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Congestion Pricing for Indian Cities: Challenges and Prospects Based on International Experiences



Kuldeep Kavta  and Arkopal K. Goswami 

Abstract Congestion pricing has demonstrated significant effectiveness in managing traffic congestion in cities around the world. While numerous cities globally have implemented or explored various congestion pricing schemes, their potential remains largely untapped in Indian cities. This paper investigates the feasibility of congestion pricing as a tool to address traffic issues in India, focusing specifically on the city of Ahmedabad. By analyzing both successful and unsuccessful international cases, the study extracts critical lessons that can inform potential implementations in the Indian context. Through a theoretical assessment, this study identifies three distinct spatial characteristics in Indian urban environments that could facilitate effective congestion pricing: (1) well-defined charging zones, (2) advantageous geographical features, and (3) compact, densely built central business districts. These features, prevalent in Indian cities, could play a vital role in achieving successful outcomes similar to those observed internationally. In addition to spatial considerations, the paper addresses the unique challenges Indian policymakers may encounter, such as garnering public support, ensuring political feasibility, and developing the necessary technical infrastructure. To assist policymakers in overcoming these challenges, the study provides practical recommendations rooted in international best practices. Overall, the research extends the discussions on congestion pricing in the Indian context, resulting in the identification of valuable insights to guide decision-making for the implementation of congestion pricing schemes, ultimately promoting sustainable urban mobility and addressing traffic congestion issues in Indian cities.

Keywords Congestion pricing · Road pricing · Congestion charge · Travel demand management · Congestion tolls · Transport policy

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1 Introduction

Urban traffic congestion is a pressing challenge that significantly impacts the environment, safety, economy, and overall living standards in cities. To tackle this issue, congestion pricing has emerged as an effective tool for reducing and redistributing traffic, and it has gained widespread acceptance among transport planners, economists, and policymakers. The theoretical foundations of congestion pricing were laid by economist Arthur Pigou in the 1920s and later refined by Nobel Laureate William Vickrey in the 1950s and 60s, making it a well-regarded approach in economics [1, 2]. While congestion pricing has been discussed for a long time, it was only in the recent decade that it saw real-life applications in cities like Singapore, London, Stockholm, and others, as they implemented this radical measure to address traffic problems. Different forms of congestion pricing, such as facility-based pricing [3], cordon-based pricing [4], and distance-based pricing [5], were implemented in developed countries. As traffic-related challenges continue to grow in many cities in developing countries like India, there is a rising demand and need for congestion pricing. However, the potential of congestion pricing in these regions remains largely untapped and unexplored. While the challenges faced by developing countries differ from those in developed countries, there are valuable lessons to be learned from global experiences with congestion pricing that can be adapted to the Indian context. The paper aims to derive these lessons from successful and unsuccessful cases of congestion pricing worldwide and apply them to the Indian setting. There is already a considerable body of literature exploring congestion pricing and its impacts from various perspectives; however, the aspect of spatial dimension could play a role [6]. The paper seeks to add a spatial dimension to the discussion by identifying the key geographical and built environment features that can either facilitate or hinder the effectiveness of congestion pricing schemes.

The paper is organized into eight sections, starting with the introduction, followed by a detailed background on India's urbanization and transportation challenges to provide context for international readers. The Sect. 3 explores existing successful and unsuccessful cases of congestion pricing, accompanied by a summary of the lessons derived from each case. The Sect. 4 delves into the specific case city of Ahmedabad in India, providing details on its traffic and transportation systems, built environment, and geography. In the Sect. 5, the focus shifts to identifying key features of Indian cities and comparing them with international congestion pricing schemes. The Sect. 6 delves into potential challenges that policymakers could face when introducing congestion pricing in Indian cities. Finally, the paper concludes with a summary of its findings and implications. *Overall, this research aims to contribute valuable insights into the spatial considerations of congestion pricing and its applicability in the Indian urban context, thereby aiding policymakers and researchers in finding effective solutions for addressing traffic congestion issues.*

2 Urbanization and Transportation Issues in India

India is currently experiencing rapid urbanization, leading to the expansion of cities to accommodate the growing population. The allure of job opportunities and improved quality of life in urban areas has triggered significant migration from rural regions. Projections indicate that between 2014 and 2050, India's urban areas will witness an addition of 404 million people, making the urban population 50% of the country's total [7]. Urbanization is particularly concentrated in metropolitan cities (with a population of over one million) and megacities (with a population of over ten million). From 2001 to 2011, the number of metropolitan cities increased from 35 to 50, according to the 2011 census [8], and it is expected that four new megacities will emerge in the upcoming years [7]. This concentrated population growth is exerting tremendous pressure on city administrations to expand existing infrastructure and service capabilities. One of the sectors significantly affected is transportation, which serves as the backbone of city life.

Data from previous decades indicates that per-capita annual travel demand quadruples every two decades. For instance, between 1980 and 2001, annual per-capita mobility increased from 862 to 3021 km [9]. The increased mobility demand is a reflection of economic growth; however, the challenge lies in the fact that this growth is not being met by sustainable transportation modes. Rising income levels and lack of public transportation options have led to a surge in private vehicle ownership [10]. Over the last two decades, the number of registered private two-wheelers and cars has increased at Compound Annual Growth Rates (CAGRs) of 10.38% and 9.64%, respectively, whereas the number of registered buses only grew at a CAGR of 3.2% [11]. This personalized mobility has resulted in severe traffic congestion in cities, posing threats to the environment, economy, and overall well-being of citizens. It is estimated that the economic loss due to delay and additional fuel consumption amounts to 6.6 and 14.7 billion US dollars, respectively [12]. Additionally, emissions from the transportation sector contribute to 7% to 43% of total pollution in six major Indian cities [13]. Consequently, it is crucial to explore solutions that promote the use of sustainable transportation modes and discourage the use of private vehicles.

In the last two decades, significant efforts have been made to improve public transportation systems, including the introduction of systems like the Bus Rapid Transit System (BRTS) in cities like Ahmedabad, Pune, Indore, Surat, Bhubaneswar, etc., and rail-based systems like the Metro rail in Delhi, Mumbai, Hyderabad, Bangalore, etc. Despite substantial investments in these large-scale projects, the actual objective of reducing traffic congestion remains unfulfilled. For example, according to the latest report on the performance of the Delhi Metro till phase 3, the actual ridership of the Delhi Metro is only about 51.97% of the projected ridership [14]. Previous research suggests the use of coercive demand management measures, alongside improvements in public transport, to achieve the desired results [15–17]. One of the widely advocated coercive demand management measures is congestion pricing,

which is seen as a potential solution to address traffic congestion. Although congestion pricing schemes have been studied in other parts of the world [18], they remain mostly unexplored in the Indian context.

