Lessons Learned from the Rise, Fall, and Rise of Toll Roads in the United States and Virginia

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Acknowledgments

The authors express their deep appreciation to Ann B. Miller at the Virginia Center for Transportation Innovation and Research for her sharp review during the development of this paper. The authors also thank Dr. Amy A. O'Leary, Roger W. Howe, and Jacqueline H. Cromwell who provided essential feedback at the inception of this research; Robert Perry who provided graphics assistance; and Linda Evans who provided editing. The authors thank Z. Barlow and A. Miller for data provided July 3 and 7, 2014 that were used to create Figure 2.

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ABSTRACT *Based on a review of the literature, this paper provides an overview of how toll roads have been used in the United States, with additional attention to Virginia. The research identified five periods associated with U.S. toll roads: Colonial/Early Federal Period (1607-1775), Turnpike Era (circa 1792-1845), Anti-Toll Sentiment Era (1879-1939), Post-World War II Era (1939-1963), and Renewed Interest in Tolling Period (circa 1976–present). Each period is characterized by a common set of circumstances, such as legislation or modal competition, with regard to the development or removal of toll facilities. Another way of examining a chronology of toll facilities was to consider factors that appeared to have influenced the likelihood of tolls being used as a way to support construction or maintenance activities. Four tentative factors were identified in this research: (1) the relative stability of revenue streams from user fees (compared to the stability of revenues from a general tax); (2) the available technologies for collecting tolls (and how this technology affects the user's experience); (3) the role of design innovations for the tolled or non-tolled facilities; and (4) consideration of the societal impact of the tolled versus non-tolled facilities. These four factors cannot be used to predict the future, but they do illustrate conditions that appeared to have influenced the use of toll facilities in the United States since the colonial period, and suggest that although a source of revenue is certainly one motivation for having a tolled facility, other factors help explain why the popularity of tolled facilities has risen or decreased over time.*

Keywords: toll road, turnpike, toll history, Virginia

Introduction

During the past three decades, "toll roads"—i.e., roads funded by some type of toll (also referred to as a user fee) attributed to using a given facility—have gained renewed interest at the national level for two distinct reasons.

1. *To build (or maintain) roads more quickly than would have been the case if toll roads had not been used.* States have recently used tolls to fund new facilities. For example, Virginia's Public-Private Transportation Act of 1995 increased the feasibility of pursuing public-private partnership (P3) projects. A longer viewpoint shows that acquiring funds for maintenance is not a trivial matter, given that facilities built during the peak construction years of the Interstate System have been approaching the end of their design life (Gomez-Ibanez et al., 1991). This concern about maintenance is not new: the 95th U.S. Congress (1977-1979) permitted federal 4R (resurfacing, restoration, rehabilitation, and reconstruction) funds to be used on certain toll segments of the Interstate System (Congressional Budget Office, 1985), and states without toll roads during the 1970s, such as Arizona and Wisconsin, considered converting interstate highways to toll roads in order to pay for maintenance (Virginia Department of Transportation, Office of Public Affairs [VDOT OPA], 2006).

2. *To influence travel behavior.* As early as the mid-20th century, this possibility had been noted. Zettel and Carll (1964) and Vickrey (1967) suggested that tolls can help reduce congestion during peak periods; thus tolls provide a societal benefit. Tolling can also cause a shift to other modes that may be beneficial for the public; for example, Pessaro and Songchitruksa (2014) reported that the implementation of tolls in Seattle was associated with a 14% increase in transit ridership—and this increase was larger than what had resulted from a previous improvement to transit service. Longer term behaviors—in terms of where to locate businesses and homes—may also be affected by tolls as noted by the Urban Land Institute (2013): when revenues from tolls exceed costs, those revenues may be applied to subsidize public transportation, thereby encouraging denser development within existing urban locations. Further, electronic toll collection has eliminated some delays previously associated with tollbooths (Washington State Transportation Commission, 2006).

Privately built toll facilities are not new. Although terms such as *congestion pricing* and *P3* have become more common than they were two decades ago, a review of how roads have been funded since the colonial period suggested the use of tolling has been cyclical. To the extent that history repeats itself (Crabtree, 1993), the conditions that have encouraged (or discouraged) the use of toll facilities can be identified and used to determine situations when future toll facilities might be more feasible than at present. In this regard, this research had two objectives: (1) to provide a history of toll roads in the United States, and (2) to identify lessons learned that can indicate when future tolled facilities rather than non-tolled facilities might tend to be implemented. Although a review of the national literature was germane, a Virginia-specific focus provided more than 400 years of examples that helped identify lessons that might be extended to other contexts.

A History of Toll Roads in the United States

The research identified five periods associated with U.S. toll roads: Colonial/Early Federal Period (1607-1775), Turnpike Era (circa 1792-1845), Anti-Toll Sentiment Era (1879-1939), Post-World War II Era (1939-1963), and Renewed Interest in Tolling Period (circa 1976-present).

Colonial/Early Federal Period (1607-1775)

Until the end of the 18th century—and in Virginia, until the 1932 Byrd Road Act (O'Leary, 1998)—roads in the North American colonies were built and maintained mainly by towns and counties, a precedent set by the English (Pennsylvania's Historical Marker Program [PHMP], 2011). Although the British Parliament established the first organized postal system in the United States in 1711, the construction of post roads, such as the long distance Boston Post Road, was managed at the town and county level (Marriott, 2010).

The first highway legislation in North America was passed in Virginia in 1632; it put church parishes in charge of road construction and maintenance. Additional legislation in 1657, 1661, and 1663 transferred this responsibility to the county courts, which in turn appointed an individual to oversee highway work. All males over the age of 16, whether free or a slave, were required to work for a specific number of days per year; such individuals were known as "titheables" and were initially supervised by the vestry of the parish. (Pawlett, 1977). This concept of annually requiring road work without payment continued for more than two centuries, becoming known as a "labor tax" or "statute labor" (Wallenstein, 2004). Its use was not restricted to Virginia; for example, in 1683, maintenance of the Pennsylvania sections of the King's Highway (which ran from Charleston, South Carolina, to Boston, Massachusetts [Schools, 2012]), was achieved by requiring residents to work on the construction of roads and bridges or to pay a fee (PHMP, 2011). Although other definitions of *titheables* exist (e.g., Alcock [1999] included non-white females), both Pawlett (1977) and later case law ("Virginia reports," 1902) suggested that for road building purposes, titheables were strictly male.

Although England had permitted tolls, they were generally not accepted in the colonies (Federal Highway Administration [FHWA], 1976). Rather, during the Colonial/Early Federal Period, transportation facilities were viewed as a public good in terms of enabling defense. In 1691, the first road in the Virginia Colony was constructed by the government, connecting the frontier forts (Pawlett, 1977) located along what is today known as roughly the I-95 corridor; during this time, the colony's population increased 14-fold from 5,000 in the 1630s to 70,000 by 1700 (VDOT OPA, 2006). Marriott (2010) illustrated the importance of defense: the (roughly) 9-mile Indian portage road that linked two key waterways, i.e., Lake Erie (thereby connecting to the Great Lakes) and Lake Chautauqua (thereby eventually connecting to the Ohio and Mississippi rivers), was widened by the French military in 1749 in part to help them claim ownership of land in the Ohio Valley.

Transportation facilities were also viewed as a public good in terms of improving freight during this period. For example, following its Virginia introduction in 1612, annual tobacco exports grew to 250 tons in less than 20 years; expansion of tobacco fields meant more tobacco needed to be shipped (VDOT OPA, 2006). A 1705 revision to the law (initially titled "An act for

making, clearing, and repairing the highways, and for clearing the rivers and creeks") specifically listed tobacco as a reason for the law, established a 30 foot wide clear zone, required the removal of trees within 48 hours (if cut by a landowner adjacent to the facility), and established fines for noncompliance with these standards (Hening, 1819). For example, a fine of five shillings was levied if a titheable (e.g., a male age 16 or older) was called by a surveyor to perform maintenance but failed to do so; this fine was doubled for a landowner who did not remove a cut tree within 48 hours (Hening, 1819). Throughout the colonies, mail freight was an explicit component of the rationale for publicly funded infrastructure: Straubenmuller (1905) wrote that when the Dutch controlled New Amsterdam (e.g., prior to it becoming New York City in 1665), three post roads (leading to the Brooklyn Ferry, the Harlem River, and Albany) were established, with the Albany Post Road being officially designated by the New York legislature in 1703 as Queen Anne's Highway (Marriott, 2010).

