ISSN 1728-5445

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ECLAC SUBREGIONAL HEADQUARTERS FOR THE CARIBBEAN

Assessment of the economic costs of vehicle traffic congestion in the Caribbean

A case study of Trinidad and Tobago

Willard Phillips
Elizabeth Thorne
Esther Chong Ling

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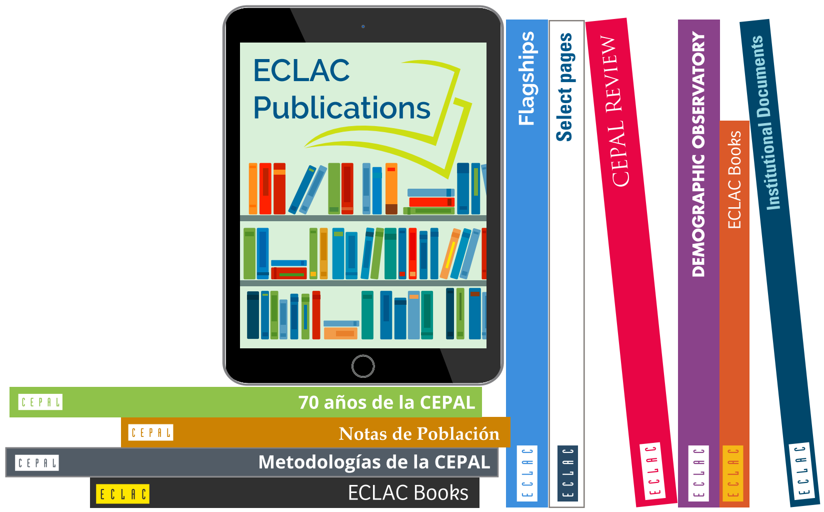

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United Nations publication
ISSN: 1728-5445 (electronic version)
ISSN: 1727-9917 (print version)
LC/TS.2023/191
LC/CAR/TS.2023/8
Distribution: L

Printed at United Nations, Santiago
S.23-00954

This publication should be cited as: W. Phillips, E. Thorne and E. Chong Ling, "Assessment of the economic costs of vehicle traffic congestion in the Caribbean: a case study of Trinidad and Tobago", *Studies and Perspectives series-ECLAC Subregional Headquarters for the Caribbean*, No. 122 (LC/TS.2023/191-LC/CAR/TS.2023/8), Santiago, Economic Commission for Latin America and the Caribbean (ECLAC), 2023.

Contents

Tables

Figures

Diagram

Maps

Abstract

Vehicle traffic congestion produces significant economic costs in most cities and metropolitan regions of the world. It is also a significant source of green house gas emissions as well as other air pollutants which in turn contribute to major health risks. Traffic congestion also generates additional impacts including stress, fatigue and depression among commuters, and is possibly linked to increased anti-social behaviour and diminished road safety. The problem has become a major challenge among Caribbean small island developing states (SIDS), especially in the context of the subregion's growing urbanization and increasing levels of motorization over the past three decades. And while several studies have been undertaken for other countries and regions around the world, the phenomenon has not benefitted from such inquiry in Caribbean countries. The present study seeks to contribute to remedying this deficiency by assessing the economic costs of vehicle traffic congestion in one Caribbean case country – Trinidad and Tobago. Towards this end, a survey was conducted to glean insights into commuters' traffic congestion experience in terms of location and time delays, and collected data were used to estimate a Value of Lost Time as a measure of direct economic costs. The assessment suggests that vehicle traffic congestion imposes a direct economic burden of roughly 1.37% of annual GDP on Trinidad and Tobago. This measure represents a lower bound estimate of economic costs, given that it does not include other social and environmental costs typically associated with the phenomenon. This estimate is likey to have important public policy implications for the country, as it seeks to implement strategies for mitigating the problem in the future.

Introduction

Vehicle traffic congestion produces significant economic costs in most cities and metropolitan regions of the world. Estimates of losses from vehicle congestion varied from 200 billion Euros or roughly 1.4% of GDP for the European Union in 2016, to US$151 billion or 0.7% of GDP for the United States, in 2020 (IDB, 2021). It has also become the highest contributor to Green House Gas (GHG) emissions as well as other air pollutants such as air particulate matter, nitrogen oxides and volatile organic compounds (EPA, 2022). Caribbean small island developing states (SIDS) face similar economic costs from traffic congestion, with cities such as Santo Domingo recording an estimated economic loss of USD180 million or 0.67% of GDP in 2019 (IDB, 2021).

Vehicle traffic congestion is also apparent in Trinidad and Tobago, which had more than 1 million registered vehicles on the road and an increase of more than 25,000 new cars in 2019 (Oxford Business Group, 2021). This amounts to a vehicle to population ratio of roughly 0.76. This challenge has been growing over the past three decades, driven by increasing urbanization and personal vehicle ownership, alongside lagging development of public transportation infrastructure. In this context, traffic congestion is seen to also cause higher levels of stress, fatigue and depression among commuters, and is possibly linked to increased anti-social behaviour and diminished road safety. While the problem has been widely studied for larger cities and metropoles (IDB, 2021; European Conference of Ministers of Transport (ECMT), 1999; Christidis and Rivas, 2012; University of California at Los Angeles (UCLA), 2016), there is little to no assessment of the economic costs of vehicle traffic congestion in Caribbean SIDS. The aim of this study therefore is to undertake an economic assessment of the costs of vehicle traffic congestion in Trinidad and Tobago. The paper is organized into six sections. After the introduction in Section 1, theoretical considerations related to vehicle traffic congestion are explored in Section 2. The status and dynamics of vehicle traffic congestion in Trinidad and Tobago are outlined in Section 3, while the study methodology is elaborated in Section 4. Section 5 presents the study findings, and policy implications and conclusions are summarized in Section 6. Some limitations of the research are presented in Section 7.

I. Traffic congestion – Theoretical considerations

All modes of transportation experience congestion at various points in time during their use. Congestion occurs because transportation infrastructure is typically provided at high capital costs and is therefore inflexible over the short run. At the same time, consumer use of transportation services fluctuates across time periods, such as seasonal peaks, in response to social, economic and environmental dynamics. In the case of road transportation, user variations manifest themselves, even daily, with road use peaking at rush-hours, as consumers pursue their day-to-day activities. Given the inflexibility of the infrastructure, road congestion arises when the finite capacity of the road network is exceeded at any given period of time. As discussed by Button (2010), fixed infrastructure capacity results in each additional road user affecting the others, as the number of users increases. Eventually, a point is reached where all users begin to experience congestion.