3 Lessons from International Successful and Unsuccessful Cases

The implementation of congestion pricing schemes has been relatively limited worldwide, with only a few cities successfully adopting them. However, many cities have made attempts to introduce such schemes, providing valuable experiences that can offer insights and lessons for Indian cities, where congestion pricing has not been implemented yet. This paper examines international case studies of congestion pricing, categorizing them into successful and unsuccessful cases. The successful cases include Singapore, London, and Stockholm, where congestion pricing schemes have been effectively implemented and are currently operational. On the other hand, the unsuccessful cases encompass Edinburgh and New York, where congestion pricing initiatives either faced rejection during the planning stage or were discontinued after initial trials.

3.1 *Singapore Electronic Road Pricing*

The island nation of Singapore implemented several demand management measures during the 1970s [19] to reduce the number of vehicles and their usage. One such measure was the “Area Licensing Scheme (ALS),” introduced in 1975 in the Central Business District (CBD) to restrict vehicle entry from 7:30 am to 6:30 pm on workdays. Drivers had to purchase a license for USD 1 per day or USD 20 per month to enter the CBD [20]. This led to a 50% reduction in traffic volume, and the average speed in the zone doubled to 36 km per hour [19]. However, due to manual monitoring difficulties, the ALS was later replaced with the advanced “Electronic Road Pricing (ERP)” in 1998. The ERP expanded the geographical area by including expressways and arterial roads, requiring vehicles to have an In-vehicle Unit (IU) with sensors to communicate with gantries on roads through a short-range communication system. The congestion charges could vary between USD 0 to USD 3 per passage every 5 min, depending on the congestion level, aiming to maintain the 85th percentile speed on the roads [21]. This technology achieved remarkable success, resulting in an additional 10–15% reduction in traffic despite lower charges compared to the ALS scheme [22]. The change from a daily to a per-trip charge affected multiple trips made by a single vehicle [23]. The average speeds increased from 30–35 KmPH to 40–45 KmPH, public transit ridership rose by 15%, and greenhouse emissions decreased by 10–15% [24]. The success of Singapore’s congestion pricing scheme can be attributed to

other complementary initiatives as well. Park-and-ride facilities outside the restricted zone encouraged citizens to park their vehicles and use public transportation to enter the CBD. Additionally, the Land Transport Authority (LTA) was formed by merging fragmented transportation authorities to ensure efficient management and operations of transportation services [20]. Singapore's centralized power structure facilitated the modification and implementation of strategies, making it an attractive destination for foreign investments. Some of the important lessons that can be drawn from the Singapore case are as follows:

- Strong centralized governments or alternative institutions with significant authority can make it easier to implement coercive measures like congestion pricing.
- A congestion pricing scheme should be designed for local conditions and updated timely manner for efficiency (e.g., ALS upgraded to ERP).
- The management and operation of a complex system like a congestion pricing scheme needs a dedicated overarching authority (like LTA in Singapore) to coordinate and manage different aspects of the system.
- A per-trip charging system would provide a fairer and more effective approach, as it can impact multiple trips made by a single vehicle and encourage behavior change to reduce overall traffic.

3.2 London Congestion Charge

Discussions on traffic control in central London began in 1960 [25]. Being the national capital of the United Kingdom and a hub of governance and economic activities, the central zone of London faced severe traffic congestion, with an average speed of 17 km per hour in the inner-city [26], resulting in a loss of USD 2–4 million [24]. To address this issue, Mayor Ken Livingstone, who had included congestion charging in his election manifesto, led a massive outreach program and consultations to gain public support for the scheme. In 2003, the congestion pricing scheme was launched for central London, covering a clearly demarcated inner-city area of 21 square kilometers. Initially, the charge for entering central London was a flat daily fee of 5 pounds, later increased to 8 pounds in 2005, 10 pounds in 2011, and 11.50 pounds in 2014 [27]. Residents of the central zone received a 90% discount, and alternative fuel vehicles were exempt from the charge. The charging area was extended in 2005 to include Westminster, Kensington, and Chelsea, but it was dropped again in 2011 after public consultation [28]. Automatic Number Plate Recognition (ANPR) cameras detected cars entering the charging zone, and payments had to be made by midnight after the day of travel through various modes like online, telephone, and auto deduct systems, with a high fine of 130 pounds for delayed payments [24]. The revenue from the congestion pricing was utilized for operational expenses of the scheme and investments in alternative transportation infrastructure, such as buses, walking and cycling infrastructure, and road repairs. The launch day saw the introduction of 300 new buses, with new bus routes progressively added and improved

frequency on older routes. Public acceptability for London's congestion pricing, as reported by Santos [29], was 70% [30], likely due to cross-subsidization favoring public transportation systems. The scheme yielded significant results, with a 30% reduction in congestion levels, a 38% increase in bus ridership, and a 79% increase in bike trips since 2001 [31]. Traffic approaching the central zone through radial roads decreased by 20% [26]. Interestingly, the reduction in traffic stabilized, and the difference was not substantial when charges were raised from 5 to 8 pounds [32]. Initially, most cost-sensitive car users switched to other modes, leaving only cost-insensitive drivers, typically wealthier individuals. In conclusion, the lessons from the London congestion pricing case include:

- A congestion charging scheme should be designed such that the revenue generated is reinvested back into the transportation system. This can increase public acceptability as reported in other studies as well [33].
- Implementing challenging urban projects like congestion pricing requires a political champion. The success of the London congestion pricing scheme is often attributed to Mayor Ken Livingstone, whose support and leadership were crucial for its successful implementation.
- The level of congestion charging should be adjusted over time to maintain the desired traffic levels. It's important to consider the elasticity of demand, which may change in the long run due to factors such as changes in income levels and inflation, when deciding to increase the congestion charge.
- Expanding the geographical extent of congestion pricing should be done cautiously, only after the success of the initial phase and after gaining public confidence. Gradual expansion ensures smoother implementation.
- An initial lower charge can significantly reduce traffic, and a later increase in charges can help in raising revenues.