Unlike roadways, ferries were directly funded with tolls (Federal Highway Administration Office of Highway Policy Information [FHWA OHPI], 2013). In some portions of the colonies, such as the area of Virginia that was east of the fall line (roughly the I-95 corridor between Alexandria, Richmond, and Petersburg), waterways were more important than the roadway system. Until the 1780s, hundreds of private ferries—canoes, rowboats, and flat-bottomed barges capable of carrying a wagon or cattle—navigated the rivers where feasible. For example, the Dutch post road from New Amsterdam to Albany actually used a ferry during the summer months (Straubenmuller, 1905). Although operation required a permit from the county court, private ferries were allowed to collect fixed fees as compensation for their services. Fees varied by location; the Pennsylvania ferry acts of 1683, 1690, and 1693 described the fixed rate of "two pence a head for carrying over every person, and with a horse, four pence," whereas the New Jersey ferry legislation of 1716 indicated specific toll rates only for a "single person" or for "horse and man" (Dunbar, 1915).

To be clear, although transportation was viewed as a public good, it became evident as the Colonial/Early Federal Period drew to a close that public monies were not sufficient for needed infrastructure investment. In order to help open western areas to new markets, the young American republic launched a road building campaign in the 1790s (PHMP, 2011). Needs were not limited to new construction: funds to repair existing facilities also exceeded what the public sector could provide (Klein, 1990). In his *Notes on the State of Virginia* in 1785, Thomas Jefferson pointed out that although bridges should be built "at the expense of the whole county," it was possible, in cases where counties could not pay the costs of construction, for funds to be sought from the state—in which case tolls might be pursued:

> If the stream be such as to require a bridge of regular workmanship, the county employs workmen to build it at the expense of the whole county. If it be too great for the county, application is made to the General Assembly, who authorizes individuals to build it and to take a fixed toll from all passengers, or gives sanction to such other propositions as to them appear reasonable (cited in VDOT OPA, 2006).

Turnpike Era (Circa 1792-1845)

After the Revolutionary War (1775-1783), trade and, as a consequence, highway traffic increased, leading the federal government to consider how road construction could support commerce and the

Table 1. Examples of turnpikes in Virginia during the Turnpike Era

Name	Date Built	Date Tolls Ended	Sources
Little River Turnpike	1802-1811	1892	Kelly (2013); National Active and Retired Federal Employees Association (2013)
Northwestern Turnpike	1827	Circa 1900	VDOT OPA (2006)
Valley Turnpike	1834	1918	National Park Service (2014)
Howardsville Turnpike	1846	1860s	Shepherd (1846)
Staunton-Parkersburg Turnpike	1838-1850	1890s	Staunton-Parkersburg Turnpike Alliance (2014)
Weston-Gauley Bridge Turnpike	1849	1917	Cruz (1998)

Note: The Northwestern, Staunton-Parkersburg, and Weston-Gauley Bridge turnpikes were located in the portion of Virginia that seceded from Virginia at the beginning of the U.S. Civil War; since 1863, when West Virginia was admitted to the Union, the turnpikes have been located in West Virginia.

development of cities (FHWA OHPI, 2013). However, there was limited constitutional support and precedent for funding roadways at the national level—and state governments were already in debt, partly because of their efforts to help construct major private roads (Hoyt, 1966). An alternative approach was to attract private capital through the construction of turnpikes, with Thomas Jefferson observing that "toll financing provided a means of building highway facilities for which there was a need but which were too complex and costly to be constructed by the counties alone" (cited in VDOT OPA, 2006). Documents from the Office of Road Inquiry—e.g., Crump (1895) and Stone (1894)—indicated that the word "turnpike" arose from medieval use in England: a traveler on a toll facility would first encounter a "pike" across the road, and after the traveler paid the toll, the "pike was turned," allowing the traveler to proceed.

The first toll road in what is now the United States was probably authorized by the Virginia legislature in 1772: the Howardsville Turnpike in Augusta County running south and west from Jennings Gap to Warm Springs (VDOT OPA, 2002) across the Blue Ridge Mountains. Other authorizations soon followed. In 1785, the legislature designated a committee to allow toll gates on the Georgetown Road and on several roads leading west from Alexandria on the Potomac River (Mullen & Barse, 2012). In 1792, the Lancaster Turnpike—the earliest private turnpike in the United States —was permitted by the board of commissioners in Pennsylvania and was publicly supported through the state's purchase of stock in the turnpike (Klein & Majewski, 2008). Table 1 gives examples of turnpikes in Virginia during this early period.

Originally, the U.S. turnpike laws were modeled on the English system (Hadley, 1903) such that once the construction debt had been repaid, tolls would cease and the public sector would take over the facility (Hunter, 1961). In practice, however, this change of ownership from the private to the public sector did not occur in New England and Virginia (Liebertz, 2010); the turnpikes remained private even after the debt was repaid.

FHWA (1976) pointed out that the initial turnpike companies focused on the areas of greatest demand, such as what is now U.S. Route 1 along the eastern seaboard. That said, the number of turnpike companies grew from 69 (in 1800) to almost 1,600 (by the end of 1845), with more than one-half of the turnpikes concentrated in the Middle Atlantic states of Pennsylvania and New Jersey and almost one-seventh in Ohio (Klein & Fielding, 1992). In New York, in which

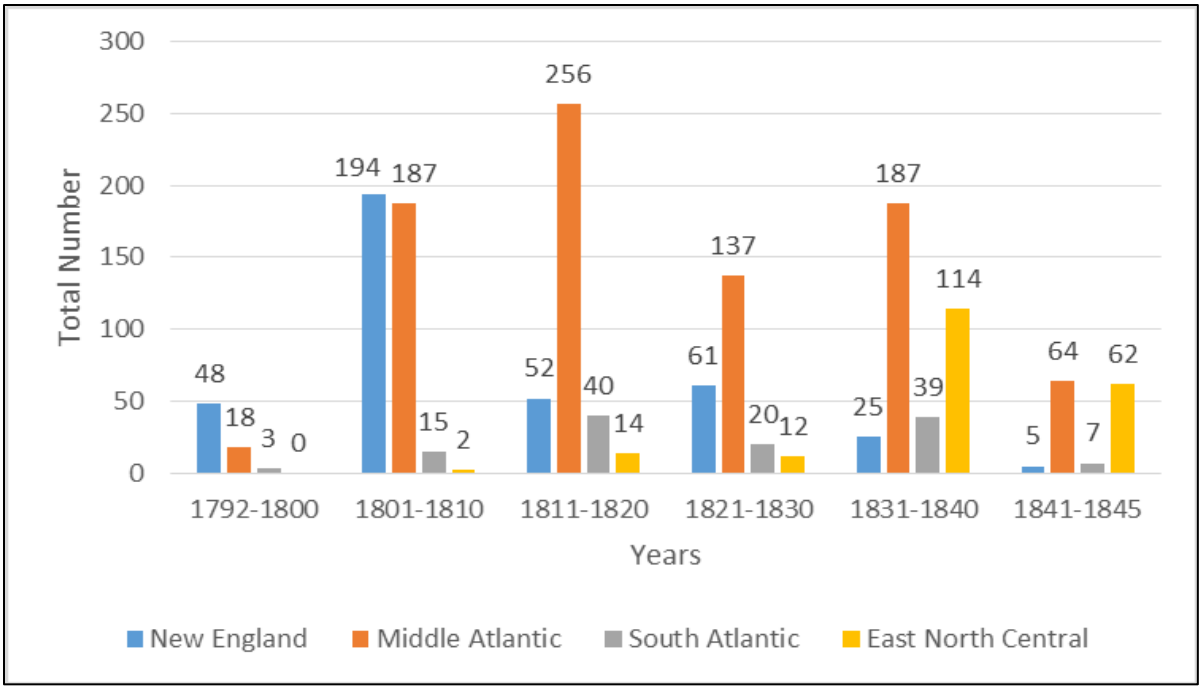

Figure 1. Turnpike corporations by region in the Turnpike Era.
Note: *New England* is defined as the five states of Connecticut, Massachusetts, New Hampshire, Rhode Island, and Vermont; *Middle Atlantic* is New Jersey, New York, and Pennsylvania; *South Atlantic* is Maryland and Virginia; and *East North Central* is Ohio. Drawn from data provided by Klein & Fielding (1992) with geographical categories based on the U.S. Census Bureau (2014).

almost 30% of the turnpikes shown in Figure 1 were located, turnpikes developed without state subsidies because many of the turnpike roads were controlled by large landowners who sometimes were more interested in selling land than in providing transportation.

Most turnpikes, except those in Pennsylvania, Virginia, and Ohio that were partially subsidized by state governments, were operated as private companies, with investors owning stock and receiving dividends. Yet "the turnpikes did not make money" (Kirkland, 1948, as cited in Klein & Majewski, 2008). This is noteworthy, given that road construction costs averaged $1,500 to $2,000 per mile (Klein & Majewski, 2008), which in today's dollars would approach $50,000 per mile (Sahr, 2014). It may be the case that a motivation for such turnpikes was the indirect benefits to farmers, land owners, and merchants resulting from the increased movement of goods. Some states were also strategic in their support of turnpikes in light of these benefits. Maryland chartered several turnpike incorporations in the 1820s to connect Baltimore with the Cumberland Road (the National Road) then being built by the federal government, with the idea that these turnpikes would make it possible to take advantage of the federal investment when the Cumberland Road reached the Ohio River (FHWA, 1976).

