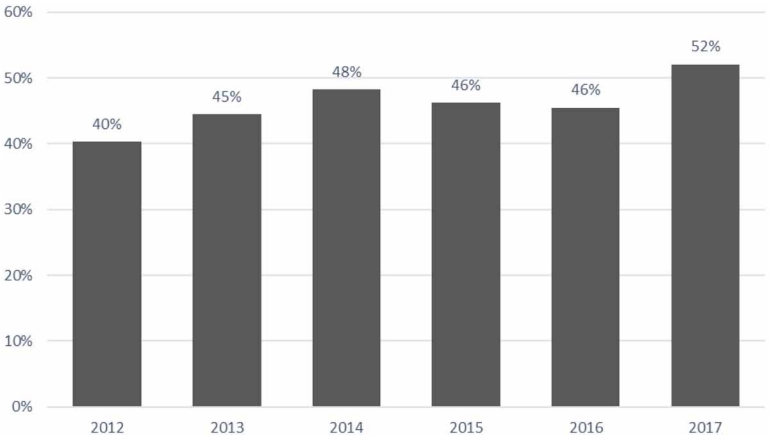


Table 3. Frequency of travel through a bridge or tunnel in Hampton Roads (2012)

Not at all	10%
Once or twice in the past month	28%
Three to four times in the past month	13%
Five to six times in the past month	10%
More than once a week	39%

Table 4. Percent of respondents who use a bridge or tunnel to commute to work or school

2014	13%
2015	15%
2016	18%
2017	17%

The South Hampton Roads Midtown and Downtown Tunnels Tolls Survey

This study also uses data from surveys obtained from the Hampton Roads Transportation Planning Organization (HRTPO). The HRTPO commissioned Christopher Newport University's Judy Ford Wason Center for Public Policy to

conduct before and after telephone surveys of tolling in January and November 2014 (Christopher Newport University Judy Ford Wason Center for Public Policy, 2014a, 2014b). The January 2014 survey was a pre-toll survey conducted just before the Downton and Midtown Tunnels tolls went into effect, and the December 2014 survey was a post-toll survey conducted approximately nine months after tolls were implemented.

The goal of the January survey was to "assess the public's views and anticipated behavior in light of the implementation of tolling" (Christopher Newport University Judy Ford Wason Center for Public Policy, 2014a, p. 3) and the stated goal of the November 2014 was to "assess the public's views and behavior ten months out from the implementation of tolling on the Midtown and Downtown tunnels" (Christopher Newport University Judy Ford Wason Center for Public Policy, 2014b, p. 3). Both survey instruments included questions about the respondent's commuting experiences, opinions about tolls, E-ZPass usage, and behavioral changes in response to tolls.

Both HRTPO surveys utilized random digit dial telephone sample comprising of landline telephone and cellphone numbers of residents of five cities that make up the core of the Hampton Roads region: Norfolk, Portsmouth, Chesapeake, Suffolk, and Virginia Beach (Christopher Newport University Judy Ford Wason Center for Public Policy, 2014a, 2014b). The pre-toll survey was conducted between January 26 and 31, 2014 and the post-toll survey was conducted between November 7 and 16, 2014. The margin of error for both surveys was $\pm 3.9\%$ at the 95% level of confidence for the sample size of 601 and 629 for the January and November surveys, respectively. This margin of error is standard for samples of this size, as well as the population size; no corrections were otherwise made.

Analysis and Findings

In this section the findings from the HRTPO and LIHR surveys are discussed. Different survey questions are considered in the analysis to provide a broad understanding of perceptions of and support for tolls, and behavioral responses to tolls. The analysis and findings are divided into four different categories: (1) awareness of toll projects, (2) preferences for tolls, (3) use of tolled roadways and (4) toll avoidance behavior. This section also summarizes the results of a traffic analysis conducted by HRTPO transportation engineers that describe the quantitative impact of tolls.