But not all forms of traffic congestion are the same, and their impacts depend on both the nature of interaction caused by additional road users on the overall traffic flow, as well as the *spatial* sequencing of the impact of the congestion to wider geographic areas of the road network. A well-recognized effort at categorizing these forms of traffic congestion is that of Vickery (1969) cited by Button, 2014, who describes the following five general categories (table 1).

Two broad approaches are typically applied in the examination of vehicle congestion. The first is an engineering analysis in which parameters such as vehicle speed, flow, density, queue length and duration are used to determine the optimal level of road use relative to the onset of vehicle congestion (IDB, 2021). Vehicle speed is the distance covered per unit of time over a road segment, while flow measures the number of vehicles which pass a particular point of the roadway during a specified time period. Density is the number of vehicles which occupy an area of roadway at a specific point in time and would usually depend on the number of lanes of the roadway. Queue length is the total distance occupied by vehicles in a single lane at a point of time when traffic is at a standstill. Finally, duration represents the quantity of time between the point where a vehicle comes to a standstill, and the point where it is subsequently in motion.

Table 1
Types of vehicle traffic congestion

Simple interaction	Occurs at comparatively low levels of traffic flow with small numbers of vehicles; careful driving by road users typically results in minimal delays, estimated as the square of the volume of traffic. Each additional road user causes a delay roughly equal to that which he/she suffers.
Multiple interaction	Occurs at higher levels of traffic flow but less than the maximum road capacity; Each additional vehicle generates greater impedance on each other compared to the simple interaction; Based on empirical evidence, for every minute delay of the additional road user, all other motorists suffer delays of three to five minutes.
Bottleneck situations	Occurs where a specific road segment is of less capacity than a preceding or subsequent segment. If the current traffic flow is less than the capacity of the bottleneck, then simple or multiple interactions can occur. However, once capacity is reached, and if sustained, this leads to rapid development of traffic queues, and a high level of congestion.
Trigger neck situations	Triggernecks arise as severe impacts of bottlenecks, where queuing of vehicles may begin to affect other vehicles not wishing to use the bottleneck. This congestion may grow to such severity as to bring traffic to a complete standstill.
Network and control congestion	This type of congestion arises from the efforts of traffic engineers to manage traffic using control devices. Traffic management goals maybe to control different types of vehicles at different times of the day. The 'blunt' calibration of such control devices might result in unintended traffic congestion at specific times and locations while solving the problem elsewhere.

Source: Authors' compilation from Button (2014).

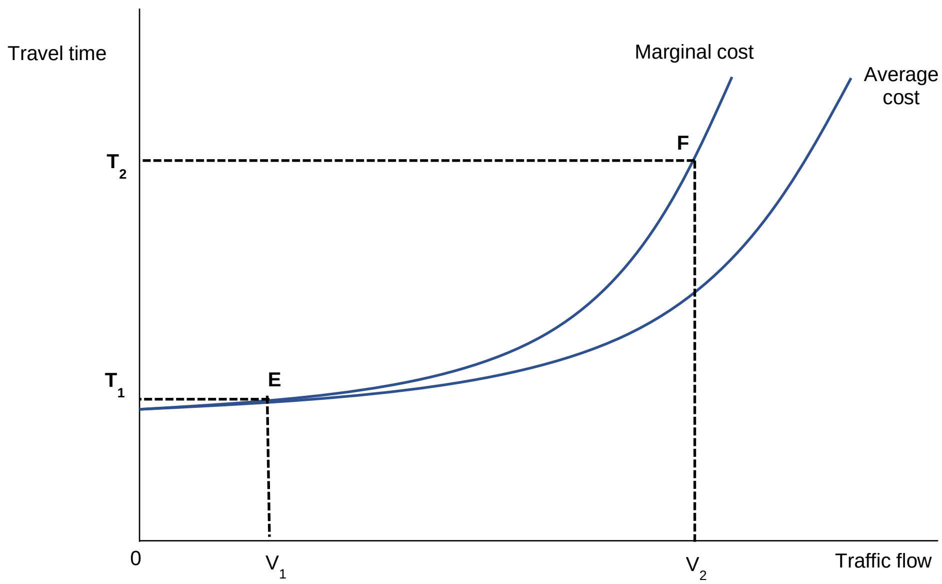
In the context of the above parameters, a speed flow relationship obtains where, given a fixed size of roadway, vehicles may traverse it at varying speeds in a given time period. The average vehicle speed depends on the number of vehicles using the roadway per time period, so that when the volume of vehicles is low, the flow impedance is also low, and all vehicles can proceed at the technically maximum, or legally allowed speed limit. However, as the number of vehicles increases, their interaction with the existing traffic slows each other, resulting in the overall reduction of average speed for all vehicles. Ultimately, a point is reached where the number of vehicles approaches the engineering capacity[1] of the roadway, as the effect of each additional vehicle joining the roadway causes a significant reduction of average speeds for all vehicles. The flow dynamic from maximum speed to this point is referred to as the Normal Flow. Beyond this point, further addition of vehicles to the roadway leads to a reduction of the *flow rate*, with an eventual reduction of speed approaching zero. This reduction of flow is not immediate, since new road users enter the increasingly congested roadway in the absence of information about the looming congestion. As the flow rate slows, vehicles are now deemed to be in a state of Forced Flow, which is the dynamic between the point of engineering capacity, and the reduction of flow rate to zero.

The second approach to congestion is an economic analysis in which the equilibria between marginal costs, average costs and the demand for road space are used to determine optimum levels of road congestion. Bull (2003) further elaborates this dynamic as presented in diagram 1. In an economic context, each road user is shown to face a fixed minimum level of congestion represented as the *Average cost* of congestion for each level of traffic flow. This represents the generalized costs, measured both in terms of money *and* time, which road users bear when using a particular roadway. This cost is measured for each road user, across all levels of traffic flow. *Marginal cost* is estimated as the *additional* cost which each road user bears, as each additional user enters the roadway. At low levels of traffic flow (V_1), where there is still excess engineering capacity, average and marginal costs converge, as shown up to point E. At this level, all road users face an individual *private* cost measured in terms of time of T_1.

[1] Engineering capacity refers to the maximum traffic flow obtainable per time period on a given roadway using all available lanes. It is usually influenced by the prevailing roadway, traffic and control conditions (Gajjar and Mohandas, 2016).