3.3 Stockholm Congestion Charge

Stockholm, a city composed of islands connected by bridges, initiated a pilot project for a congestion pricing scheme in 2006 to alleviate traffic on the bridges leading to the central city Fig. 1. The cordoned area covered 35 square kilometers, housing about 66% of the city's population, and had 18 entry-exit points [24]. Similar to London, Stockholm used ANPR cameras to detect vehicles entering the charging zone, and drivers received a permanent receipt at the end of each month. Before the trial, 80% of the residents opposed the proposed congestion pricing scheme. However, during the first week of the trial, traffic volumes decreased by 22%, and congestion levels dropped by 30–50%. Interestingly, acceptance of the congestion pricing significantly increased, with 67% of residents supporting the scheme after its implementation [22]. Consequently, the scheme was permanently launched in 2007, and the charge was officially defined by parliament as a "tax" to be utilized for bridge maintenance and transit improvements. To accommodate specific situations, certain exemptions were made for drivers who had no alternative but to cross the charged

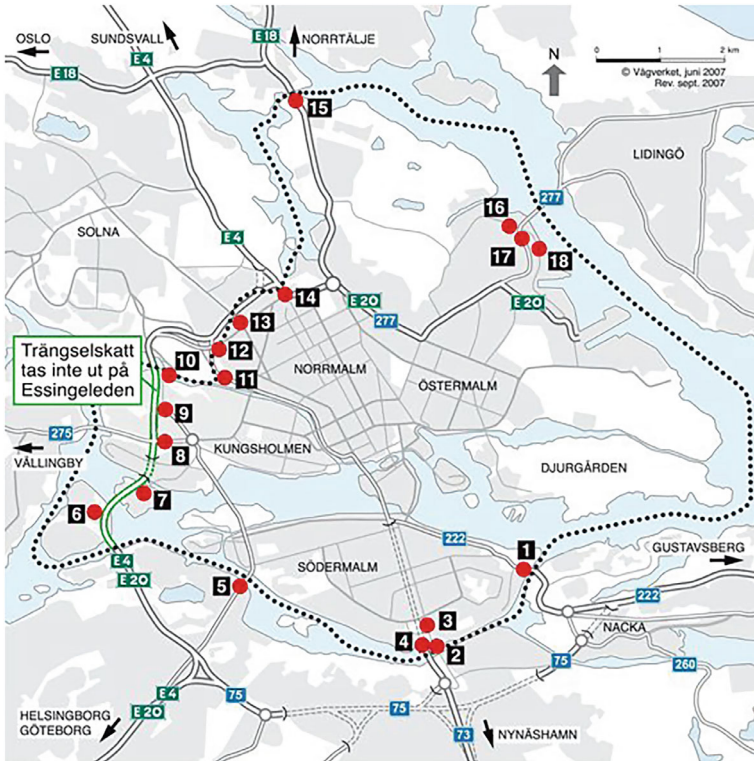


Fig. 1 Stockholm cordon zone

zone to reach their workplaces. These drivers were not required to pay any charge if they exited the zone within 30 min at any toll station [34]. The lessons that can be learned from the Stockholm congestion tax are as follows:

- The acceptability of congestion pricing can significantly increase once people experience its positive impacts on reducing traffic congestion and improving traffic flow.
- Geographical features like bridges that provide clear boundaries for a city center are well-suited for implementing cordon-type congestion pricing schemes.
- To ensure fairness and address the concerns of those most affected by congestion pricing, exemptions should be provided to certain groups, such as residents within the cordon zone and users who have no other viable option but to cross the cordon area for work or essential activities. These exemptions can help alleviate the burden on those individuals and make the scheme more equitable.

3.4 *Edinburgh Congestion Charge*

The city of Edinburgh, a major city in the Southeast of Scotland, faced worsening congestion, prompting its local body, the Edinburgh City Council, to consider congestion charging as a solution. The council had the authority to introduce congestion charging, and plans were advanced in 2005 after extensive consultations and negotiations with neighboring councils affected by the scheme [36]. Unlike the London congestion charging scheme, where the final decision rested with the mayor, in Edinburgh, the central government (Scottish Executive) had the ultimate approval power. The proposed scheme in Edinburgh involved two cordons for charging vehicles: an outer cordon with a £2 one-time charge from 7 am to 10 pm and an inner cordon with the same charge from 7 am to 6:30 pm Fig. 2. Notably, vehicles driving inside the cordons or between them were not charged, providing relief to residents of Edinburgh city. However, this exemption was perceived as biased against residents of neighboring councils who commuted to Edinburgh for work, leading to disagreements among the city councils. The lack of clear objectives and benefits of the scheme raised doubts among the public, resulting in a demand for a referendum. A postal referendum was conducted in February 2005, with overwhelming rejection (3:1) of the Edinburgh congestion charging scheme. The important lessons from the Edinburgh congestion charging scheme are as follows.

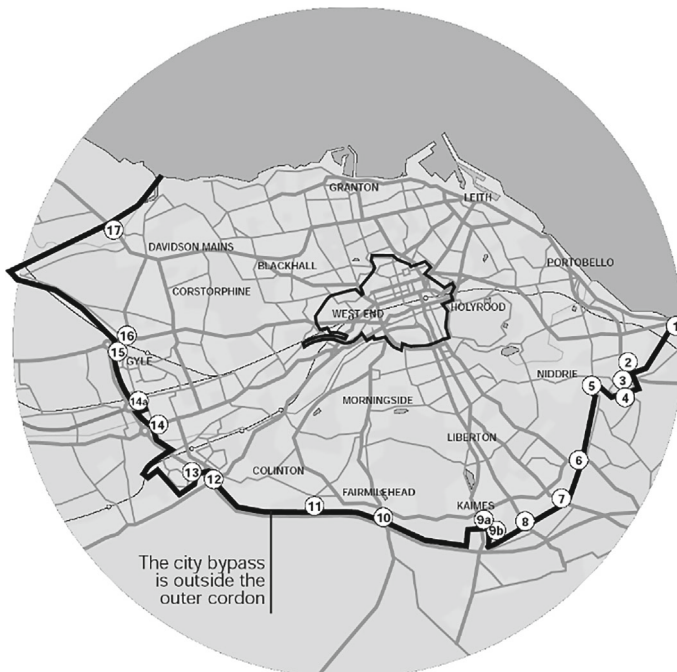


Fig. 2 Edinburgh congestion pricing [35]

- The congestion charging scheme should be designed to be straightforward and easy to understand to develop consensus among stakeholders. The complexity of the scheme, such as having two zones in Edinburgh, could lead to ambiguity and may contribute to the rejection of the proposal [37].
- Involving multiple levels of government in the decision-making process can complicate matters. In the case of Edinburgh, the scheme's approval depended on the Scottish Executive, unlike the London congestion charging scheme, where the mayor had the final decision-making power [36].
- Conducting trials, similar to Stockholm, can be beneficial to gain first-hand experience and remove hypothetical biases. In Edinburgh's case, not conducting trials before the referendum might have contributed to the lack of clarity about the scheme's benefits and resulted in the rejection of the congestion charging proposal. A trial with a subsequent referendum can provide residents with real-world experience and help in making more informed decisions.