Awareness of Toll Projects

Tolling has become a contentious issue in many of the communities where toll facilities have been implemented, including in Hampton Roads (Cook, 2014; Kimberlin, 2012; Laing, 2014; Rasmussen Reports, 2014; Zmud, 2008). As such,

a key pre-cursor to public preference of and support for tolls is the level of public awareness of potential toll projects. In advance of the Elizabeth River Crossing Project, LIHR survey respondents were asked about their awareness of toll roads within the Hampton Roads region. The Elizabeth River Crossing Project was agreed upon in 2011, and in the 2012 and 2013 LIHR surveys, respondents were asked "Are you aware of any planned toll roads in the Hampton Roads area?" Survey results suggest that there was a high level of awareness among the region's residents of planned toll projects. In 2012, 68% of respondents indicated awareness and in 2013, 60% indicated they were aware of planned toll projects.

In the HRTPO January 2014 survey, respondents were asked "How much have you heard about the tolls that are coming to the Midtown and Downtown Tunnels?" A majority of respondents (76%) indicated they had heard 'a lot' about the future tolls. Eleven percent said they heard about coming tolls 'some' while only 9% indicated they had heard 'a little' and 4% had heard 'none.' Overall, the findings indicate that the majority of Hampton Roads residents were aware of the impending toll roads in the area.

Preferences and Support for Tolls

HRTPO and LIHR survey respondents were asked about their opinion for funding improvements to the Midtown and Downtown tunnels through tolling. The LIHR survey included questions about toll preferences in the years leading up to toll implementation. In 2012, respondents were asked what sources of funding they would support if additional funds were needed to maintain or expand the road, highway, and bridge systems in Hampton Roads. Among the top three responses was implementing tolls on highways (31.3%), in addition to increasing state vehicle registration (32.1%) and increasing the state tax on vehicle purchases (31.7%).

In 2013, the LIHR survey respondents were asked to think about the Downtown and Midtown Tunnels and how to pay for the expansion of existing bridges and tunnels. Less than one in four respondents supported contracting with a private company to set tolls at the downtown and midtown tunnels to pay for tunnel expansion (23.4%). Paying for the expansion in some other way was supported by just under half of the respondents (47.4%) while almost one in five opposed tunnel expansion (19.7%). Almost ten percent (9.5%) of respondents responded "don't know."

Respondents who indicated that they did not want private contractors to use tolls to expand the downtown and midtown tunnels were asked to specify another way to fund these projects. The most commonly recommended solution was to increase taxes to cover the cost of expansion. More specifically, respondents were willing to pay more in gas taxes, but a few also mentioned increasing property tax and/or sales tax. Another general suggestion was that the local and federal government

should be responsible by using bonds and/or grants. Reworking the budget was also recommended by several individuals, although these respondents did not specify state, local, or federal budget. Some of these suggestions included borrowing money from the state lottery, ceasing to fund ineffective government-sponsored programs, and reducing the salaries of high paid government employees.

When looking at the results from the 2016 LIHR survey (about two years after tolls had been implemented), there appeared to be general support for the tolls when used to finance tunnel improvements. Respondents were told that the tolls on the Midtown and Downtown Tunnels were being collected to finance transportation improvements, including constructing a second tunnel for the Midtown Tunnel and increasing it from two to four lanes. The tolls would also be used to rehabilitate the existing Midtown and Downtown Tunnels. Respondents were asked if they generally support or oppose the tolls being used for these improvement purposes. As shown in Table 5, almost two-thirds of respondents reported they generally support the tolls being used for transportation improvements (61.9%), while less than a third of respondents reported they oppose the tolls being used to pay for transportation improvements (28.7%). Another 6.1% of respondents reported they had no opinion on the tolls being used to finance transportation improvements and 3.2% of respondents reported they did not know if they support or oppose the tolls.

The HRTPO surveys provide a comparison of acceptance for tolls before and after toll implementation. In both the January and November 2014 surveys, respondents were asked the question: "The tolls on the Midtown and Downtown tunnels are being collected to finance transportation improvements, including expanding the Midtown Tunnel from one tube to two tubes, resulting in a total of four lanes. Would you say that you generally support or generally oppose the toll for this purpose, or don't you have an opinion either way?" As shown in Table 6, support for tolls outweighed opposition to tolls in January 2014 (44% to 36%). However, the support for toll decreased only 34% of respondents expressing general support for tolls in November. In the short-term period following toll implementation, the HRTPO survey data show that support for tolls decreased and opposition increased.

Table 5. Preferences for Tolls from the LIHR 2016 survey

Generally support	62%
No view	6%
Generally oppose	29%
Don't know	3%

Note: Percentages may not add to 100% due to rounding.