However, as traffic flow increases (V_2), marginal costs begin to increase more rapidly than average costs, as the effects of traffic congestion kick in. As shown at point F, the more rapidly increasing cost variable is seen to be time as commuters now take a longer time (T_2), at slower speeds, to traverse a fixed portion of roadway. The gap between the average and marginal cost curves may be interpreted as an estimate of the overall *social costs* which all road users bear in making a trip.

Diagram 1
Economic concept of traffic congestion



Source: Authors' modification from ECLAC(2003)Traffic congestion: The problem and how to deal with it.

It is also important to consider traffic flows that are less than the optimal. In this case, consumer surplus from trip-making is less than is possible since the roadway is not being utilized up to its optimal traffic flow. In practice, this situation might arise where, based on experience, road users defer economic and/or social activities on the presumption that traffic congestion is occurring on a specific roadway at a particular time, when in fact it is not.

The engineering and economic insights from the analysis point to two broad elements as the cause of vehicle traffic congestion. In the former case, capacity constraints related to roadway design, and the inability to continuously vary road capacity to respond to road demand is evident. This is often made worse by deteriorating infrastructure such as poor surface, unclear signage and markings, poor lighting, and malfunctioning control devices. The latter case reflects the motorists' unawareness of the additional social costs they impose on each other when they seek to use a designated roadway. This is effectively a dynamic market failure of incomplete information, as well as limited opportunity to recoup the full social costs of each motorist's use of the public good that is the road network.

More broadly, additional factors which drive vehicle traffic congestion include inappropriate driver behaviour; poorly designed and maintained roadways; growth in urbanization; as well as historical physical planning decisions which cannot now accommodate newly evolving social, economic and environmental dynamics. These additional variables, in the context of the *economic approach*, frame the following case analysis of vehicle traffic congestion in Trinidad and Tobago.

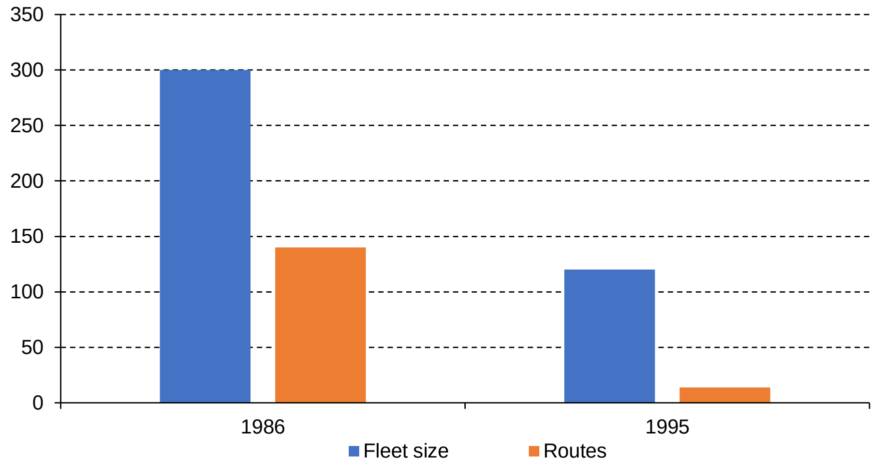
II. Vehicle traffic congestion in Trinidad and Tobago

The evolution of the road network and transportation system provides a useful framework for examining the issue of vehicle traffic congestion in Trinidad and Tobago. Historically, the road transportation network in the island of Trinidad was fashioned around the movement of people and goods between the agricultural plantations and ports (Mohammed and Balbosa-Phillip, 1999). Eventually, a railway system was developed which consisted of two 105 km express lines, one running from Port of Spain to San Fernando and another from Port of Spain to Sangre Grande (Oxford Business Group, 2020). A third line was also established from the West-Central region of Chaguanas to the South-Eastern region, ending in the town of Rio-Claro (Library of Congress, 2023). However, by the early 1960's, high operating costs along with other challenges led to its decommissioning and replacement by a transit bus service –the Public Transportation Service Corporation (PTSC) in 1965 (Mohammed and Balbosa-Phillip, 1999). Initially, the PTSC managed to keep pace with commuter travel demand. However, a fall in demand for the service due to increasing unreliability, led to declining revenues and an eventual downsizing of its fleet and reduction in the number of routes served during the 1980s to 1990s (figure 1).

Furthermore, government policy to facilitate the import of more affordable reconditioned vehicles resulted in increased private vehicle ownership. This, coupled with the expansion of the roadways running east-west and north-south, facilitated the movement of people but with increasing congestion and bottleneck challenges for the society. As noted by Wright and Townsend (2020), this dynamic was especially evident as the demand for travel into the capital city of Port of Spain increased. At the same time, private car owners preferred to use their personal vehicles for their daily commute, as they increasingly regarded public transportation as being generally uncomforatble and inconvenient due to longer travel times. All of these factors caused an increase in the number of vehicles on the country's roadways.

Similar dynamics obtained in Tobago, where the earliest established road infrastructure consisted of one major loop road which ran from the main town of Scarborough to the smaller towns of Roxborough and Plymouth. Two additional main roads via Shirvan and Auchenskeoch, linked this loop to the Crown Point airport and other communities located on the southern end of the island (Library of Congress Country Studies, 1987).

Figure 1
Effect of public transportation service corporation downsizing, 1986–1995



Source: Authors' adaption from Mohammed and Baldosa-Phillip, 1999.

By the early 1980s, the total road network in Trinidad and Tobago was approximately 8,000 km of roadway, of which 4,000 was unpaved and in need of upgrading (Mohammed and Balbosa-Phillip, 1999).

A. The road transportation system in Trinidad and Tobago

The evolution of the country's road network reflects the typical experience of SIDS where their smallness, relatively small population, and limited land resources, pose challenges of economic scale and scope in the development of infrastructure. Their physical geography also has a bearing on mobility and choice of transportation since many of these countries are hilly with limited options for expanding public infrastructure (Wright and Townsend, 2020).

In the case of Trinidad and Tobago, these prevailing factors fostered the creation of a multi-level transportation system, in which the public transportation choices are the PTSC buses, the paratransit modes of transport (maxi-taxis , route and PH taxis) and privately owned cars.

The paratransit modes thrive in Trinidad and Tobago as in other Caribbean SIDS, because they generally service routes not covered by government-owned vehicles, essentially lying between conventional public transportation and private cars. Because they also offer greater flexibility and affordability to underserved areas, these modes of transportation provide much needed service to the public (Wright and Townsend, 2020).