3.5 New York Congestion Charge

The proposed congestion pricing scheme in New York City, put forth by Mayor Bloomberg in 2007, aimed to charge cars entering and leaving midtown and lower parts of Manhattan Island between 6 am and 6 pm [30]. The scheme received significant support from city authorities, advocacy groups, and business quarters, largely due to the promise of reinvesting the generated revenue into much-needed metro and bus infrastructure, which was crucial for the city's transportation backbone. The success of the London congestion pricing scheme of 2003 served as an established example and played a significant role in garnering support for the New York proposal. Public opinion polls in March 2008 indicated a 67–27% margin in favor of congestion pricing, provided that the funds would be used for mass transit improvements [38]. The proposed charge could be paid through various means, including the already installed E-ZPass electronic tolling system, cash, credit cards, etc. To support the implementation of the scheme, the Metropolitan Transportation Authority (MTA) secured \$354 million in Urban Partnership funds from the Federal government. However, the funds were contingent on the congestion pricing system being implemented by March 2009 after clearing legislative procedures. Unfortunately, the proposal faced opposition from elected officials representing New York Boroughs close to Manhattan. Residents in these areas heavily relied on cars and had limited access to transit facilities, leading to resistance against the congestion pricing scheme [38]. As a result, the Democratic majority in the state assembly blocked the vote, causing the Urban Partnership funds to be reallocated to other cities. The lessons from the New York congestion pricing scheme include:

- Despite having a wide support base and strong champion leadership, political feasibility plays a crucial role in the successful implementation of a congestion

pricing scheme. Opposition from elected officials representing areas affected by the scheme can hinder its progress, as observed in the case of New York City.

- Advocacy groups focused on the environment and urban matters can play a vital role in garnering support for congestion pricing among the general public. If these groups are convinced of the benefits of the scheme, they can effectively communicate its advantages and generate broader public acceptance.
- To ensure wider acceptability of the congestion pricing scheme, it is essential to consider the concerns and views of residents and elected officials from the adjoining areas of the congestion pricing zones. Engaging with these stakeholders and addressing their specific needs and worries can help in building consensus and minimizing opposition.

4 Indian Case Study Area: Ahmedabad Old City

Ahmedabad is a major metropolitan area in the western state of Gujarat, India, with a rich history dating back to the eleventh and fifteenth centuries [40, 41]. The central part of the city, known as the “old city” or “walled city”, was historically characterized by a properly demarcated boundary wall with entry gates. This 7.5 square kilometer area exhibits mixed land-use development, with a high population density of around 680 persons per hectare, Fig. 3 [39]. It has been a prominent residential location and serves as the Central Business District (CBD) with a thriving wholesale market for various goods, including clothes, grains, groceries, and fruits [42]. Additionally, the old city houses important locations such as the central railway station, bus station, and educational institutions, attracting trips from other parts of Ahmedabad city. Despite its historical charm, the old city was not originally designed to accommodate automobiles. The increasing number of vehicles in the city has led to congested roads, with the average traffic speed in the old city being as low as 20 km/hr, the slowest compared to other areas of Ahmedabad [40]. Two-wheelers and cars dominate the vehicle composition, accounting for 73% and 12.5% of the total vehicles, respectively [43]. It is worth noting that while the discussions in the paper are specific to Ahmedabad’s old city, they are relevant to other Indian cities with similar characteristics. Many major Indian cities have central areas marked by dense mixed-use development, historical significance, demarcated boundaries, narrow roads, and high vehicular traffic. Some examples include Hyderabad (old city), Delhi (Purani Dilli), Kolkata (Bada Baazar area), Jaipur (Purana saher), and Bhopal, among others. Due to the need to address traffic congestion in these areas and their resemblance to Ahmedabad’s old city, it was selected as a case study area to explore potential solutions.

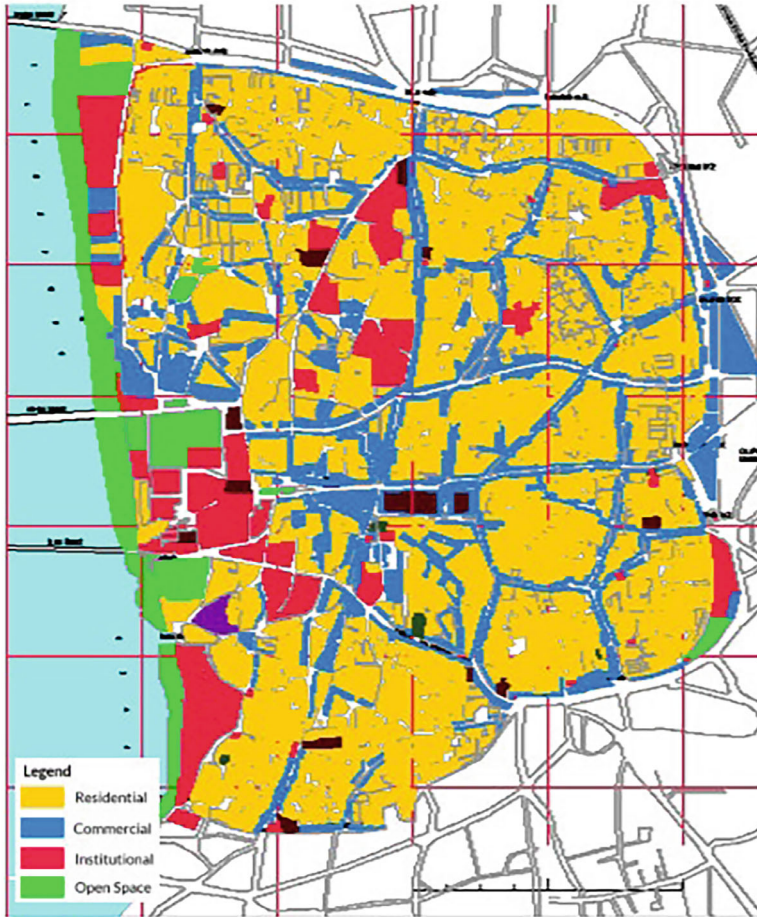


Fig. 3 Ahmedabad old city land-use map [39]

5 Favorable Spatial Features for the Ahmedabad Old City

Based on the background and review of congestion pricing schemes provided in Sect. 3, we identified key spatial features that could play a role in the successful implementation of congestion pricing in Ahmedabad’s old city in the following subsections. It is important to note here that the identified geographical features increase the effectiveness of congestion pricing, but do not necessarily guarantee success.