Table 6. Preferences for tolls from HRTPO surveys

	January 2014	November 2014
Generally support	44%	34%
No view	18%	24%
Generally oppose	36%	42%
Don't know	2%	0%

Note: Percentages may not add to 100% due to rounding.

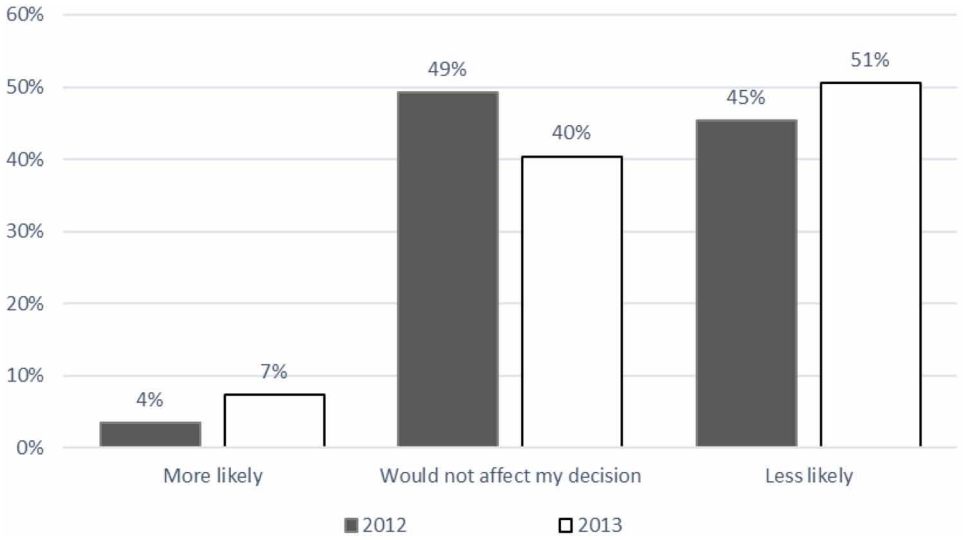
Similar to the LIHR 2013 survey, the HRTPO surveys also asked respondents to indicate support for different methods of paying for transportation improvements in Hampton Roads. The options included tolls, regional or state gas taxes, and regional or state sales taxes. Consistent with the LIHR 2013 survey results, 24% of the HRTPO survey respondents (in both January and November 2014) identified tolls as the funding option they support the most.

Use of Tolled Facility

Both the LIHR and HRTPO surveys question respondents about their use of toll bridges and tunnels (LIHR survey), and the Midtown and Downtown Tunnels specifically (HRTPO survey). Use of the tolled facility is critical to the success of tolling as a revenue raising mechanism. While a decline in usage would indeed accomplish one of the goals of relieving congestion, such decline in usage may also fail to raise sufficient funds for maintenance and improvements of the tunnels. Understanding drivers' anticipated and actual use of a tolled roadway can provide insight for decision makers into issues such as messaging and toll rates.

After the announcement of tolls on the Midtown and Downton Tunnels, the LIHR survey asked respondents about their likelihood of using a tolled roadway (see Figure 3 for a summary of responses). Specifically, the 2012 and 2013 LIHR surveys asked if respondents would be more or less likely to use a bridge tunnel when there is a toll on it or if the toll would not affect their decision. The response in 2012 was that about half of the respondents (49%) indicated no effect; however almost as many (45%) indicated that they were less likely to use a tolled bridge or tunnel. A year later, but still prior to the implementation of tolls, slightly more than half of the respondents (51%) indicate that they would use a tolled roadway less. The likelihood of no effect in usage of a tolled facility declined to 40%. Perhaps the additional year was enough time for more people to become aware of the new tolls, especially on facilities that were previously not tolled. Interestingly, there

Figure 3. Likelihood of using a tolled bridge or tunnel
Note: Does not include 'Don't Know' responses.