Liebertz (2010) stated that "turnpikes were not a technological innovation, but a legislative authorization to construct roadways and collect a toll." Turnpike corporations enjoyed a more stable revenue stream than their public counterparts—which directly affected maintenance. The private Pittsburgh Turnpike and a public alternative route, the trans-Appalachian section of the National Road (from Cumberland, Maryland, to Wheeling, West Virginia), may be considered

examples. According to the comparison by Klein and Majewski (2008), even though per-mile costs for the latter ($13,455) were triple those of the former ($4,805), the Pittsburgh Turnpike continued to be profitable and well maintained, although the National Road, which relied on unstable government revenues for maintenance, deteriorated.

The Turnpike Era drew to a close for two reasons. First, and most important, modal competition—primarily the 31,000 miles of railroad in place by 1860 following the first-ever charter for a commercial railroad (the Baltimore and Ohio Railroad in 1827)—took passenger and freight traffic. Whereas early U.S railroads in the 1830s were operated by horse power (with speeds of 8 to10 mph), by 1840, steam engines were in use (with speeds of 16 to 20 mph) (Chatburn, 1923). FHWA (1976) noted that railroads enjoyed a tremendous advantage relative to roads not only because of higher speeds but also because freight was being moved relatively cheaply. For example, the completion of the Pennsylvania Railroad to Pittsburgh in 1854 was accompanied by the bankruptcy of Pennsylvania's western wagon road (FHWA, 1976). In specific east-west markets where canals were constructed, notably western New York to the Great Lakes (because of the 1825 Erie Canal) and Philadelphia-Pittsburgh (because of Pennsylvania's 1831 "river-canal" system), canals took freight, but not necessarily passenger, traffic from the turnpikes, which also decreased earnings (FHWA, 1976). For example, the Erie Canal reduced freight travel on New York's Albany & Schenectady Turnpike, Mohawk Turnpike, and Seneca Turnpike (Baer et al., 1992), eventually ending New York's toll road expansion (Larkin, n.d.). In fact, by the 1840s, few turnpikes had generated consistent profits: most did not pay taxes, and of a sample of 37 turnpikes that were operational in Virginia at some point during the years 1816 through 1848, only 10 ever paid a dividend. Even in those instances, the average rate of return was lower than what could be expected for other types of investments, leading Hunter (1957) to note that most buyers of the stock "were aware that the return would be either slight or absent altogether."

Second, events during the U.S. Civil War (hereinafter Civil War) damaged some facilities in the South; the literature gives descriptions of damage to bridges and/or roads in Louisiana (Smith et al., 2012), Mississippi (Harrison, 2014), Tennessee (Smith, 2013), and Virginia (VDOT OPA, 2006). Hostile actions were a clear contributor, as described, for example, by Smith (2013); however, it is also likely that even if the destruction had not been deliberate, the movement of troops and heavy supplies alone would have damaged these facilities. For most turnpikes, toll revenues were insufficient to repair this damage, leading to a cessation of maintenance and travelers refusing to pay further tolls. As a result of this loss of profitability, shorter toll roads became feeder lines for railroads (Pawlett, 1977). One mechanism for this conversion was a turnpike enactment that transferred ownership to state or local government (Hoyt, 1966). As an example, some sections of the Lancaster (Pennsylvania) Turnpike (once considered to be the best road in the United States) were returned to public control around 1880, with the private entity being dissolved in 1902 (Hulbert, 1904). In other instances, turnpike corporations simply ceased operation and abandoned their facility (Williamson, 2012).

There is some question as to whether the Turnpike Era should be defined as closing in 1861. For example, in Virginia, turnpikes were legally permitted by enabling acts, i.e., legislation allowing the construction of a particular turnpike. Although turnpikes were constructed as late as

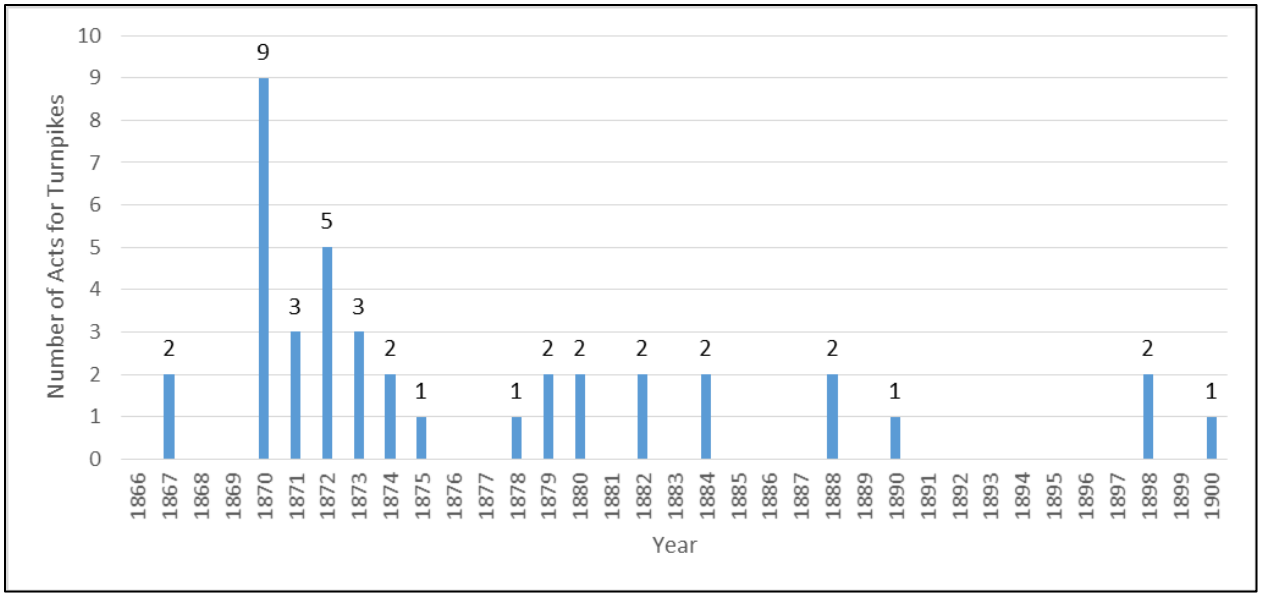

Figure 2. Number of turnpike enabling acts passed in Virginia by year after the Civil War.

Note: Figure 2 is created based on an index of Virginia turnpikes (Virginia Department of Highways, 1932) and an accompanying map (Tompkins, 1928).

Highways, 1932), most enabling acts for turnpikes occurred before the Civil War. Of the 272 such enabling acts passed from 1795 to 1900, only 40 were passed from 1867 and 1900 and none was passed from 1862 to 1866. The rate of enabling acts for such turnpikes after the Civil War (1.2 per year as shown in Figure 2) was roughly one-third of the rate (3.4 per year) before the Civil War.

Anti-Toll Sentiment Era (1879-1939)

As the Turnpike Era drew to a close, abandoned turnpikes became public feeders for railroads (Daley, 1999; Majewski et al., 1993). Since many such converted roads had no toll, they rapidly deteriorated; rutting was evident where the wheels had traveled. Plank roads—so named for roads constructed from wooden planks—were an inexpensive, appealing alternative (Norris & Ireland, 2006), although it was difficult to keep these roads in good condition. In a relatively short period known as the Plank Road Boom, more than 1,000 corporations constructed over 10,000 miles of plank roads across the United States during the 19th century, as shown in Figure 3 (Klein & Majewski, 2008). In Virginia, enabling acts suggest that 19 plank roads were constructed during the period 1850 through 1858 (Tompkins, 1928; Virginia Department of Highways, 1932). Thus it is possible that although many turnpikes had been abandoned by the late 1870s, the improvement of plank roads may have stimulated public interest in better transportation.