5.1 *Geography of the Old City*

The natural advantage of Ahmedabad's old city, lying on the bank of the Sabarmati River and connected to the rest of the city through bridges, provides a practical advantage for the implementation of congestion pricing Fig. 4. This geographical condition is similar to the cordon zone in Stockholm, where islands are connected by bridges, making it easier to implement the congestion pricing system [44]. In Ahmedabad's case, having bridges as the primary access points to the old city ensures that drivers approaching the area are more likely to comply with paying the congestion charge. The presence of physical barriers like rivers and limited access points increases the practicality and effectiveness of the charging system, especially in developing countries where compliance with paying charges might be a concern. New York City's congestion charging scheme also had plans to put tolls on tunnels and bridges connecting the charging zone of Manhattan. While the natural geographical feature offers practical advantages, the success of congestion pricing still depends on gaining support from the legislature and other stakeholders. Several other major Indian cities, including Surat (river Tapi), Kolkata (river Hooghly), and Hyderabad (river Musi), have similar geographical advantages, with their city centers or old city areas located on the banks of rivers and connected by bridges. Implementing congestion pricing in these cities, with the natural advantage of geographical features, could potentially contribute to managing traffic congestion more effectively. While natural geographical features do not guarantee the success of congestion pricing, they offer practical advantages and can be leveraged to design and implement congestion pricing schemes that address traffic congestion and promote sustainable transportation options in cities with similar spatial characteristics.

5.2 *Physical Demarcation of the Central Area*

Having a clearly demarcated area is crucial for the successful implementation of a congestion pricing scheme. Ambiguity in the scheme can lead to complications and reduce support from drivers and stakeholders. The failure of the congestion pricing scheme in Edinburgh, where a "double-cordon" pattern complicated the system, is an example of the detrimental impact of such complexities [37]. In contrast, the success of the London congestion charging scheme can be attributed, in part, to the presence of a clear physical demarcation with the Inner Ring Road separating the cordon zone from the rest of the city, providing clarity to drivers. Similarly, the old city of Ahmedabad also benefits from a demarcated boundary, historically marked by a wall with 12 entry gates Fig. 5. Though the wall no longer exists in its entirety, the ring road on the periphery of the old city serves as a modern-day continuation of the demarcation (refer to the dotted line in Fig. 4). Utilizing the twelve entry-exit points as charging points for entering or leaving the old city can provide a straightforward and well-defined system for congestion pricing. The concept of walled cities with physical

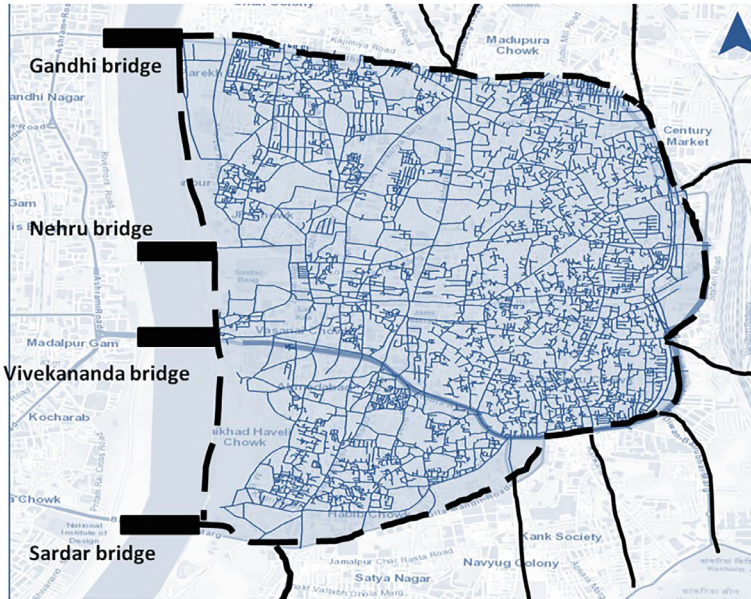


Fig. 4 Ahmedabad old city entry points

demarcations is prevalent in many old cities in India, facing severe traffic congestion. Examples include Jaipur (Fig. 6), Hyderabad, and Amritsar (Fig. 7). By leveraging the historical demarcation of these old cities, congestion pricing schemes can be effectively designed and communicated, reducing confusion and enhancing public support for traffic management initiatives. The presence of physical boundaries and gates in these cities can aid in creating a clear and practical framework for the implementation of congestion pricing, making it easier for drivers to understand and comply with the charging system.

5.3 The City Center/CBD Advantage

The success of congestion pricing schemes in several European cities, such as London, Milan, Gothenburg, and Stockholm, is primarily attributed to their implementation in historic city centers and Central Business Districts (CBDs). These areas are characterized by high-density and mixed-use developments, where streets were not originally designed to accommodate motorized vehicles. The bustling business activities and attractions in these areas draw trips from all parts of the city, resulting in severe traffic congestion. In cities like London, before implementing congestion pricing, a significant majority of residents believed there was excessive traffic, and they were concerned about travel times and air pollution[24]. This perception of



Fig. 5 Ahmedabad old city gate



Fig. 6 Jaipur old city gate

high traffic congestion often makes people more receptive to coercive measures like congestion pricing.

Similarly, Ahmedabad's old city, once the official CBD of the city, shares many similarities with the historic city centers of European cities. It was not originally planned for motorized vehicles and continues to be the main area for commerce, business, tourism, and major regional transportation centers. As a result, it attracts trips from all other parts of Ahmedabad for various purposes. Considering the success of congestion pricing in European CBDs, it can be expected that Ahmedabad's old city, with its historic significance and central role in the city's activities, could also



Fig. 7 Amritsar old city gate

benefit from congestion pricing as an effective traffic management measure. The implementation of congestion pricing in the old city could potentially alleviate traffic congestion, improve air quality, and enhance the overall urban environment. The provided figures show the congestion zone for both Ahmedabad (Fig. 8) and London (Fig. 9) [45]. These images highlight the central areas where congestion pricing schemes have been implemented, further emphasizing the similarities between the two cities and their potential for successful congestion pricing measures.

6 Challenges for Congestion Pricing in Indian Cities

Congestion pricing appears to be a promising solution for tackling traffic congestion in Indian cities. However, policymakers may encounter several challenges unique to the Indian context. It is crucial to acknowledge and address these challenges to ensure the successful planning and implementation of congestion pricing schemes. The following subsections outline the challenges and possible solutions to consider.