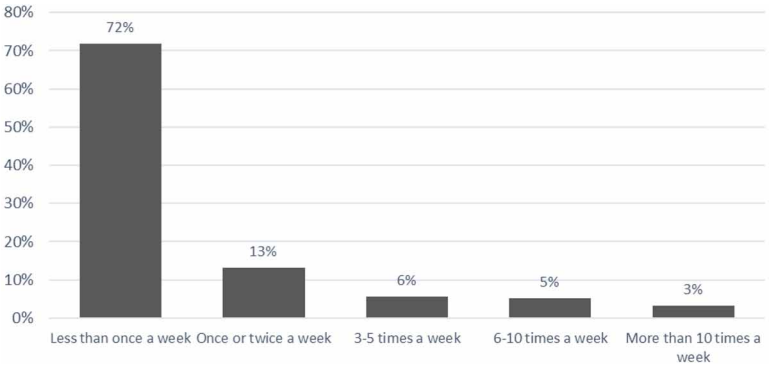


was an increase from 4% to 7% of respondents who stated that they have a greater likelihood of increasing use of a tolled facility, which may reflect an anticipation of decrease in congestion or reflects an increase in the number of respondents who will be affected by the new tolls.

In 2016, the LIHR survey further probed the weekly use of a tolled bridge or tunnel. All respondents who reported a commute time of greater than zero minutes were asked how many times in a typical week they use a toll bridge or tunnel (see Figure 4). While the majority of respondents reported using the toll facility very infrequently (less than once a week), 13% used a toll bridge or tunnel once or twice a week. Just over three percent of respondents used a toll bridge or tunnel more than ten times a week.

The HRTPO survey asked respondents how frequently they use the Midtown and Downtown Tunnels. The results are shown in Table 7. In January 2014, a month before implementation of the new tolls, 16% of respondents reported daily usage of the Midtown and Downtown Tunnels and 13% reported using the tunnels once a week. Following toll implementation, in November 2014, daily usage increased to 18% and once a week usage decreased to 11%. Interestingly, the largest change in reported usage frequency was in the never category, with reported 10% of respondents reporting never using the tunnels in January and 15% in November. Responses in the very seldom and almost never categories declined between January and November. This suggests that those who used the tunnels less than a few times a month may

Figure 4. Frequency of use of a toll bridge or tunnel in a typical week (2016)
Note: Percentages may not add to 100% due to rounding.



have resorted to never using the tunnels. Obviously, those who use the tunnels daily have a greater need to travel on a route via the tunnels than the least frequent users who may have simply stopped using the tunnels.

Toll Avoidance Behavior

Survey respondents were asked about avoidance of the tolled facilities. In the HRTPO survey, respondents of the pre-toll (January 2014) survey were given a list of potential ways to avoid the toll. In the post-toll (December 2014) survey, the respondents were asked if they had actually engaged in the toll avoidance behaviors. Table 8 reports the percent answering yes or no to each type of toll avoidance behavior. The results reveal a clear pattern of less involvement in actual avoidance behavior than predicted in the earlier survey. This could be due to the uncertainty of the effect

Table 7. Usage frequency of midtown and downtown tunnels

	HRTPO January 2014	HRTPO November 2014
Daily	16%	18%
Once a week	13%	11%
Few times a month	22%	22%
Very seldom	19%	16%
Almost never	18%	20%
Never	10%	15%

Note: Percentages may not add to 100% due to rounding.

Table 8. Anticipated (January 2014) and actual (November 2014) toll avoidance behaviors

	HRTPO January 2014	HRTPO November 2014
Change where you live or work to avoid tolls		
Yes	19%	12%
No	77%	86%
Change your commute to avoid the tolls		
Yes	57%	41%
No	38%	55%
Avoid traveling to destinations that require paying the tolls		
Yes	58%	45%
No	38%	53%
Telecommuting or working from home		
Yes	33%	15%
No	60%	80%
Ride the bus		
Yes	20%	7%
No	77%	92%
Ferry		
Yes	40%	12%
No	57%	87%
Carpool		
Yes	53%	24%
No	44%	75%

Note: Does not include 'don't know' responses

of tolling prior to the start of tolling. Once respondents understood the full impact of tolling on their travel times, the toll avoidance behavior may have become less attractive or more burdensome in time and effort than expected. Residents seem to have found the tolling less disruptive than they had imagined, as they generally reported avoiding tolls to a lesser degree (Christopher Newport University Judy Ford Wason Center for Public Policy, 2014b).