To be clear, poor roadway conditions contributed to the demand for better facilities. Better facilities were found in cities or in short segments connecting one town to another, but the

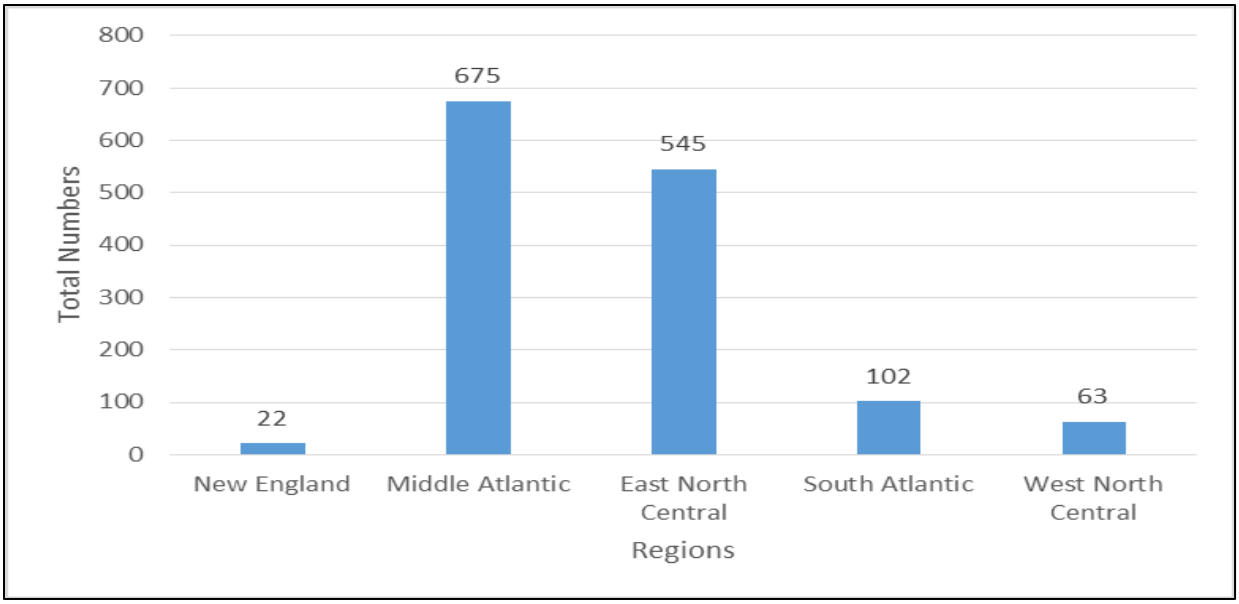

Figure 3. Plank roads by regions in the Anti-Toll Sentiment Era (circa 1844-1858).

Note: *New England* is defined as the states of Connecticut, Massachusetts, and Vermont; *Middle Atlantic* is defined as New Jersey, New York, and Pennsylvania; *East North Central* is defined as Ohio, Wisconsin, Michigan, and Illinois; *South Atlantic* is defined as North Carolina, Maryland, Georgia, and Virginia; and *West North Central* is defined as Missouri and Iowa. Drawn mostly from data provided by Klein & Fielding (1992) with additional Virginia information from Tompkins (1928), Virginia Department of Highways (1932), and Barlow (2014). Geographical classification is from the U.S. Census Bureau (2014). Years are approximate because they vary by state (e.g., Ohio data are through 1851, and Maryland data are through 1857 (Klein & Fielding, 1992); Virginia data include plank roads through 1858 (Barlow, 2014).

majority of roads in the countryside were unpaved. Even in 1904, more than 90% of the roads were unpaved or ungraded (Lee, 2012) such that most goods and people moved by railroad (Deakin, 1989). However, the invention of two additional modes—the bicycle and theautomobile—also generated demand for improvements. Rough unpaved facilities were viewed as an obstacle by users of bicycles, which were first manufactured in the United States in 1878 and which included pneumatic tires starting in 1888 (Mozer, 2014). This inexpensive mode had popular appeal: Garrison and Deakin (1992) pointed out that "bicycles were the first mode to make personal transportation widely available," which influenced public opinion. For example, in 1891, the growth of bicyclists led to the establishment of the Good Roads Association in Missouri, and similar organizations were soon established in other states to generate sentiment favorable to more and better road building (Keane & Bruder, 2003). Following the Duryea brothers 1895 creation of the first gasoline powered auto company in the United States, the Ford Motor Company produced 1,695 cars in 1904 and 14,887 in 1907—an almost 10-fold increase in just 3 years (VDOT OPA, 2006). Both modes required a harder and smoother surface, which contributed to the growth of America's road network (Klein & Majewski, 2008).

One manifestation of the demand for better facilities was the emergence of the Good Roads Movement. This movement was characterized by a series of laws, public policies, and local interest in higher quality facilities; as pointed out by Merchant (2013), it encouraged governments to "pave more roads to accommodate the newly-invented bicycle." Although the

initial good road laws were adopted by North Carolina in 1879 and Iowa in 1883, the Good Roads Movement grew rapidly in the 1890s. Examples of this growth include the circulation of *Good Roads* magazine by the League of American Wheelmen in 1892 (Quinn, 1968); the creation of federal highway departments such as the Office of Road Inquiry in 1893 and the Office of Public Roads in 1905 (FHWA OHPI, 2013); and state-specific groups such as the Virginia Good Road Association established in 1894 by the Young Business Men's League of Roanoke (VDOT OPA, 2006). These facilities offered public benefits for freight also: the U.S. Department of Agriculture had established the Office of Road Inquiry because poor roads prevented farmers from transporting their products to railroad terminals or nearby towns in a timely fashion (Williamson, 2012).

The Good Roads Movement gained momentum as freight demand grew (resulting from the U.S. involvement in World War I) and as passenger demand grew (after the war). Initially, freight volumes grew exponentially as a result of Europe's extensive purchases of U.S. supplies, with the trucking industry growing rapidly as the nation's railroads were overburdened. During the early war years of 1914 and 1915, the nation's roads deteriorated as a result of heavy truck use (Williamson, 2012). After the end of World War I, the ability to own an automobile spread to the middle class (FHWA OHPI, 2013); annual sales more than tripled from 1.6 million (in 1921) to 5.3 million (in 1929), and more than one-half of American households owned an automobile by that time (Weingroff, 2014b).

During the Anti-Toll Sentiment Era, private ownership of facilities was discouraged. The 1906 opinion of a New York county board of supervisors showed well the common sentiment for toll road companies at that time:

> The ownership and operation of this road by a private corporation is contrary to public sentiment in this county, and the cause of good roads, which has received so much attention in this state in recent years, requires that this antiquated system should be abolished. . . . That public opinion throughout the state is strongly in favor of the abolition of toll roads is indicated by the fact that since the passage of the act of 1899, which permits counties to acquire these roads, the boards of supervisors of most of the counties where such roads have existed have availed themselves of its provisions and practically abolished the toll road (cited in Klein & Majewski, 2008).

This sentiment was also evident at the federal level. The federal government barred the use of tolls on highways for which federal monies were spent to (re)construct facilities as described in the Federal-Aid Road Act of 1916 and the Federal-Aid Road Act of 1921. Even though exceptions such as toll bridges and tunnels existed, this ban on tolls remained in effect some 70 years. In that context, the Interstate System as it is known today (e.g., as authorized by the Federal-Aid Highway Act of 1956) was to be constructed as a toll-free network of transcontinental roads, which consisted of approximately 47,000 miles of the roughly 1 million miles of the federal-aid highway system (Williamson, 2012).

Up to four factors appear to explain at least some of the public opposition toward tolls during this era.

1. *Although projected revenues exceeded projected costs for some individual segments, it was not the case that all proposed toll facilities were economically viable.* Although President

Franklin Roosevelt had considered a system of tolls to finance anticipated future construction, a subsequent 1938 feasibility study of six national toll routes (three running north-south and three running east-west) (as reported by Weingroff [2013] and Mohl [2002]) concluded that "the construction of direct toll highways cannot be relied upon as a sound solution of the problem of providing adequate facilities for . . . necessary highway transportation of the United States or to solve any considerable part of this problem" (Bureau of Public Roads [BPR], 1939). This BPR study (1939) showed that of a total of 14,336 miles that comprised these national routes, by 1960 toll revenues would exceed costs for just 172 miles—about 1% of the network. Further, a review of list of the 75 segments that would comprise such a toll network (BPR, 1939) showed that the median ratio of revenue to 1960 costs would be about 41%.

2. *"Concerns about potential abuses" may have contributed to federal opposition to toll facilities* (Deakin, 1989). Given that Semmens (1987) suggested that intercity facilities (with fewer or no parallel routes) are more susceptible to excessive pricing because of a monopoly (than urban streets with multiple alternatives), such concern would seem warranted.

3. *Because automobiles could travel faster than nonmotorized transportation, the comparative delay from stopping to give a toll collector a fee may have been larger (Klein & Majewski, 2008).*

4. *It is possible that no technology (whether wooden or paved) was immune to the market forces that affected the viability of toll facilities.* The Plank Road boom in the mid-1850s ended rather suddenly because the plank roads, although faring better than gravel roads in poor weather, lasted only 5 years (Majewski et al., 1991). Their replacement after 4 years was reported ("Macadamized vs. plank roads," 1856).