6.1 Public Acceptability

The primary challenge lies in gaining public acceptance for the congestion pricing scheme. Coercive Travel Demand Management (TDM) measures, like congestion pricing, often face resistance from the public upon introduction. An example of this

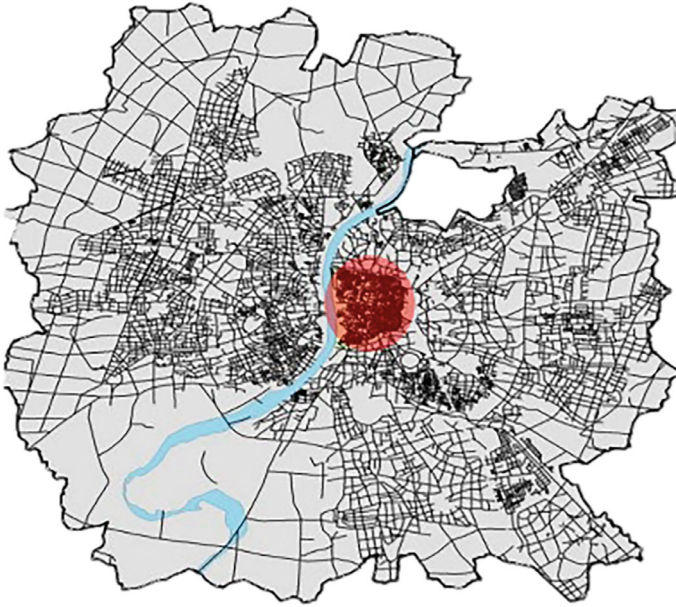


Fig. 8 Ahmedabad central zone

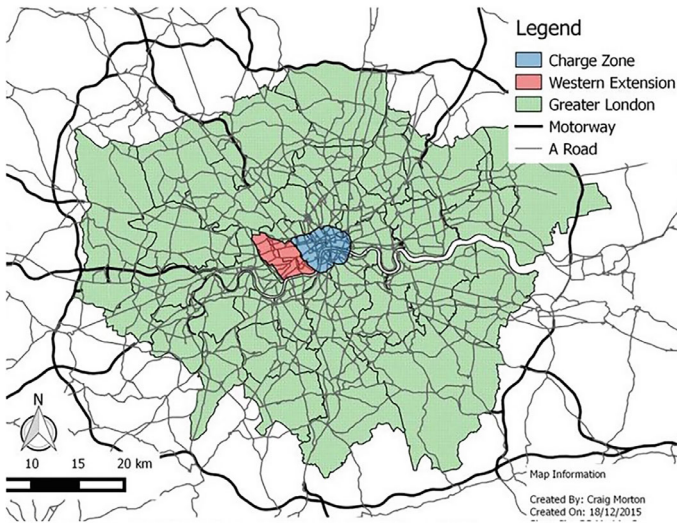


Fig. 9 London CZ

was seen in the Edinburgh congestion charging scheme in the UK, which was overwhelmingly rejected by the public in a 3:1 vote during a referendum. The major reason for this rejection was the public's lack of conviction in the scheme's ability to reduce congestion and improve public transportation [35]. Another possible reason for the public's rejection could be attributed to the limited press coverage on the merits and benefits of the scheme [36]. To improve public acceptability, possible solutions can be derived from the results reported in a study [46]. The study analyzed factors influencing public approval and found that respondents familiar with congestion pricing and trusting in its reported benefits were more likely to accept congestion charging. Stockholm's example demonstrates this phenomenon, as trials of congestion pricing were first introduced for nearly six months, followed by a public referendum that resulted in support for the congestion tax. Similar results were observed in Milan, where the implementation reduced emotional opposition to road pricing [47]. Based on the above discussion, the following suggestions can be formulated for congestion pricing in India:

- (a) Introducing congestion pricing on a trial basis, as seen in Stockholm, can allow the public to experience the benefits firsthand. A temporary trial (e.g., six months) can help alleviate concerns, allowing residents to observe tangible improvements in traffic flow and air quality. Trials can also serve as a basis for public feedback, providing an opportunity to make adjustments that address public concerns before permanent implementation [48, 49].
- (b) Demonstrating that congestion pricing revenue will be reinvested in expanding and upgrading public transportation can significantly increase public support. During the trial phase, visible improvements to the public transit system, such as increased bus frequency, better service coverage, or reduced fares, can help the public see the direct benefits of the scheme, thereby fostering greater acceptance [33, 50].
- (c) Proactively publish the trial results through various platforms to raise awareness of the scheme's benefits [52]. This can help counteract biased coverage and improve public understanding. Additionally, conduct an exhaustive marketing campaign and outreach events before the trials to develop acceptance for the scheme, as persuasive communication enhances the acceptability of pricing [51].
- (d) Engaging the community through workshops, seminars, and town hall meetings can be instrumental in addressing concerns and providing a platform for open dialogue. These events can help demystify congestion pricing, answer common questions, and correct misconceptions. Local leaders, transport experts, and government representatives can use these events to build rapport with the community, enhancing credibility and public trust.
- (e) Working with trusted local leaders, media influencers, and community organizations can help garner grassroots support. When local figures endorse the scheme and communicate its benefits, it can foster a sense of community backing and reduce resistance. Partnerships with environmental and civic groups can also strengthen the public's trust in the scheme's motives, as these organizations

often hold significant influence over public opinion on urban and environmental issues.

6.2 Political Feasibility

Political feasibility is a significant challenge for the effective implementation of a congestion pricing scheme, especially in countries like India with democratic governance structures and overlapping responsibilities between different levels of government (Central, state, and cities). An example of political challenges can be seen in the New York congestion charging scheme, where opposition from elected officials led to its blockage despite the support of the mayor [30, 38]. In contrast, the London congestion pricing scheme faced fewer political hurdles due to the authority vested in the Mayor of London for managing transportation, including congestion pricing [27]. India's city-level self-governing bodies, empowered by the 74th amendment, hold significant power to implement urban transportation-related schemes. However, the presence of overlapping powers may result in passing on responsibilities, especially for unpopular measures like congestion pricing. Proper coordination and clear-cut distinction of responsibilities between authorities are essential for the successful implementation of the scheme. Some potential solutions to address the political feasibility challenges are presented below. These strategies emphasize the need for coordinated governance and transparency to bolster political support, which is crucial for introducing congestion pricing as a sustainable urban mobility solution in India.