Still, the advent of tolling appears to have spurred some toll avoidance behaviors. In November 2014, 12% of respondents had moved or changed their place of employment, 41% changed their commute, and 45% avoided traveling to destinations that require paying tolls (Christopher Newport University Judy Ford Wason Center for Public Policy, 2014b).

Furthermore, approximately 20% of respondents indicated an improvement in travel time, which might be attributed to less peak time usage by casual drivers. This suggests that "regular commuters are using the tunnels a bit more while occasional commuters are using them a bit less" (Christopher Newport University Judy Ford Wason Center for Public Policy, 2014b, p. 15). Residents' bluffs may have been called, as the comparison of survey responses generally showed fewer than predicted instances of telecommuting or working from home, changing commute to avoid the tolls, avoiding traveling to destinations that require paying the tolls, or changing places of work or residence.

In the LIHR surveys (from 2014 through 2017), respondents were asked the question of whether they undertook specific actions to avoid a toll, including changing or intending to change job locations, reducing travel during peak periods, increasing use of buses or light rail, and carpooling with others. Responses across the years post-toll implementation are summarized in Table 9. Of those who indicated that they intentionally avoided tolls, taking a different route to work or school was the most common avoidance behavior (51% to 62% depending on the year). Reducing travel during peak periods became more popular in recent years (22% in 2014 compared to 49% in 2017).

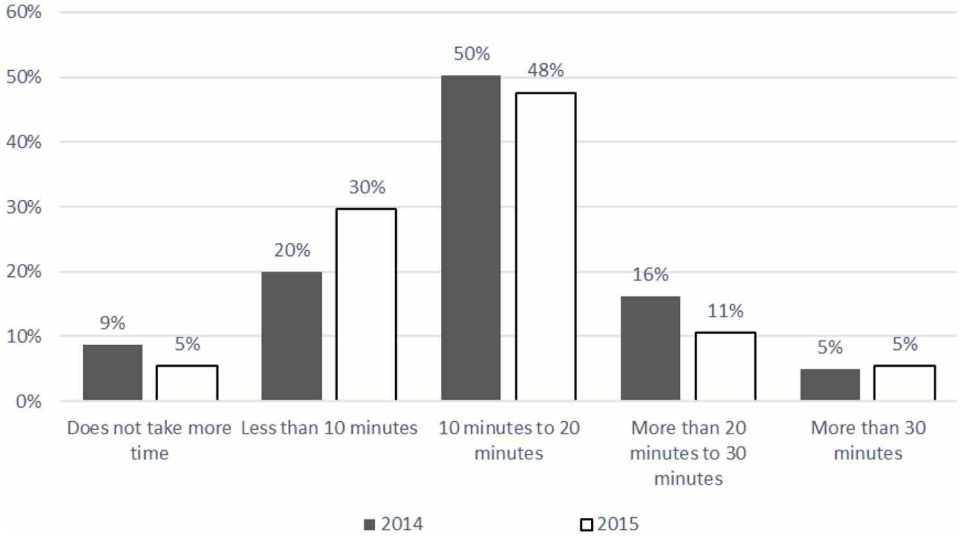
In the LIHR 2014 and 2015 surveys, respondents were also asked: "If you take a different route now for your commute (to avoid tolls), how much more time does it take you?" As summarized in Figure 5, about half of respondents in each year indicated their alternative commute took 10 to 20 minutes longer. Only 5% percent of respondents indicated that their extra commute took more than 30 minutes in either year. Only 5% (2015) and 9% (2014) said that their alternative route did not take more time.

Table 9. Percentage of LIHR respondents reporting specific toll avoidance behaviors

	2014	2015	2016	2017
Changed or intend to change your job location	13%	11%	8%	13%
Changed or intend to change your home location	14%	6%	8%	9%
Carpooled with others	9%	13%	15%	17%
Taken a different route to get to work or school	62%	51%	59%	57%
Changed your work or school schedule	9%	6%	9%	11%
Increased your use of buses or light rail	6%	5%	6%	6%
Reduced your travel during peak periods	22%	37%	38%	49%

Note: Does not include 'Other' responses.

Figure 5. Increase in commute time by taking an alternate route to avoid tolls
Note: Percentages may not add to 100% due to rounding.