The federal government actively supported road construction during this period through financing and technical assistance. As an example of the latter, the Office of Public Road Inquiries developed an inventory of all roads in the United States outside cities and used lectures, publications, and consultations to assist in road improvement (FHWA, 1976). As an example of the former, the Federal-Aid Highway Act of 1916 offered matching funds for postal routes in states that had established professionally staffed highway departments (Lee, 2012). After World War I, demand for "a nationwide interconnecting system of highways" increased (a contributing factor being the need for defense) (FHWA OHPI, 2013). Further, the Federal-Aid Road Act of 1921 provided financial assistance for states connecting metropolitan areas (Slattery et al., 1992).

That said, it would be an oversimplification to state that tolled facilities did not exist during this period. Table 2 lists six facilities that operated during the 1920s in Virginia. Further, Congress awarded 75 "franchises" for bridges; this number does not include awards made by the states (FHWA, 1976). There were other exceptions to the federal ban on toll road financing for the federal-aid highway system, notably the Pennsylvania Turnpike and Merritt Parkway. The Pennsylvania Turnpike was a modern high-speed heavy-duty interstate highway, supported by public bonds, that used an abandoned rail right of way; it was a success as soon as it opened in 1940 (Fisher et al., 2007). The Merritt Parkway, a 37-mile modern landscaped parkway that opened in 1938, connected Westchester County's Hutchinson River Parkway in New York State to

Table 2. Examples of toll facilities in Virginia during the 1920s

Name	Date Built	Date Tolls Ended	Source
Boulevard Bridge (Route 161)	1925	Tolls are still used	Hester (2010)
South Norfolk Jordan Bridge (Route 337)	1928	Tolls are still used	VDOT (2014), South Norfolk Jordan Bridge (2013)
James River Bridge	1928	1975	Kozel (2004)
Northwestern Turnpike	1831	Circa 1900	Miller (2011), Tompkins (1928)
Southwestern Turnpike	1846	1871	

Note: As of 1863, the Northwestern turnpike was located in West Virginia. The Northwestern and Southwestern turnpikes were first identified on a map (Tompkins, 1928) and then dates were confirmed from Miller (2011).

the Housatonic River (FHWA, 1976). For an extension to Hartford, the Connecticut legislature decided in 1939 to impose a toll, and thereafter the parkway was profitable for the state, earning $320,664 (with a net operating revenue of $280,000) within 6 months. Another proposed toll facility was rejected because of a legal challenge: Westchester County also tried to impose a toll on the Hutchinson River Parkway in order to overcome heavy debt, but the New York Court of Appeals forced the county to stop collecting the toll and refund what had already been collected. The court held that although built entirely with county funds, the Hutchinson River Parkway had been used as an artery of the state highway system on which the collection of tolls was prohibited (*Engineering News-Record* [ENR], 1940, as cited in FHWA, 1976).

Post-World War II Era (1939-1963)

The large construction activity for what is known today as the U.S. primary highway system—for which construction had begun in 1921—came to an end with the U.S. entry into World War II in 1941. Although the 1920s had seen the designation of a 168,902-mile network as the federal-aid system (Weingroff, 1996), funds for this system dropped in the early 1940s, supporting the (re)-construction of 12,936 miles (in 1941), 10,178 miles (in 1942), and 8,445 miles (in 1943) (Weingroff, 2014b). Reduced federal-aid funds were invested mainly to construct new roads for national defense and to mitigate traffic congestion generated by war activities.

After World War II, the public's willingness to pay for better service increased interest in advanced highway systems. Automobile travel was growing as a result of suburbanization, automobile ownership, and the use of the automobile for social and recreational trips. Although prohibitions on using federal dollars for toll facilities continued, several states—Florida, Illinois, Maine, Maryland, and New York—created independent authorities to sell bonds and construct new state-of-the-art highways (ENR, 1941, as cited in FHWA, 1976). As indicated in Table 3, the success of the Pennsylvania, Maine, New Hampshire, and New Jersey turnpikes showed that the public was willing to pay for modern and well-maintained highways.

Despite the popularity of these turnpikes, objections to federal support of tolled facilities remained, primarily because access points had to be spaced far apart to reduce the cost of toll collection. Therefore, local traffic would not benefit from these facilities. Further, if trucks were prohibited on toll facilities, states would have to provide parallel free highways. In another feasibility study requested by the 83rd Congress (1953-1954), BPR (1955) recognized that local

Table 3. Examples of successful turnpikes in the Post-World War II Era

Turnpike	Details	Date Opened
Pennsylvania	• Before WWII: $500,000 loss (1.04 million vehicles paying $1.78 million in tolls) • After WWII: net operating revenue of $5.6 million per year in 1948 and $15.1 million per year in 1953 (resulting in the extension of 100 miles east to Philadelphia and 60 miles west to the Ohio state line)	1940
Maine	Surplus on a toll of about 1.5¢ per mile in 1947 and net operating revenue of $1.3 million per year in 1953 (the 47-mile road from U.S. Route 1 between Kittery and South Portland and thereafter a northern extension to Augusta)	1947
New Hampshire	• 20¢ for a passenger car on New Hampshire's 15-mile portion of U.S. Route 1 • Net operating revenue of $0.4 million per year in 1953	1950
New Jersey	Net operating revenue of $18.2 million per year in 1953 (117-mile principal artery between the George Washington Bridge and the Delaware River)	1952

Note: Table 3 was created based on a review of material in ENR (1945, as cited in FHWA, 1976); BPR (1955); and Jacobs Engineering Group (2009).

traffic would not benefit from toll facilities and thus strongly supported the continued prohibition of using federal funds for such facilities, even though about 6,900 miles of heavily travelled roads would be feasible from BPR's feasibility study. Most of these roads—6,700 miles—were on the "National System of Interstate Highways," which had been designated, but not funded, by the Federal-Aid Highway Act of 1944 (FHWA, 1976).

Thus, the 84th Congress (1955-1957) offered no federal support for new toll road construction but instead created a highway trust fund supported by dedicated fuel taxes. For the most part, the Federal-Aid Highway Act of 1956 did not allow tolls on public highways. However, in response to demand for better systems, by 1954 toll road authorities existed in at least 15 states: Connecticut, Indiana, Illinois, Ohio, Kansas, Kentucky, Florida, Georgia, Louisiana, Massachusetts, Michigan, North Carolina, Rhode Island, Texas, and Virginia. Contrary to the corporations of the Turnpike Era, these authorities used a variety of financing mechanisms: bonds backed by the state's full faith and credit, bonds secured only by tolls, motor fuel credits, bonds backed by highway funds, and direct subsidies from state and local government (Deakin, 1989). By the end of 1954, 1,382 miles of toll roads with estimated costs of $2.3 billion were under construction by these authorities, and they were making plans or studies for 3,314 additional miles ($3.75 billion). As of January 1955, 1,239 miles of toll roads ($1.55 billion) had already been completed by these authorities. During this period, the turnpike authorities had invested three times more funding in regional highways than state highway departments had invested (FHWA, 1976). Visual inspection of the 1947 map of the Public Road Administration's National System of Interstate Highways (FHWA, 1976) shows that these routes often, but not always, followed the proposed interstate routes: routes in Maine (from Portland to the New Hampshire border) and Oklahoma (from Tulsa to Oklahoma City) are clearly evident on the map; however, the map shows the Denver route as passing north to Cheyenne rather than northwest to Boulder. Table 4 provides examples of toll roads during this era.

Although the use of federal funds was generally not allowed for toll roads, exceptions existed. The Federal-Aid Highway Act of 1956 provided for a coast-to-coast highway system, connecting important cities and industrial centers. Although the system was tax-supported, Congress authorized the use of federal funds for approach roads connecting toll roads to the free

Table 4. Select toll roads from the 1940s through the 1960s

State	Road Description	Date Built	Source
Colorado	17-mile Denver–Boulder Turnpike	1952	Danish (2011)
New York	426-mile New York Thruway (New York City–Buffalo)	1956	Eastern Roads (2014)
Oklahoma	88-mile Turner Turnpike (Oklahoma City–Tulsa)	1953	Oklahoma Historical Society (2010)
Virginia	Chesapeake Bay Bridge-Tunnel (Route 13)	1962	Morrison (2014)
	George P. Coleman Bridge (Route 17)	1952	Historic American Engineering Record (1993)
	Governor Harry W. Nice Memorial Bridge	1940	Maryland Transportation Authority (2014)
	Hampton Roads Bridge-Tunnel (I-64)	1957	Kozel (2007)
	Norfolk–Virginia Beach Expressway (Old Route 44, now I-264)	1967	VDOT (2010)
	Richmond-Petersburg Turnpike (I-95)	1953-1958	Samuel (1997)
West Virginia	2-lane toll road (Charleston–Princeton)	1954	Hohmann (1999)

portions of the Interstate System (Fisher et al., 2007). Further, the act allowed existing tolled expressways to be included in the Interstate System when the toll roads followed interstate routes, met interstate standards, and were accompanied by parallel free roads. However, this permit was conditioned on the state's agreement to convert the toll section to a free section after bonds had been repaid (Kirk, 2013). By 1957, the Interstate System included more than 2,000 miles of toll roads (Kirk, 2013), but by 1963, when the last toll roads already planned prior to the establishment of the federal-aid system were completed, few new tolled facilities were being considered (Fisher et al., 2007).