- (a) Create an SPV specifically for congestion pricing, with a clear mandate and designated authority, to streamline decision-making and implementation. Successful examples of SPVs in urban transport projects, such as metro systems in India, indicate that this approach is both viable and effective for complex initiatives like congestion pricing.
- (b) As seen in London, the successful implementation of the congestion pricing scheme played a crucial role in the re-election of the Mayor, Ken Livingstone, in 2004. Present case studies of cities like London, where congestion pricing led to tangible benefits and even political gains, to illustrate the potential for positive outcomes in India. Highlighting these successes can help policymakers appreciate the long-term value and may provide a political incentive for supporting similar initiatives.

6.3 Technological Challenges

Implementing a congestion pricing scheme indeed demands a complex and sophisticated system involving equipment, software, data centers, and monitoring systems. Failures in cities like Manchester and Edinburgh highlight the risks posed by overly complex systems, which often confuse users and strain authorities' ability to monitor

effectively (52). For India, designing a simple, user-friendly system leveraging advanced technology will be crucial to success. Some of the potential solutions to address technological feasibility.

- (a) Following Singapore's example of electronic road pricing, India should invest in automated and digital systems rather than manual approaches. A simple, scalable, and easy-to-understand technology setup can help reduce confusion and make the scheme more accessible for a broad population.
- (b) Socio-economic considerations are vital when implementing congestion pricing in diverse Indian cities, where residents vary in income, education, age, etc. The scheme should account for these differences and offer alternative arrangements for those who may face challenges with the main system. For instance, providing options for prepaid cards could accommodate individuals without access to electronic banking systems, ensuring inclusivity.
- (c) Automatic Number Plate Recognition (ANPR) systems can be very effective for congestion pricing but require standardized, readable plates. India should consider updating vehicle number plates across cities to ensure ANPR compatibility, an approach already used in other cities for traffic enforcement. This standardization can streamline system operations and improve efficiency.
- (d) Effective operation of a congestion pricing system demands centralized monitoring and control rooms staffed with trained personnel. Investing in these facilities will enhance real-time tracking, issue resolution, and overall management, ensuring the technology functions smoothly and accurately.
- (e) Leveraging India's existing FASTag system for congestion pricing offers a cost-effective and scalable solution by using familiar RFID infrastructure to automatically charge vehicles in designated zones, making implementation easier, more inclusive, and adaptable for dynamic traffic management.

7 Conclusion

This paper examines the prospects and challenges of implementing congestion pricing in India, drawing valuable insights from global case studies. Beginning with an overview of India's urban transportation issues, the paper highlights the need for coercive measures like congestion pricing to effectively reduce congestion. Through an in-depth analysis of international cases, both successful and unsuccessful, the study provides valuable lessons for Indian policymakers, focusing on scheme design, political dynamics, geographical considerations, and public acceptability. Using Ahmedabad's old city as a case study, the paper identifies favorable spatial characteristics, such as natural boundaries, defined congestion zones, and its economic centrality, that could support the introduction of congestion pricing. Additionally, the study suggests that similar Indian cities could benefit from congestion pricing schemes in the future, provided these contextual features are leveraged. Looking forward, this paper emphasizes the importance of proactively addressing anticipated challenges of public acceptability, political feasibility, and technological

complexity by leveraging global lessons. Specifically, it proposes trial-based implementations and extensive public outreach to enhance public support, the formation of a Special Purpose Vehicle (SPV), and the use of existing technologies like the FASTag system to address technological requirements efficiently. The insights from this study provide a foundation for developing congestion pricing policies that can address these challenges, ensuring the feasibility and success of congestion pricing in India. By strategically applying global insights, Indian policymakers have a unique opportunity to pioneer effective urban mobility solutions and set a precedent for emerging economies.

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References

1. Pigou AC (1920) *The economics of welfare*. Macmillan and Co., London
2. Vickrey W (1969) Congestion theory and transport investment. *Am Econ Rev* 59(2):251–260
3. Morgul EF, Ozbay K (2010) Simulation-based evaluation of a feedback based dynamic congestion pricing strategy on alternate facilities
4. Meng Q, Liu Z (2012) Impact analysis of cordon-based congestion pricing on mode-split for a bimodal transportation network. *Transp Res Part C: Emerg Technol* 21(1):134–147. <https://doi.org/10.1016/j.trc.2011.06.007>
5. Daganzo CF, Lehe LJ (2015) Distance-dependent congestion pricing for downtown zones. *Transp Res Part B: Methodol* 75:89–99. <https://doi.org/10.1016/j.trb.2015.02.010>
6. Loo BPY, Huang Z (2021) Delineating traffic congestion zones in cities: an effective approach based on GIS. *J Transp Geogr* 94. <https://doi.org/10.1016/j.jtrangeo.2021.103108>
7. United Nations (2014) *World urbanization prospects: the 2014 revision, highlights*. United Nations
8. Ministry of Housing and Urban Poverty Alleviation (2009) *Urban poverty report 2009*, India
9. Singh SK (2012) Urban transport in India: issues, challenges, and the way forward. *Eur Transp/Trasp Eur* 52:1–26
10. Verma A, Harsha V, Subramanian GH (2021) Evolution of urban transportation policies in India: a review and analysis. *Transp Dev Econ* 7(2):1–15. <https://doi.org/10.1007/s40890-021-00136-1>
11. Ministry of Road Transport and Highways (2021) *Annual report 2020–2021*. New Delhi
12. Mitra S (2014) *Operational efficiency of freight transportation by road in India*, 3rd edn
13. Guttikunda SK, Goel R, Pant P (2014) Nature of air pollution, emission sources, and management in the Indian cities. *Atmos Environ* 95:501–510. <https://doi.org/10.1016/j.atmosenv.2014.07.006>
14. Comptroller and Auditor General of India (2021) *Implementation of phase-3 Delhi mass rapid transit system by DMRC*
15. Habibian M, Kermanshah M (2013) Coping with congestion: understanding the role of simultaneous transportation demand management policies on commuters. *Transp Policy* 30:229–237. <https://doi.org/10.1016/j.tranpol.2013.09.009>
16. Kavta K, Goswami AK (2021) A methodological framework for a priori selection of travel demand management package using fuzzy MCDM methods. *Transportation*. <https://doi.org/10.1007/s11116-020-10158-0>