Quantitative Impact of Tolls

Nichols and Belfield (2016) quantified the impact of the Midtown and Downtown Tunnels tolls, given the heavy daily congestion before the tolls during commuting hours or other traffic disruptions (e.g., accidents, tunnel repairs). They compared different factors present before and after the implementation of the tolls on both tunnels (pre- and post- January 2014), including traffic volumes, travel time, and public transportation ridership. Data were collected from twelve locations, including the two tunnels.

The analysis found that there was a decrease in travel time at tolled locations and, conversely, travel time increased at non-tolled locations (Nichols & Belfield, 2016). Specifically, the study found that weekday peak period delays decreased by 53% at the tolled facilities, as compared to similar periods in 2013 and 2014. In contrast, two of the untolled bridge facilities showed a 16% increase during this period. However, it was noted that, over time, travel volume on the tolled facilities was slowly increasing, erasing some of the reductions in travel time that was observed in the period immediately following toll implementation. The research also found that public transportation ridership increased during the first month following the toll implementation but returned to normal a few months later.

FUTURE RESEARCH DIRECTIONS

As an area that has limited alternative travel routes between its cities, Hampton Roads is a natural laboratory for further research on tolling implementation and subsequent behaviors. The rivers, creeks, and bay provide environmental barriers to vehicular traffic. Given these physical characteristics, conditions in the landscape will not change significantly and allow researchers to observe changes in future driver behavior.

For example, will tolls be normalized and just become routine? Will tolling attitudes grow in resistance or will passive acceptance rule? The method of tolling, for those with E-ZPass transponders, is nearly invisible; a user account can be replenished at will via debit or credit card. This becomes a small bill for those with disposable income but may have a significant impact on lower wage earners. The question to be answered is whether sufficient numbers would consider this fee to be a significant part of daily life or just a price to be paid.

Additionally, moving behavior could be a factor of interest in future studies. As this chapter's results show, the surveyed response of threat of moving or job change (pre-toll) may not happen as a matter of reality (post-toll). Nevertheless, what will need to be examined is not only the net movement of people but changes in locational economic factors. The net change of population may be zero or low, but the changes in income and other financial factors may change if there are moves that achieve home-and-job convergence.

Finally, increased availability of alternative transportation options through transportation network companies (TNCs) such as Lyft and Uber may also need to be considered in terms of how it may affect behavioral responses to tolls. In 2015, the Virginia Department of Motor Vehicles passed legislation that authorized the operation of TNCs and required registration of partner (driver) vehicles. Vehicle registrations began in June of 2015, and by the end of September of 2015, there were over 50,000 registered vehicles. The number of registered vehicles in the state grew by over 185% by the end of September 2016 (Virginia Department of Motor Vehicles, 2016). In the first month of the requirement, Virginia Beach and Norfolk had the most registered TNC vehicles, outnumbering licensed taxis in those cities at a ratio of 2.5 to 1 (Forster, 2015). However, despite the growth in the availability of TNC vehicles as a transportation option for commuters, it is unclear how this option may support toll avoidance. As opposed to reducing toll costs by carpooling or using public transportation, toll costs are passed on to TNC passengers as part of the fare or surcharge.

High Occupancy Toll (HOT) Lanes in Hampton Roads

In January 2018, high occupancy toll (HOT) lanes were initiated by the Virginia Department of Transportation on interstate I-64 in southeastern Hampton Roads (Hafner, 2018). The intent of the HOT lanes was to increase the number of carpools and other transit use, while allowing drivers to pay a fee drive on less congested roadways (Pascale, 2017). The former HOV lanes had previously been open with free access during defined non-commuting hours and open only to HOV car, hybrid vehicle, or motorcycle traffic during specific commuting periods. The switch from HOV to HOT brought a dynamic pricing structure to the area during commute hours (Hafner & Pascale, 2018).

HOT lanes had been implemented in Northern Virginia with some mixed success (Pascale, 2017). While helping with traffic flow, the dynamic pricing model has been controversial due to a wide variance in the upper price range (Chesley, 2018). However, a large portion (80%) of the Northern Virginia HOT lane users used them in a range of one to five times in a month (Pascale, 2017). Approximately 5% used the Northern Virginia HOT lanes on a regular basis.