The government owned PTSC, operates a fleet of buses with an occupancy of fifty-five to sixty-five passengers. Smaller buses are utilized to serve rural areas. Although PTSC's fares are the lowest in the sector because they are highly subsidized, its service is significantly underutilized. According to the Ministry of Works and Transport (MOWT, 2021), fifty-six percent of citizens (728,000 commuters) use public transportation daily. However, only three to five percent utilize the PTSC bus service. This low ridership was acknowledged to be on account of limited number of routes covered —only 50% of the routes nationally— as well as commuters' stated preference for the paratransit modes due to PTSC's deficiency in providing a robust and well-functioning transit service (Wright and Townsend, 2020).

At the same time, Wright and Townsend (2020) note a high subscription of commuters to the maxi-taxis. These privately owned, but publicly regulated fleets are managed by their own association, and ply their trade throughout the country, interconnecting all routes. There are approximately five thousand registered maxi-taxis which are licensed to transport between nine to twenty-five passengers. Overall, they transport an average of two million passengers annually.

The route taxis mainly cover residential areas and are not confined to specific routes. There are approximately twelve thousand, five hundred of these registered vehicles which transport one hundred and twenty-five thousand passengers yearly (Wright and Townsend, 2020).

Finally, the widely utilized Private for Hire (PH) taxis, serve passengers along routes that are not well serviced by public buses, maxi taxis or route taxis. Although they are deemed to be operating outside the legal requirements of licensed public transportation vehicles, they are often critical transportation services to underserved communities. In recent years, there has been a further proliferation of this informal and non-conventional transportation in the form of "White T-Vans" (MOWT, 2023). These vehicles operate as non-regulated maxi taxi's, providing a further supplemental transit service to underserved suburban and rural areas.

B. Causes of traffic congestion in Trinidad and Tobago

Apart from the prevailing infrastructure and transportation systems, a number of historic and contemporary developments provide a good context for examining the causes and effects of traffic congestion in Trinidad and Tobago. Among these are population growth, increased urbanization, growth in the rate of motorization, limited expansion of infrastructure, and the lag of physical planning in keeping pace with these developments.

Although population growth and urbanization expanded rapidly on both islands over the years, the physical infrastructure lagged behind (Library of Congress Country Studies, 1987). Data from the CSO (2012) show the 2011 population of Trinidad and Tobago to be 1,324,699 persons which represented a 4.9% increase from 1,262,366, between the censuses of 2000 and 2011.

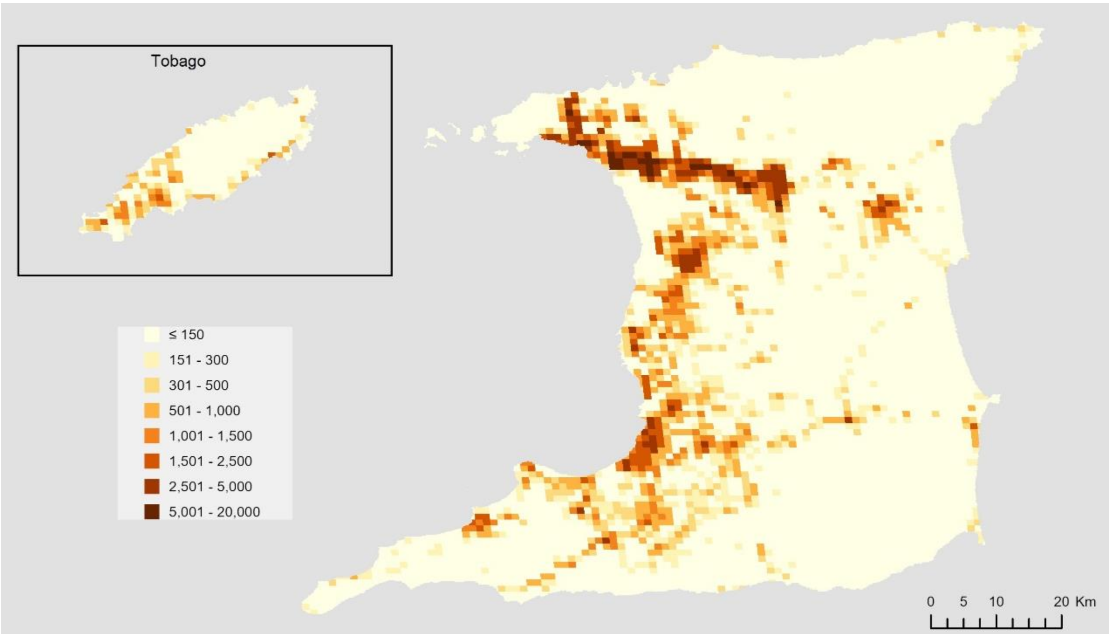
At the time of the 2011 census, 1,267,889 persons lived in Trinidad while 56,810 persons resided in Tobago. Map 1 shows the population distribution by community.

Concomitant urbanization resulted in settlements forming or expanding primarily along the western side of Trinidad and the south-west end of Tobago, as the population increased between the two census years. For instance, there was growth in the urbanized population in the Chaguanas, Sangre Grande, and Couva/Tabaquite/Talparo regions with the highest of 49,450 people occuring in Couva/Tabaquite/Talparo. At the same time, there were losses from Port of Spain, San Fernando, Diego Martin and San/Juan Laventille.

In Tobago, while none of the parishes showed any population declines, there were increases in the parishes of St Patrick, St Andrews and St George, with the highest increase being in St. George (NSDS Surveying the Scene, 2013).

Besides population growth itself, where people live and their flux in movement are also important dynamics when examining the issue of vehicle traffic congestion. In this regard, it is notable that seventy-two percent of the population of Trinidad and Tobago reside in urban areas (NSDS Surveying the Scene, 2013).

Map 1
Population grid of Trinidad and Tobago indicating population density
(Inhabitant per 1-square kilometre)



Source: Generated by the authors using National Population Census Data.
Note: The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations.

Growth in population and urbanization was also accompanied by increasing levels of motorization. This trend is evidenced by the number of vehicles entering the nation's stock since the 1990s. As shown in table 2, vehicle registration across all categories increased significantly between 1990 and 1999.