During this period—and consistent with the Anti-Toll Sentiment Era—the public policy generally favored toll bridges to a greater extent than toll roads. As an illustration, the Virginia State Highway Commission established a 20-year plan for upgrading all road systems and sought to replace most of the state's remaining ferries. For example, during Fiscal Year 1946 and Fiscal Year 1947, the commission decided to construct toll bridges to replace ferry crossings on the York River at Yorktown and the Rappahannock River at Grey's Point and to acquire from private owners the ferries that carried vehicles across Hampton Roads between the Norfolk and Lower Peninsula area. By separate legislation, the Virginia General Assembly created a special authority to replace the Chesapeake Bay ferries with a 17.6-mile toll bridge-tunnel facility (VDOT OPA, 2006). An example from Pennsylvania shows a favorable state government view of toll bridges. In 1943, Pennsylvania decided to purchase the privately owned intrastate toll bridges in the state and had authorized the issuance of $10 million in bonds for that purpose (Pennsylvania State Archives, 2014).

Renewed Interest in Tolling Period (circa 1976–Present)

Although restrictions regarding the assessment of tolls on federally funded projects remain, five key changes in the political, economic, and land use environment since the late 1970s have led to renewed interest in tolling and changes to Virginia and federal policy.

1. *Budgetary pressures increased.* The roads built during the 1960s—the peak construction years of the Interstate System—were approaching the end of their design life (Gomez-Ibanez et al., 1991). The funding gap was exacerbated by a sharp increase in highway construction costs coupled with a reduction in fuel tax receipts because of increased vehicle fuel efficiency (Deakin, 1989).

2. *Opposition to taxes made it preferable to defer construction—even if this meant forgoing new construction projects because of increased maintenance needs*. As an example, excluding its urban system, Virginia maintains the nation's third-largest highway system, with approximately 58,371 centerline miles of interstate, primary, and secondary roads as of 2012 (Virginia Department of Transportation [VDOT], 2012). Prior to the passage of new state transportation funding legislation in 2013, Chase (2011) reported that only 19% of Virginia's future transportation dollars would be available for future construction in Virginia; the remainder would be needed to maintain the existing system. In fact, the state showed greater interest in devolving certain state maintenance responsibilities for secondary roads to counties (Chase, 2011).

3. *Urban congestion (affecting commuter and daily trips) became a greater concern than congestion in rural areas (affecting longer distance trips).* According to surveys from several toll states, these states preferred tolls over other possible options for facility rehabilitation and upgrading (Wuestefeld, 1988, as cited in Deakin, 1989). Even states without toll roads, such as Arizona and Wisconsin, tried to assess the possibility of building new toll roads or converting interstate highways to toll roads in order to pay for maintenance (Congressional Budget Office, 1985). Although there was still public opposition to tolls, by the mid-1980s, the American Association of State Highway and Transportation Officials had decided to support states' use of tolls on new roads and existing roads without loss of federal aid (Deakin, 1989). Unlike the interest in turnpikes after World War II, in the 1980s the interest in the construction of toll roads was mainly concentrated in new rights of way in urban and suburban areas (see Table 5). Virginia's growth exemplified this need for metropolitan infrastructure: by the 1970s, more than two-thirds of the state's 4.6 million people were in and around cities (VDOT OPA, 2006). According to Deakin (1989), fast-developing suburban areas needed more roads because existing roads were heavily congested; however, public funding for new roads was not sufficient to support these demands immediately (Deakin, 1989).

4. *Starting in the 1980s, tolls appeared to be a reasonable way to manage—rather than add to—highway congestion.* In the 1960s, Zettel and Carll (1964) and Vickrey (1967) had suggested that tolls during peak hours could reduce demand; the commensurate decrease in travel costs (in terms of delay) would increase societal welfare. The idea of congestion pricing was related to the feasibility of electronic toll collection: because vehicles no longer needed to stop at a tollbooth, tolls became a way of reducing—not increasing—congestion (Washington State Transportation Commission, 2006). Many motorists with Smart Tag or E-ZPass transponders could travel throughout eastern states such as Maryland, New Jersey, New York, Pennsylvania, and Virginia without having to stop to pay tolls (Crabtree et al., 2008). However, tolls did not always influence behavior in the manner expected. For example, Burris et al. (2004) showed that in one location, variable tolls had a lesser impact on individuals' time of departure than other literature had shown. That said, a review of Parsons Brinckerhoff et al. (2009b)

indicated that tolls have been considered as a mechanism that could possibly influence a variety of behaviors such as shifting the hour of the commute trip, choosing transit or carpooling, or changing the location and type of land development.

Table 5. Examples of urban and suburban toll roads in the 1970s and 1980s

State (City)	Road Description	Opening Year	Source
Illinois (Chicago)	17-mile North-South Tollway	1990	Enstad (1990)
Texas (Houston)	22-mile Hardy Toll Road	1987	Schott (2009)
	88-mile Sam Houston Tollway	1990	
Virginia (Richmond)	The Downtown Expressway VA-195	1976	Joint Legislative Audit and Review Commission (2000), Bruno (2011)
	The Powhite Parkway Extension VA-76	1988	
Virginia (near Washington, DC)[a]	12-mile Dulles Toll Road	1984	Metropolitan Washington Airports Authority (MWAA) (2014a)
	17-mile extension (the Dulles Greenway)	1995	Michael Baker Jr., Inc. and ATCS, P.L.C. (2009)

[a] Route 267 (VDOT, 2003) is composed of two different toll facilities: an eastern segment (the Dulles Toll Road that opened in 1984) and a western segment (the Dulles Greenway that opened in 1995) (Michael Baker Jr., Inc. and ATCS, P.L.C., 2009). These are parallel to the Dulles International Airport Access Road that serves airport traffic only; it opened in 1962 and was extended to I-66 in 1983 (MWAA, 2014b).

5. *Toll roads could be constructed in a shorter period of time than roads that received federal aid, as some federal planning and environmental review standards would not apply.* Sandlin (1989) notes that for projects not using federal funds, some environmental standards—and the "elaborate planning and approval process" of USDOT are not applicable; in fact, an FHWA official quoted therein compared building a road without federal funds to building a shopping center. As a consequence, toll projects in Illinois, Texas, and Colorado were shifted from federal-aid funding to toll funding because the latter has fewer environmental requirements (Deakin, 1989). Further, Schneider (1985) indicated that toll roads had better pavement quality (e.g., an average of 17% better than that of non-tolled interstate segments), which reduced costs for highway uses by about 5%. Munroe et al. (2006) noted that toll roads had improved fuel efficiency and lower travel time and crash rates compared to non-tolled facilities.

Several states approved toll facilities in this period, with the private sector taking additional financial risk. For example, in 1992, the Toll Road Corporation of Virginia built a 15-mile private toll road between Dulles Airport and Leesburg, Virginia, which extended the state-owned Dulles Toll Road between the airport and Washington, DC, built in 1984 (Miller, 2000). Legislation, such as the Virginia Highway Corporation Act of 1988 and the Public-Private Transportation Act of 1995, enabled private entities to assume longer term risk and potential profit from highway construction activities (Farley & Norboge, 2014). In 1989, the California legislature approved private financing and construction of as many as four general transportation facilities during the 1990s. These new facilities provided connections between existing highways (e.g., a new San Francisco Bay bridge and an existing 30-mile Los Angeles freeway). During this period, Colorado, Illinois, and Missouri started to allow the construction of private toll roads. For example, the Front Range Toll Road Company in Colorado proposed building and operating a 210-mile toll highway between Pueblo and Fort Collins (Gomez-Ibanez et al., 1991).

Table 6. Tolling programs made available to states by SAFETEA-LU

Program	Description
New Interstate System Construction Toll Pilot Program	• Applies to interstate highways, bridges, or tunnels for the purpose of constructing interstate highway • Limited to 3 projects in total; prohibits a participating state from entering into an agreement with a private person that would prevent the state from improving adjacent public roads to accommodate diverted traffic
Interstate System Reconstruction and Rehabilitation Toll Pilot Program	• Established in the Transportation Equity Act for the 21st Century (TEA-21) in 1998 • Allows up to 3 interstate tolling projects for the purpose of reconstructing or rehabilitating interstate highway corridors that could not be adequately maintained or improved without the collection of tolls
Value Pricing Pilot Program	• Authorized under the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) • Supports the costs of implementing up to 15 variable pricing pilot programs nationwide to manage congestion and benefit air quality, energy use, and efficiency
New Express Lanes Demonstration Program	• Allows a total of 15 demonstration projects to permit tolling to manage high levels of congestion, reduce emissions in a nonattainment or maintenance area, or finance added interstate lanes for the purpose of reducing congestion • Eligible toll facilities include existing toll facilities, existing high-occupancy vehicle (HOV) facilities, and a newly created toll lane • Variable pricing according to time of day or level of traffic for HOV facilities • Automatic toll collection required

Note: Table 6 was created based on a review of material in Office of Legislation and Intergovernmental Affairs (2005).