In Hampton Roads, the HOT lanes are only on the restricted portion of the highway, thereby creating a market-based choice (Pascale, 2017). The end-goal is to lessen congestion on the standard lanes and make better use of highway space compared to the prior HOV system in this particular corridor. The Virginia Department of Transportation believes that the HOT lanes will assist in reducing traffic in the standard lanes by up to 20%. Given the popularity of HOT lanes, research is needed to understand both public decision-making related to the use of HOT lanes and the effectiveness of HOT lanes for congestion management. Future research could use the Hampton Roads HOT experience as a basis for expanding knowledge about the behavioral responses beyond this chapter's focus on the introduction of tolls on previously untolled facilities (to expand and improve the facilities) to include scenarios where tolls are implemented on previously untolled HOV lanes.

CONCLUSION

Chen (2014) argues that financial sustainability is a critical foundation for overall transportation sustainability. This chapter used the case study of the recent tolling experience in Hampton Roads to assess, from the public's perception, tolls as a means to generate revenues while simultaneously managing congestion. This chapter utilizes survey data pre- and post-toll implementation to better understand not only the public's preferences and support for tolls, but also the expressed intent to avoid

tolls and actual toll avoidance behaviors undertaken. Analysis of survey responses indicate a decline, over time, in opposition to toll projects and less reported toll avoidance behaviors.

The analysis shows that as a source of revenue for transportation infrastructure, between a fifth to a third of residents prefer tolls. The percentages of residents who prefer tolls are about on par with those who prefer increases to vehicle registration fees, vehicle sales taxes, gas taxes, or sales taxes. General support for tolls, even when the revenues are dedicated for specific transportation improvements, range between a low of 34% (November 2014) to a high of 62% (summer 2016). The analysis also shows that the tolls may not be as decisive a factor in deciding on whether to use a bridge or tunnel. In 2012, for example, 49% of LIHR survey respondents indicated the toll would not affect the decision to use a tolled bridge or tunnel, while 45% indicated the toll would make them less likely to use the bridge or tunnel. However, the analysis suggests that tolls may make a difference to infrequent users; those who use tunnels less frequently may decide not to use the tolled facility at all.

Not surprisingly, the findings indicate that people do respond to tolls by undertaking specific toll avoidance behaviors such as changing commutes or taking different routes to avoid tolls. However, analysis of pre- and post-toll survey data show that respondents reported fewer actual toll avoidance behaviors once tolling was implemented compared to toll avoidance behavior they anticipated using before tolling was implemented. Toll avoidance behaviors also change over time. Specific behaviors that reduce congestion, such as carpooling and reducing travel during peak periods, increased over time. Other behaviors that can be considered more drastic, such as changing job or home location and changing work or school schedules, on the other hand, remained fairly consistent or declined. This suggests that tolling with congestion pricing built in may be an effective tool for reducing congestion by impacting driver behavior. Simultaneously, the findings indicate that policy makers must remain conscious of social justice implications of tolls on under-resourced individuals. The financial costs of tolls may prompt some individuals to undertake toll avoidance behaviors such as taking alternative routes that can produce longer commutes. That more than half of LIHR survey respondents from 2014 through 2017 report taking a different route to school or work (to avoid tolls), which for about half of them add an extra 10 to 20 minutes to the commute, indicate that this is a concern that should not be taken lightly.

Finally, quantitative analysis using traffic data and public transportation ridership provide additional support for the findings from the survey data. Following the introduction of tolls, tolled facilities saw a decrease in travel time while some non-tolled facilities saw increases in traffic. This is consistent with the toll avoidance behavior reported in the LIHR and HRTPO surveys. The quantitative analysis also

indicates that some of the effects of tolls, such as a decrease in tolled facility use and an increase in public transportation use, were only temporary.

This chapter's analysis of the acceptability of tolls and behavioral responses to tolls provide some insights into the long-term adequacy of tolls as a revenue source and the effectiveness of tolls as congestion pricing mechanisms to change driver behavior. Specifically, the findings suggest that opposition to tolling, while initially quite vocal, does appear to diminish over time. Tolls appear to become more acceptable in the longer term, assuming there are no incidents (e.g., massive toll rate hikes, infrastructure quality issues, etc.) that may generate opposition to tolls. This suggests that tolls may have longevity as a revenue source and may contribute to long-term financial sustainability of the transportation system.