17. Kavta K, Goswami AK (2022) Estimating mode choice of motorized two-wheeler commuters under the influence of combined travel demand management measures: an ICLV modeling approach. *Transp Policy* 126:327–335. <https://doi.org/10.1016/j.tranpol.2022.08.004>
18. Metz D (2018) Tackling urban traffic congestion: the experience of London, Stockholm and Singapore. *Case Stud Transp Policy* 6(4):494–498. <https://doi.org/10.1016/j.cstp.2018.06.002>
19. Goh M (2002) Congestion management and electronic road pricing in Singapore. *J Transp Geogr* 10(1):29–38. [https://doi.org/10.1016/S0966-6923\(01\)00036-9](https://doi.org/10.1016/S0966-6923(01)00036-9)
20. Seik FT (2000) An advanced demand management instrument in urban transport: electronic road pricing in Singapore. *Cities* 17(1):33–45. [https://doi.org/10.1016/S0264-2751\(99\)00050-5](https://doi.org/10.1016/S0264-2751(99)00050-5)
21. Menon G, Guttikunda S (2010) Electronic road pricing: experience & lessons from Singapore. SIM-air working paper, vol 33, p 15
22. Van Amelsfort D, Brundell-Freij K (2018) Congestion charging: policy and global lessons learned
23. Olszewski P, Xie L (2005) Modelling the effects of road pricing on traffic in Singapore. *Transp Res Part A Policy Pract* 39(7–9):755–772. <https://doi.org/10.1016/j.tra.2005.02.015>
24. Tri State Transportation Campaign (2017) Road pricing in London, Stockholm and Singapore—a way forward for New York City
25. Thomson JM (1967) An evaluation of two proposals for traffic restraint in central London. *J R Stat Soc* 130(3):327–377
26. TfL (2004) Congestion charging impacts monitoring, second annual report
27. Lehe L (2019) Downtown congestion pricing in practice. *Transp Res Part C Emerg Technol* 100(January):200–223. <https://doi.org/10.1016/j.trc.2019.01.020>
28. TfL (2008) Non-statutory consultation on the future of the western extension of the congestion charging zone. No. London, Transport for London
29. Santos G (2004) 11. Urban road pricing in the UK. Elsevier
30. Selmoune A, Cheng Q, Wang L, Liu Z (2020) Influencing factors in congestion pricing acceptability: a literature review. *J Adv Transp* 2020. <https://doi.org/10.1155/2020/4242964>
31. USDOT. Lessons learned from international experience in congestion pricing. Accessed 26 Apr 2021
32. Evans R (2008) Demand elasticities for car trips to central London as revealed by the central London congestion charge. *Transp London Policy Anal Div*
33. Gu Z, Liu Z, Cheng Q, Saberi M (2018) Congestion pricing practices and public acceptance: a review of evidence. *Case Stud Transp Policy* 6(1):94–101. <https://doi.org/10.1016/j.cstp.2018.01.004>
34. Jarl V (2009) Congestion pricing in urban areas congestion pricing in urban areas—theory and case studies
35. Allen S, Gaunt M, Rye T (2006) An investigation into the reasons for the rejection of congestion charging by the citizens of Edinburgh
36. Rye T, Gaunt M, Ison S (2008) Edinburgh’s congestion charging plans: an analysis of reasons for non-implementation. *Transp Plan Technol* 31(6):641–661. <https://doi.org/10.1080/03081060802492686>
37. Gaunt M, Rye T, Ison S (2006) Gaining public support for congestion charging: lessons from referendum in Edinburgh, Scotland. *Transp Res Record J Transp Res Board*:87–93
38. Schaller B (2010) New York city’s congestion pricing experience and implications for road pricing acceptance in the United States. *Transp Policy* 17(4):266–273. <https://doi.org/10.1016/j.tranpol.2010.01.013>
39. Suthar N (2017) Study of mode choice behaviour for public transportation. CEPT University
40. Delhi Metro Rail Corporation Ltd (2015) Detailed project report for Ahmedabad metro rail project (phase 1)
41. Centre of Conservation Studies CEPT University (2016) Historic city of Ahmedabad India nomination dossier for inscription of the world heritage list
42. Swamy S, Baindur D (2013) Managing urban logistics in an expanding city—case study of Ahmedabad. *World Conf Transp Res* 380009:1–21

43. Islam M, Brussel M, Grigolon A, Munshi T (2018) Ridership and the built-form indicators: a study from Ahmedabad Janmarg bus rapid transit system (BRTS). *Urban Sci* 2(4):95. <https://doi.org/10.3390/urbansci2040095>
44. Hysing E, Isaksson K (2015) Building acceptance for congestion charges—the Swedish experiences compared. *J Transp Geogr* 49:52–60. <https://doi.org/10.1016/j.jtrangeo.2015.10.008>
45. Morton C, Lovelace R, Anable J (2017) Exploring the effect of local transport policies on the adoption of low emission vehicles: evidence from the London congestion charge and hybrid electric vehicles. *Transp Policy* 60(November):34–46. <https://doi.org/10.1016/j.tranpol.2017.08.007>
46. Odioso MS, Smith MC (2008) Perceptions of congestion charging: lessons for U.S. cities from London and Stockholm. In: *Proceedings of the 2008 IEEE systems and information engineering design symposium (SIEDS 2008)*, pp 221–226. <https://doi.org/10.1109/SIEDS.2008.4559715>
47. Beria P (2016) Effectiveness and monetary impact of Milan’s road charge, one year after implementation. *Int J Sustain Transp* 10(7):657–669. <https://doi.org/10.1080/15568318.2015.1083638>
48. Andersson D, Nässén J (2016) The Gothenburg congestion charge scheme: a pre-post analysis of commuting behavior and travel satisfaction. *J Transp Geogr* 52:82–89. <https://doi.org/10.1016/j.jtrangeo.2016.02.014>
49. Jagers SC, Matti S, Nilsson A (2017) How exposure to policy tools transforms the mechanisms behind public acceptability and acceptance—the case of the Gothenburg congestion tax. *Int J Sustain Transp* 11(2):109–119. <https://doi.org/10.1080/15568318.2016.1197348>
50. Santos G, Caranzo A (2022) Potential distributional impacts of road pricing: a case study. *Case Stud Transp Policy* 10(1):1–31. <https://doi.org/10.1016/j.cstp.2021.07.015>
51. Hsieh HS (2022) Road pricing acceptability and persuasive communication effectiveness. *Transp Policy* 125:179–191. <https://doi.org/10.1016/j.tranpol.2022.05.004>
52. Hensher DA, Li Z (2013) Referendum voting in road pricing reform: a review of the evidence. *Transp Policy* 25:186–197. <https://doi.org/10.1016/j.tranpol.2012.11.012>