Compared to previous federal surface transportation reauthorizations, the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) permitted tolling to a much greater degree on federal-aid facilities, allowing new toll road construction (except on interstates); conversion (if rebuilt) of bridges and tunnels to tolled facilities including interstates (FHWA, 1992; Weiner, 1992); and, notably, a congestion pricing pilot program allowing up to three toll projects on the Interstate System (U.S. Department of Transportation, 1991). The Safe, Accountable, Flexible, Efficient, Transportation Equity Act: A Legacy for Users (SAFETEA-LU), signed into law in 2005, afforded states more flexibility in adopting tolling to control congestion and fund road infrastructure improvements, as shown in Table 6 (Williamson, 2012).

In 2012, President Barack Obama signed the Moving Ahead for Progress in the 21st Century Act (MAP-21). MAP-2 1 relaxed the general tolling prohibition on interstate highways (Kirk, 2013; Ungemah, 2012) and incorporated more flexibility for tolling:

> Tolling of newly constructed lanes added to existing toll-free Interstate highways is now permitted . . . so long as the facility has the same number of toll-free lanes after construction as it did before (excluding HOV lanes and auxiliary lanes). (This authority was previously available under the Express Lanes Demonstration Program). Tolling for initial construction of highways, bridges, and tunnels on the Interstate System is now permitted. . . . Prior to MAP-21, such authority was limited to non-Interstate facilities. . . . This change effectively mainstreams the Interstate System Construction Toll Pilot Program (FHWA, 2012).

Lessons Learned from the History of Toll Roads in the United States

Figure 4 describes the timeline for U.S. toll road development for the five historical periods classified in this study. This chronology and the descriptions of each period suggest (1) how toll facilities are likely to be considered in the future; (2) conditions conducive to the use of toll

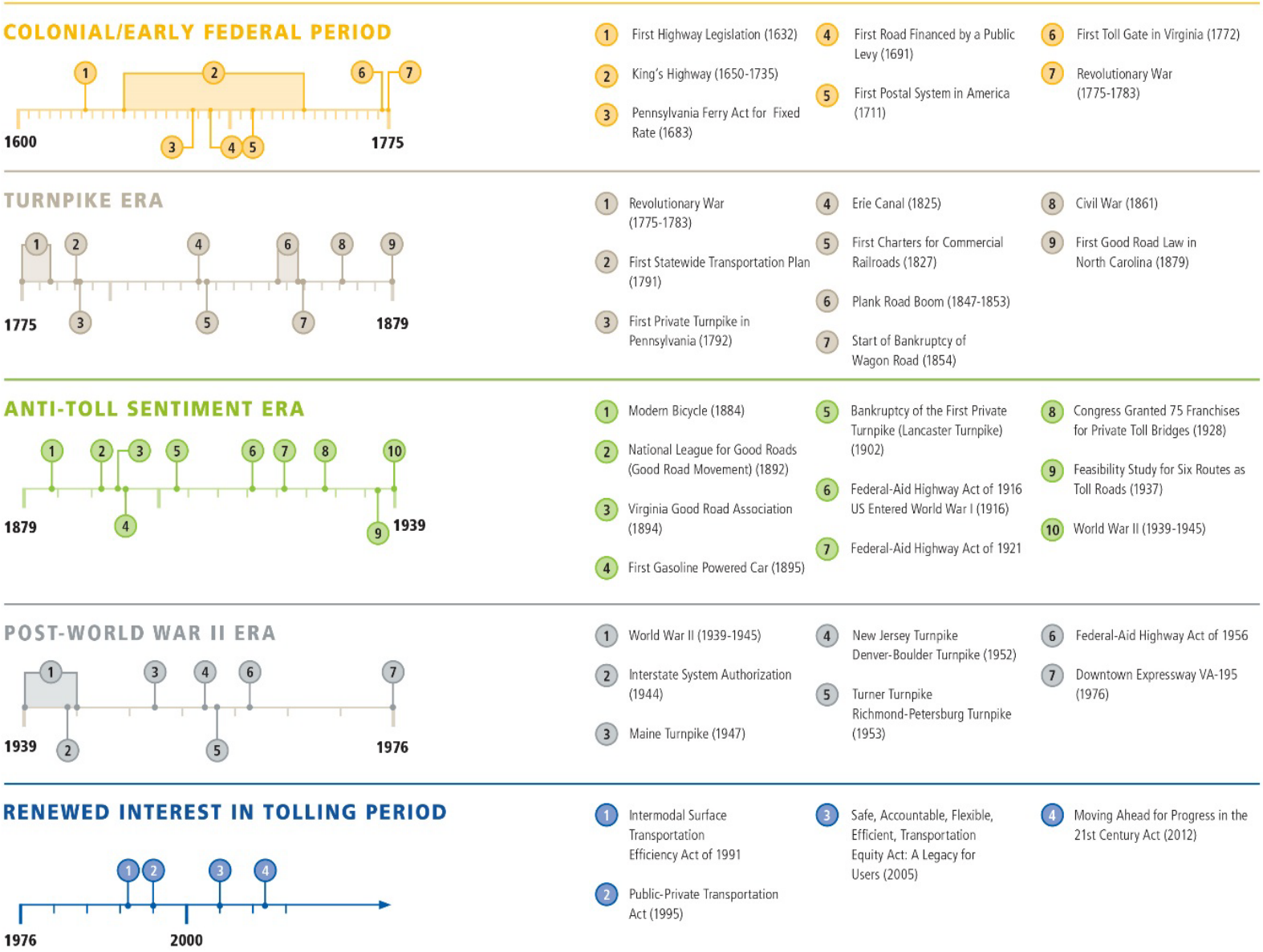

Figure 4. Timeline for U.S. toll road development.

facilities vs. conditions conducive to the use of non-tolled facilities; (3) factors that may determine the viability of a given toll facility; and (4) how the lessons learned may be applied to determine feasibility in new situations.

How Toll Facilities Are Likely to Be Considered in the Future

The history of how tolls have been used offers lessons for the present and the future—four are noted here. Although none of these lessons may surprise observers of modern facilities, it is of interest to note that these lessons have applied in the past.

1. *Instances can be identified from the distant past—i.e., more than 70 years ago—where the quality of the user experience was better on tolled facilities (than on non-tolled facilities) and vice versa.* As an example of the latter, privately owned turnpikes decreased in the mid-19th century, attributable in part to damage from the Civil War but also from modal competition, i.e., the railroads. As tolled facilities fell into disrepair, the user experience suffered such that the system of paved roads suitable for pneumatic tires that emerged in the early 20th century was clearly superior to the roads of the turnpike era. As an example of the former, although the concept of a limited access facility today is well understood, when the Pennsylvania Turnpike was introduced in the 1940s, its design concepts—medians, 12-foot lane widths, acceleration ramps for entry, and interchanges rather than at-grade intersections (Pennsylvania Turnpike Commission, 2015)—could be considered innovative at the time. In fact, Weingroff (2014a) provided a quotation from an engineer who at that time contrasted the design of existing facilities where design standards (e.g., curvature, lane width, and so forth) could "fluctuate every few miles" with the more uniform design of the Pennsylvania Turnpike. In general (not just for the Pennsylvania Turnpike), Rose (1979) noted that in 1939 (when the Turnpike's design would have been underway), "few states" permitted designers to prohibit immediate access points for a roadway.

2. *Consideration of societal impacts has influenced popular perception of both non-tolled and tolled facilities.* As an example of the former, the Good Roads Movement reflected an interest in accommodating users of new types of vehicles with pneumatic tires (an increasingly large class of users) and the economic benefits of improved trade contributed to the development of an early federal policy of financing facilities that would eventually comprise the U.S. system of highways. As an example of the latter, in the Turnpike Era, turnpikes provided better road facilities to nearby merchants, farmers, land owners, and ordinary residents; as a consequence, this facilitated more movements and trade among these users, as noted by Klein and Majewski (2008). Majewski (2000) quoted Thomas Gordon, an individual from the Turnpike Era in 1832: "None have yielded profitable returns to the stockholders, but everyone feels that he has been repaid for his expenditures in the improved value of his lands, and the economy of business." As another example of a considered societal impact, i.e., congestion reduction, it appears that peak period pricing was a consideration for tolls during the Renewed Interest in Tolling Period. In short, externalities (e.g., positive or negative impacts that are not reflected in the price [Meyer & Miller, 2013]) matter, but their degree of influence has varied over time.