The analysis presented in this chapter, while US-centric, has implications beyond tolling experiences in the U.S. The introduction of tolled facilities has increased not just in the U.S., but across the world, due in part to greater reliance on public-private partnerships (PPPs) to deliver infrastructure (Gurgun & Touran, 2013; Liyanage & Villalba-Romero, 2015; Willems et al., 2017). Much of the literature on transportation PPPs and tolling has focused on lessons learned in terms of management and governance (Dyble, 2011; Hodge, Boulot, Duffield, & Greve, 2017; Puentes & Istrate, 2011; Rouhani, Gao, & Geddes, 2015), managing risk (Chung, Hensher, & Rose, 2010; Lemp & Kockelman, 2009; Roumboutsos & Pantelias, 2015; Shan, Garvin, & Kumar, 2010; Wang, 2015), pricing and rate setting (Gross & Garvin, 2011; Jang, Song, Choi, & Kim, 2014; Light et al., 2015; Roumboutsos & Pantelias, 2015), and success factors (Hwang, Zhao, & Gay, 2013; Liyanage & Villalba-Romero, 2015; Osei-Kyei & Chan, 2015; Shi, Chong, Liu, & Ye, 2016; Willems et al., 2017). Fewer have examined public support for and behavioral responses to tolls (Gomez, Papanikolaou, & Vassallo, 2016; Jagers, Matti, & Nilsson, 2017; Yusuf et al., 2014). This chapter's analysis and findings fit well within this body of research and provide another in-depth case study of tolling and its implications

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KEY TERMS AND DEFINITIONS

Congestion Pricing: A surcharge imposed to manage the flow of traffic or curtail the overcrowding of roadway by regulating demand and thus making it possible to manage congestion without increasing demand. The objective of congestion pricing (also known as congestion charging) is to use price mechanisms to make drivers conscious of their costs during peak demand periods and encourage them to redistribute their demand in time and/or space.

E-Z Pass Transponder: A tool mounted on the vehicle that signals the equipment at the tolled facility to electronically charge the owner of the transponder for the use of the tolled facility without requiring the driver to stop.

Federal Highway Trust Fund: A fund that receives the proceeds of the federal fuel tax on gallons of gasoline and diesel fuel.

Hampton Roads: A region of southeastern Virginia bounded by the Atlantic Ocean, the Chesapeake Bay, James River, and the Elizabeth River.

High Occupancy Toll (HOT) Lanes: Lanes accessed by vehicles with multiple occupants and charged a fee for use (especially at high traffic times) to encourage

carpooling and a less congested route for the drivers while also reducing congestion on alternative routes. A form of transportation demand management.

High Occupancy Vehicle (HOV) Lanes: Lanes accessed by vehicles with multiple occupants (especially at high traffic times) to encourage carpooling and a less congested route for the drivers while also reducing congestion on alternative routes. A form of transportation demand management.

Motor Fuel Tax: In the U.S.A. the motor fuel tax is a federal or state excise tax levied per gallon of gasoline or diesel fuel used by vehicles. The motor fuel tax is the primary source of revenue for transportation in the U.S.A.

Public-Private Partnership: A cooperative agreement between at least two public and private sector organizations for the delivery of goods or services to the public.

Road Pricing: A direct charge imposed for the use of roads to generate revenues and/or as a transportation demand management tool to manage the flow of traffic or curtail the overcrowding of roadway. Also known as road user charges, road pricing is a broad term that includes tolls, distance or time-based fees, and congestion charges.

Social Equity: A concept concerned with the fair and equitable provision, implementation, and impact of services, programs, and policies.

Toll Road: A road or highway that drivers must pay a fee or toll to use. In the U.S.A. toll roads are also known as a turnpike or tollway. The toll revenues are generally used to recoup the cost of road construction and maintenance.

Tolling: A form of road pricing in which a fee is assessed for use of the tolled facility.

Transportation Demand Management: A set of strategies and policies with the goal of influencing travel behavior to reduce travel demand or redistribute demand, thus managing or reducing congestion.

Transportation Network Company: "Ride-share" company that matches contracted, independent drivers and passengers via mobile apps as an alternative to public transportation and taxi cab service. Sometimes known as mobility service providers or ride-hailing services. TNC services include those provided by Uber and Grab.