Table 2
Vehicle registration by type

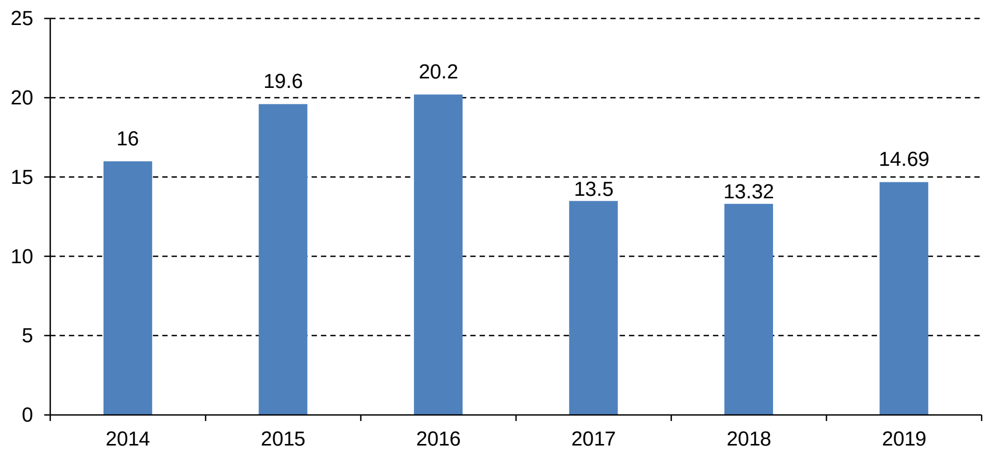
Year	Private	Hired	Omnibus
1990	171 870	26 663	267
1991	139 310	21 454	288
1992	144 235	21 757	291
1993	135 397	20 492	271
1994	137 209	20 523	271
1995	141 047	20 689	271
1996	152 754	21 443	271
1997	165 489	22 285	271
1998	182 253	24 084	272
1999	192 227	25 415	317

Source: Authors' Adaptation from Mohammed and Baldosa-Phillip, 1999.

More recently, vehicle sales continue to trend upwards with 10,707 units sold in *the final quarter* of 2019 (International Organization of Motor Vehicle Manufacturers, 2019). The average addition to the national stock was approximately 15,000 units per year from 2010 – 2019 (Statista.com, 2023). Growth in motorization rates has been facilitated by government policies which have made it easier for citizens to import reconditioned vehicles since the early 1990s.

This has resulted in a high per capita car ownership of 0.5 vehicles per person in Trinidad and Tobago, thus contributing to the intense traffic congestion and long commutes experienced by citizens (Townsend and Wright, 2020). Figure 2 shows motorization trends for Trinidad and Tobago between 2014–2019.

Figure 2
Number of motor vehicles in Trinidad and Tobago from 2014–2019
(In 1,000 units)



Source: Authors' adaptation from: Statistica https://www.statista.com/statistics/880454/motor-vehicle-unit-sales-trinidad-tobago/.

The inability of physical planning to keep pace with the rates of population growth, urbanization, and motorization is also a factor that has exacerbated the level of traffic congestion in Trinidad and Tobago. One important measure in this regard is the expansion of the road network, which currently stands at 9,592km (Ministry of Works and Transport, 2023). Based on figures by Mohamed and Balbosa-Phillip, (1999), this represents an increase in the road network infrastructure of just 1,592 km, or an annual increase of roughly 0.5% per year over the past four decades.

All of these factors together provide reasonable insights into the current traffic congestion situation in Trinidad and Tobago, notwithstanding past efforts to alleviate the problem. The present study gives focus to the potential burden of this phenomenon on the national economy.

III. Study methodology

The literature for quantifying the cost of traffic congestion takes, as a general approach, the calculation of an Aggregate Delay Index[2], and a subsequent estimation of the Value of [such] Time lost. (VoT). This is regarded as a *direct* measure of economic costs and is often supplemented by *indirect* assessments of the social and environmental costs. Typically, these estimations are made for well-defined traffic congestion areas either in city centres or selected transit corridors within broader metropolitan areas. Methodological applications therefore vary by the specific tools used to measure time delays, or the techniques applied with respect to the valuation of time. Naturally, the assumptions made, as well as the approach to the aggregation and/or disaggregation of overall costs, will also have some bearing on the study method.

A. Review of methodological approaches

Among the studies which formed the basis of the present analysis is an estimation of the direct economic costs of traffic congestion (World Bank, 2012), for the Greater Cairo Metropolitan Area in Egypt. This approach used vehicle performance and road engineering analytics such as average freeway speed, volume of vehicles per lane and average daily traffic to impute a measure of time delay. This study also disaggregated costs by types of vehicles and roadways and estimated indirect environmental costs using proxies for CO_2 emissions due to excessive fuel consumption caused by traffic.

Another study undertaken by Harriet, Poku and Emmanuel (2013) looked at the effect of traffic congestion on productivity in Urban Ghana. Unlike the above study, this approach used a survey questionnaire to gauge the numbers of trips *and* incomes made by drivers and commuters over five selected road links, and across peak and non-peak hours. The mean differences in incomes earned with and without traffic, were imputed as the opportunity costs of traffic congestion in that city.

Jayasooriya and Bandara (2017) also undertook an estimate of traffic congestion costs for a section of the Galle corridor in the city of Colombo, Sri Lanka. In this study, the researchers focused on

[2] This is a summation of the total time lost by economic agents due to traffic delays.

vehicle occupancy, number of vehicles, and average vehicle speeds over time in order to arrive at a measure of time delay. On this basis, the opportunity cost of traffic delay was estimated as a direct economic cost for traffic congestion in that city.

With the increasing application of internet enabled technology for monitoring traffic, more recent studies have employed data captured by these tools to model traffic delay times. One such study was conducted by Muneera and Krishnamurthy (2020), in the estimation of traffic congestion costs at selected signalized intersections in Thiruvananthapuram, the state capital of Kerala in India. Using strategically mounted cameras, data were captured on traffic volumes and related approach and stoppage times at selected intersections. One novel element of this approach was the researchers' ability to partition the data according to vehicle type, viz. passenger cars, buses, auto rickshaw, and two wheelers. A random utility model for passengers' value of time by each mode was then used to estimate traffic delay costs at intersections.

For the city of Chittagong in Bangladesh, Fatah, Morshed and Al-Kafy (2022) used a combination of manual counting and video recording to arrive at the average value of delay time for use in evaluating the socio-economic impact of traffic congestion in the port and industrial areas of that city. In this case, these data were used to calculate a Volume to Capacity Ratio as the measure of traffic flow and related this to consumer's willingness to pay for the reduction of traffic congestion as the basis for estimating overall traffic delay costs. Unlike the previous studies, this research also estimated levels of stress as well as fuel loss costs as proxies for social and environmental costs.