3. *In the past there has been a trade-off between construction cost and service life.* The advantages of plank roads —good quality and low construction costs as feeder roads—brought a boom period (when more than 1,000 such roads were built), but this period appears to have been short lived when compared to the duration of each of the five historical periods noted herein. In fact, the aforementioned pre–Civil War article ("Macadamized vs. Plank Roads," 1856) advised farmers to use macadamized roads, noting that the cost of repairs for plank roads was 30% of their construction cost on an annual basis. For longer service life, therefore, the use of wood for these feeder roads was to be avoided. More than a century later (although the topic was not plank roads), the Council on Virginia's Future (2014), in its discussion of transportation performance, acknowledged the choice between reducing initial outlays and reducing design life. Using the example of a bridge, the council stated that "there is a trade-off between cost and longevity" as a larger initial construction cost may result in a bridge that lasts longer.

4. *Coordination between public and private entities can increase the societal benefits of both tolled and non-tolled facilities, and the form of this coordination can vary.* This coordination can certainly refer to establishing an acceptable user fee. Toll roads were first introduced because state governments sought to satisfy demands for additional road construction without using public funds—and even then, public protections existed. As noted by FHWA (1976), the operating agreements typically called for tolls to be reduced if profits rose above roughly 15% annually. This coordination can also refer to route planning: the Federal-Aid Highway Act of 1921 encouraging states to connect metropolitan areas (Slattery et al., 1992) was a form of intergovernmental coordination. This coordination can also refer to condition monitoring. Many private turnpikes, such as those that competed with the Erie Canal or railroads, went into bankruptcy, resulting from a cycle of decreased revenues, lack of funds for maintenance, and thus poor service. This suggests that private facilities are not a panacea but rather can benefit from some type of monitoring to ensure that an appropriate level of service is rendered. That is, well-defined roles of public and private entities can increase the success of tolling, such as the public sector establishing performance criteria to achieve a specific objective for a privately operated facility (FHWA, 2013). Examples of criteria might be billing-related customer service, incident response times, and minimum speeds; these could support objectives such as maximizing bus occupancy, auto occupancy, number of alternative-fueled vehicles using the facility, reduced emissions, and so forth (as noted, for example, by Parsons Brinckerhoff et al. [2009a]). It is not surprising that the agreements between public and private entities for the construction of these toll facilities can be quite detailed.

Conditions Conducive to the Use of Toll Facilities vs. Conditions Conducive to the Use of Non-Tolled Facilities

Conditions conductive to the use of toll facilities appear to be the following:

1. the availability of a more reliable funding stream than a more general tax base;

2. technology that could collect fees from users without additional negative impacts such as stopping;

3. an ability to exploit new design approaches compared to existing designs; and

4. an ability to extract fees from a specific market segment.

As an example of Conditions 1 and 4, the high population density of a New York City suburb (Westchester County)—and the employment opportunities in New York City—probably contributed to the feasibility of offering a premium transportation service for a cost between these two points. As an example of Condition 2, literature in the history of electronic toll collection showed that relative to having only manual collection points, the use of new technology could reduce delays by half—even if only 10% of users participated in an electronic collection approach (Al-Deek et al., 2000). Further, during the same year that ISTEA (which permitted tolls to a greater degree than previous authorizations) was passed, the description of Colorado's E-470 toll road suggested that electronic toll collection would not only minimize delays, it would also help manage incidents (Willett, 1991). As an example of Condition 3, the Pennsylvania Turnpike, designed in the late 1930s, used limited access points, wider lanes, smoother grades, and as noted by Weingroff (2014a), consistency in these elements of design such that the motorist was not surprised every few miles by changes in roadway geometry. Compared to other facilities in existence then, the turnpike's creative design—creative in the sense that geometry was uniform for a long segment rather than varying every few miles as was the case with other facilities at the time—allowed motorists to travel at higher speeds.

If these four conditions indicate conditions conducive to the use of toll facilities, their opposite can suggest conditions conducive to a non-tolled facility. Such conditions appear to be the following:

1. the relative reliability of tax revenues versus revenues from a tolled facility;

2. technology that could collect taxes without adverse consequences for users;

3. a need to accommodate an entire class of users who benefit from consistent design standards; and

4. a recognition of the external benefits of roadways accruing to more than the roadway users.

These conditions extend to both passenger and freight movements; for example, difficulties with road deterioration attributable to heavy truck use during World War I contributed to the system of U.S. highways in the 1920s. As an example of Condition 1, the steady federal investment in postal routes (Lee, 2012) and routes connecting metropolitan areas (Slattery et al., 1992) provided a dependable financial resource for the early 20th century U.S. system of highways. As an example of Condition 2, technology existed during the mid-20th century to collect taxes from users—notably through the fuels tax levied at the pump—without adverse consequences for operations. As an example of Condition 3, the popularity of the Good Roads Movement (Keane & Bruder, 2003) was driven at least in part by recognizing that paved smooth facilities could benefit an entire class of users—notably bicyclists. As an example of Condition 4, whereas a specific market niche—Westchester County residents traveling to work—helped make the Merritt

Table 7. Conditions conducive to the use of toll roads vs. conditions conducive to the use of non-tolled roads

Condition No.	Condition	Conducive to Toll Roads	Conducive to Non-Tolled Roads
1	Reliable funding from users vs. taxes	Reliable funding from users allows for routine maintenance to keep the road in good condition (e.g., Pittsburgh Turnpike).	The revenue from taxes allows routine maintenance to keep the road in good condition (e.g., Federal-Aid Highway Act of 1956).
2	Existing technology for collecting tolls vs. taxes	Technology exists to collect tolls from users without adverse consequences for operations (e.g., transponders).	Technology exists to collect taxes from users without adverse consequences for operations (e.g., fuels tax collection at the pump).
3	Design exceptions vs. design standards	An innovative design makes the road more attractive (e.g., allows faster travel).	Consistency of design standards strengthens network effects (e.g., smoother pavements are amenable to bicyclists and automobiles).
4	Market segment vs. societal impact	There are premium users defined by location or time who will pay market rates to use the toll facility.	The societal impact (e.g., benefits flowing to others, including those who do not use the facility) is perceived to be greater than the revenue generated by the market (e.g., the transport of goods).

Note: Table 7 does not show two factors that negatively affect any type of facility: competition from new modes of transportation and the failure of new technology.

Parkway possible, the opposite of such a concentrated niche—notably dispersed farmers who needed to get their goods to market—helped encourage the Office of Road Inquiry to support better transportation facilities generally (rather than solely in a single location). That is, the societal benefit was perceived as large and did not rely on a geographically concentrated group. Another example of Condition 4 was the use of public support for designated postal routes at two instances almost 200 years apart—earlier during the Colonial/Early Federal Period (e.g., the Albany Post Road in 1703) and later during the Anti-Toll Sentiment Era (e.g., the Federal-Aid Highway Act of 1916); in both cases, the broad societal benefits made public facilities appealing.

Table 7 contrasts the conditions that are conducive to the use of toll facilities and those that are conducive to the use of non-tolled facilities.

Factors That May Determine the Viability of a Given Toll Facility

Table 7 suggests that over the long term, determination of whether a given toll facility will be viable may depend on four factors that extend well beyond the scope of the facility:

1. the relative stability of revenue streams from user fees (compared to the stability of revenues from a general tax);

2. the available technologies for collecting tolls (and how this technology affects the user's experience);

3. the role of design innovations for the tolled or non-tolled facilities; and

4. consideration of the societal impact of the tolled versus non-tolled facilities.

Although these four factors are presented as discrete items, they can be related. For example, in the early 1950s, turnpikes—although popular—were not a model for the federal-aid system because the cost of manual toll collection (Factor 2) meant that access points had to be spaced far apart—a design that could not meet the demands of local travel for all patrons (Factor 4).

Application of Lessons Learned to Determine Feasibility in New Situations

The five-period history of toll roads in the United States revealed conditions that can help in the assessment of the feasibility of a tolled facility. Although there is no guarantee that the future will replicate the past, consideration of these conditions may help determine feasibility in new situations. For example, in determining whether a toll road in a particular location is likely to be successful, the reliability of user tolls vs. the reliability of revenues (from taxes) is one condition that can influence this success. Reliability can be generalized beyond revenue to other aspects of construction, such as the duration of the environmental review process, time required to garner public acceptance, and amount of review required for alternative designs. That is, as noted by Sandlin (1989), toll roads can be constructed in a shorter period of time than non-tolled roads because of the additional flexibility of the review process when certain federal requirements do not apply. Thus, whether tolled facilities receive more, less, or the same scrutiny as non-tolled facilities may affect a project's financial viability, as is the case with reliability of revenue.

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