While several studies focused on the movement of *vehicles*, others have used *individual* mobile telephony data to gauge the overall movement of passengers. One such case study was done by Fulponi (2022), who utilized cell-phone GPS referenced and GIS data to analyze "flows of people, their origins, their destinations, the routes they have used and even the speeds at which they have circulated". In what was effectively a big-data application, congestion data from Waze, and car flow data from TomTom[3] were used to establish a mapping of congestion intensity for the Buenos Aires Metropolitan Area in Argentina. A specific programming algorithm was then used to segment the areas of varying intensity and differential traffic speeds in order to arrive at an estimate of delay times.

IDB (2021) extended this big-data approach using Waze data to assess traffic congestion costs for ten cities[4] in Latin America and the Caribbean (LAC). Given the large data set employed, and the extensive road networks for several metropolitan areas, a deep neural network model was used to arrive at the number of relevant lanes over which aggregate time delays were to be estimated for the analysis. This, in combination with an index of Value of Time based on the literature, was used to determine traffic congestion costs for the selected cities.

Finally, although the present study makes no attempt to directly assess social costs of congestion, the application of Vickery's 1969 bottleneck model by Kim (2019), also provided some insights for forming an opinion about these possible costs. This approach estimates several econometric models based on variables which reflect individual consumer daily trip making decisions, choices, and queuing times from a United States National Household Travel Survey. These data were supplemented by the Highway Performance Monitoring System data which show geographic distribution of traffic congestion over time. Model coefficients for individual queuing times were used to aggregate total traffic congestion costs based on the numbers of employees who commute daily. From a social standpoint, it is assumed that the quantum of queuing times by commuters approximate the level of economic costs endured by all consumers.

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3 Waze and TomTom are Big Data traffic navigation apps used by commuters to manage their daily commute.

4 Bogota, Buenos Aires, Sao Paulo, Lima, Santo Domingo, Montevideo, Mexico City, Santiago, Rio de Janeiro and San Salvador.

B. Methodology: case study for Trinidad and Tobago

In the Trinidad and Tobago case, a field survey was used to gather data for assessing overall delay times due to traffic congestion. A key assumption which underpins this method is that commuters (both drivers and passengers) are the best assessors of their traffic congestion experience, and able to provide good estimates of the amount of time they spend in traffic during their daily commute.

Further, recognizing that all forms of commuting will incur some amount of time, commuting time for the least congested period was assumed to be the free flow or normal commute time during which vehicle movement was *not* constrained by traffic congestion. For the purpose of this analysis, commuting times for Sundays were deemed to be the free flow traffic times and used as a baseline for the study. Total Traffic Delays were calculated as the difference between Average Delay Time for weekdays (ADT_W) (including Saturdays) and Average Delay Times for Sundays (ADT_S).

Another important element of the methodology is the scope of the study, which was applied to *all* of Trinidad and Tobago. This is an important departure from the typical approach, given that as a small geographic space, it was presumed that all commuters could experience traffic congestion, since there was the possibility of traversing the whole island in any given day, and they could therefore routinely experience traffic jams in any part of the country.[5]

This approach also holds implications for aggregating the Value of Time Lost (VoT) as it allows for the use of a national wage index, as well as the labor participation rate in calculating the overall economic burden of traffic congestion in Trinidad and Tobago. Hence, VoT in this instance is the product of the Aggregate Delay Index, the indexed wage rate, and the number of workers for a range of occupations per unit of time.

On that basis, the *Aggregate* Direct Cost of Traffic Congestion is estimated by the following equation:

$$Aggregate\ Direct\ Cost\ =\sum_{i=1}^{n} ADI(WI\ x\ LPR\ x\ P)$$

Where:

- ADI = Aggregate Delay Index
- WI = Wage Index for each Occupational Category
- LPR = Share of Labour Participation Rate for individual Occupational Categories (%)
- P = Number of Workers in each Occupational Category
- *n* = Number of Occupational Categories

In order to provide a richer analysis for future policy making, the methodology also seeks to *spatially* disaggregate traffic congestion impacts by capturing commuters' reporting of traffic delays across geographic locations in Trinidad and Tobago. Additionally, congestion costs are partitioned to various daily time periods and adjusted for seasonal and/or other social events during the year.

The methodology also broadly assesses additional costs for averting behaviors in which commuters indulge in order to mitigate the impacts of traffic congestion and uses a Likert summated

[5] Note that although Trinidad and Tobago is a twin island state, there is significant movement of passengers and vehicles by ferry between the islands daily, thus making it conceivable for a commuter to experience traffic congestion on either island on any given day.

ratings scale to summarize social impressions of traffic congestion to commuters in Trinidad and Tobago. Specific elements of the methodology are further elaborated below.

1. Survey design

Based on reviews of similar studies undertaken, as well as focused group discussions and cognitive interviews with commuters, a survey instrument was designed to obtain commuters' assessment of their daily time loss due to traffic congestion. In order to capture the spatial dimensions of the problem, the survey instrument facilitated the identification of traffic congestion points using a digital map of Trinidad and Tobago. Additionally, summary data on routine traffic congestion from Waze Traffic Maps were used to identify forty-two (42) commuting routes from which respondents were asked to specify their traffic congestion experience. The survey instrument is presented in the Annex.

2. Sampling method

In order to minimize data collection costs, and to enhance the reach of the survey, data collection was implemented using online Social Networking Sites (SNS). As observed by Ortiz-Ospina (2019), the emergence and use of SNS has resulted in a positive outcome for the distribution of online questionaries. Apart from costs, this approach affords further survey benefits such as reduction in paper wastage and minimizing time spent in distribution.

Considering the sample frame, the target for the study was the population of Trinidad and Tobago. The target was further narrowed to participants who experience traffic congestion either as a vehicle driver, as a commuter who utilized public transportation, or as a passenger who shared a ride in a private vehicle. From the standpoint of SNS, there were 1 million social media users in Trinidad and Tobago as at June, 2023.[6] Of this number, Facebook was the most widely used with a reach of 47.6% of the total population, followed by Instagram with 36.9% of the total population. Twitter (now X™) was utilized by 11.2% of the total population, while LinkedIn enjoyed a much smaller share of just 3.3%. These figures allowed for confident speculation that the survey would reach a wide scope of potential respondents if deployed online.

With respect to targeted sample size, while there's no consensus on the expected response rates from online surveys, Dusek, Yurova and Ruppel (2015), observed response rates ranging from 8% – 32% depending on the nature of the study, as well as the level of promotion, provision of incentives, and the length of time that the survey is 'in the field'. However, researchers such as Schneider and Harknett (2022) point to the decline in response rates for surveys in general, citing respondent fatigue, and changes in overall communication technologies as possible factors.

In this context, the traditional statistical measure of variability within the targeted population remains an important basis for determining the sample size. For the present study, a daily commuting population of 702,000 was used based on estimates provided by Boneo and Townsend (2022). However, given the small physical size of the country alongside the spatial pervasiveness of traffic congestion, the variability of the vehicle traffic congestion experience was assumed to be low. Hence a relatively modest expected sample size of 500 respondents was deemed to be a reasonable target for the survey.

In order to draw this sample, the chain referral technique known as snowball sampling[7] was used in the data collection. This technique uses current survey respondents to refer additional respondents,

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6 https://www.connectivepros.com/post/2023-social-media-statistics-in-trinidad-and-tobago-part-2.

7 In sociology and statistics research, snowball sampling (or chain sampling, chain-referral sampling, referral sampling is a nonprobability sampling technique where existing study subjects recruit future subjects from among their acquaintances. Thus, the sample group is said to grow like a rolling snowball. As the sample builds up, enough data are gathered to be useful for research (Wikipedia).

thereby building on existing SNS structures which comprise the survey respondent's groups and subgroups. The use of the snowball sampling method, which is not a probabilistic sampling approach for accessing potential respondents via social media, creates important challenges. While recent literature (Schneider and Harknett, 2022), suggests strategies for enhancing representativeness, non-probability sampling still limits the researcher's ability to measure the likelihood of each survey respondent being selected. In order to enhance representativeness in the sample, deliberate targeting of under represented subgroups was undertaken during data collection.

3. Data collection

Enketo's web-based survey platform, KoboToolbox™ was used to deploy this study, due to its strengths in capturing spatial data, as well as the elimination of the need to manually enter data into data analysis programs. The survey was opened for online completion over a period of three months from 20 June, 2023, to 26 September, 2023. The online launch was done primarily during the afternoon and evening hours (4:00 p.m. - 7:00 p.m.) since these were the timeframes that participants would check their SNS for updates. This was also the period when there was extensive traffic congestion on main roads and highways in Trinidad and Tobago.

The main SNS's employed were Facebook, Instagram, LinkedIn and WhatsApp, and involved the creation of Posts, Reels as well as Stories. ECLAC social media pages were used in the dissemination of the survey where its followers amounted to 4,700 on Facebook and 2,789 on LinkedIn. These specific social media were prioritized since Facebook primarily attracts users that utilize the site for social purposes whereas the LinkedIn attracts more professionals. This mix of SNS was selected to gather a wide range of survey participants. WhatsApp was also used to target respondents who do not use Facebook and LinkedIn due to data privacy reasons and age categories. The survey was also shared with primary contacts within professional and personal networks, who were then encouraged to reshare it amongst groups. As noted above, a further effort to boost sample representativeness was made through the facilitation of the Trinidad and Tobago Unified Maxi-Taxi Association which randomly distributed 4,000 shareable cards bearing the survey link and Quick Reference (QR) code to commuters.

Online respondent validation tools were also used to ensure that only Trinidad and Tobago residents who experienced traffic congestion could complete the survey. Further, digital survey submission audits provided by KoboToolbox allowed for only a single submission of the survey by a respondent from a specific device.

As the data collection proceeded, the response rate of the survey was monitored, and the need for target adjustment was apparent due to the reduced life expectancy of social media posts. Invitation adaptation was therefore implemented in data collection so as to ensure that the survey reached the target audience. Since it was important to keep the survey respondents engaged, reminders were sent, and graphics and other visual representations were created to garner an emotional response to traffic congestion and were regularly reposted to the SNS. All of these efforts resulted in a 47% increase in responses, from that achieved as at mid-August, 2023.

4. Data analysis

The survey data were analyzed using SPSS – Version 21 for the generation of summary statistics, and QGIS 3.22.3, for the mapping of spatial data. Hourly wage rates were calculated from average monthly wages for occupational groups as published by the Central Statistical Office (CSO) of Trinidad and Tobago (CSO, 2022). Estimated mean traffic delays were then used to calculate annual VoT's for the various occupational groups and to aggregate overall direct economic costs of traffic congestion in Trinidad and Tobago. Sample data were also used to estimate marginal impacts of seasonal activities and events on traffic costs in the country.

IV. Study findings: results of analysis

A. Survey demographics

After three months, 264 respondents completed the online survey, yielding a response rate of 52.8%. Fifty-six percent (56%) of respondents were female with the remainder being male. The majority (83%) commuted at least three times per week and did so by self-driven private vehicle (81%). Significantly, most self-driving commuters carried no passengers on their daily commute, as indicated by a mode of zero for response to this question. In terms of age distribution, 53% were in the 31-45 years category; 17% were between 46 – 55 years; and 7% were between 56 – 65 years. Most respondents classified their occupation as "professionals" (56%). Further, 11% categorized themselves as "technicians and associated professions", and 10% as "clerks". Only 9% regarded themselves as "legal, senior officials and managers" and 6% were in "services (including defense) and sales" (figure 3). Considering commuting expenses, respondents spent an average of $TT1,037 every month on fuel/bus or taxi fares. These figures are largely consistent with estimates of socio-demographic characteristics presented in related studies by Stephen and Townsend (2020) and Wright and Townsend (2020).

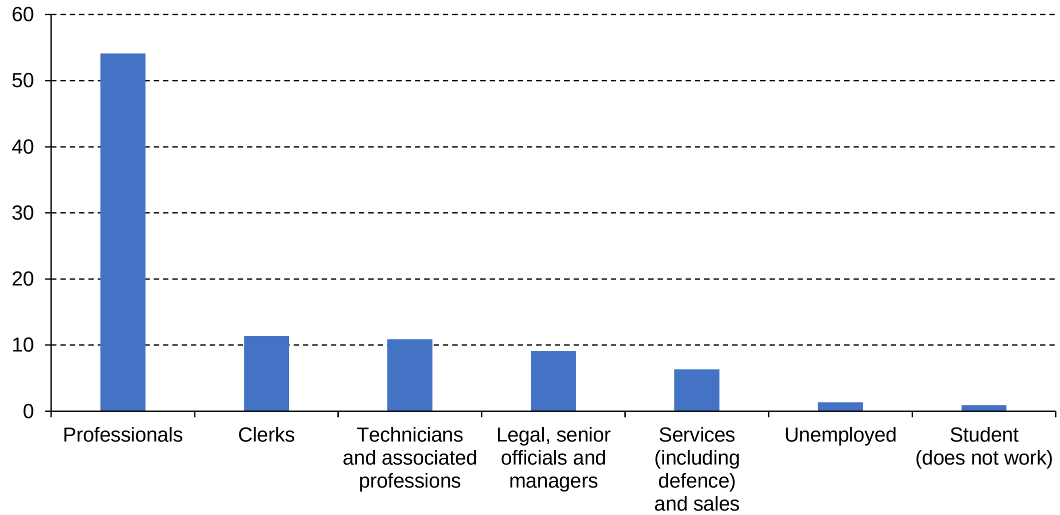
B. Aggregate time delays

The average daily time delays for *weekdays* for various time periods ranged from a low of 3 minutes for "Nights/Late Nights" to a high of 58 minutes for "Late Afternoons". For any given weekday, peak traffic delays occurred in the "Early Mornings" from 4AM – 9AM (averaging 52 minutes), and again in the "Late Afternoon" from 3PM – 6PM (averaging 58 minutes). Afternoon delays were marginally longer than those which occurred in the mornings.

For weekends, Saturdays saw generally longer delay times compared to Sundays, although such delays were significantly less than those of weekdays. This ranged from 2 minutes on Saturday Nights to 15 minutes around the Lunch Hour. This range was however more evenly distributed throughout the day on Saturdays, compared to weekdays.

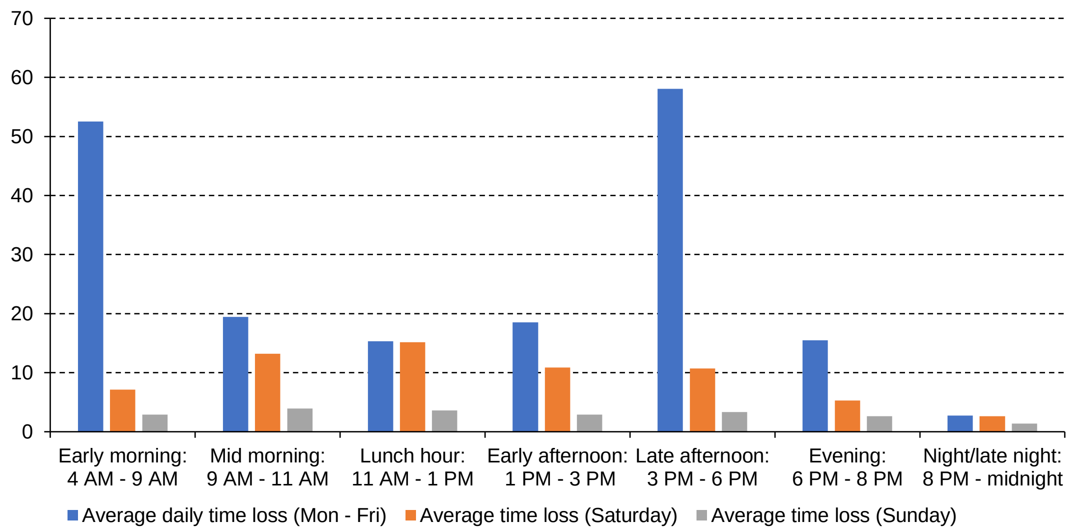
Sundays reported generally minimal traffic time delays from 2 minutes on Sunday Nights to 4 minutes during the mid-morning period. Given that all traffic takes time, the Sunday delays were used as baseline free-flow traffic times in the study (figure 4).

Figure 3
Distribution of occupations in the survey
(Percentages)



Source : Author's compilation from survey data.

Figure 4
Average daily time loss to traffic congestion
(Minutes-weekdays and weekends)

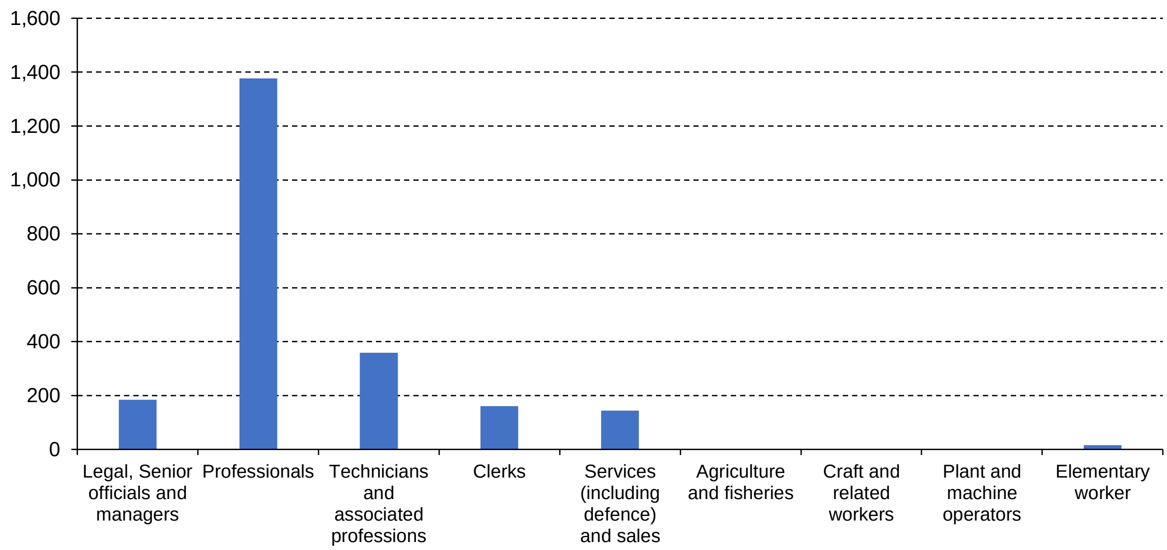


Source: Authors compilation based on survey data.

C. Estimate of direct economic costs

Given the weekly average time lost from the survey, total *annual* time lost *per worker* for Trinidad and Tobago was estimated at 793 hours.[8] This approximates to 16 hours per worker for each workweek. The distribution of lost time across daily time periods is summarized in Table 4. Using hourly wage rates partitioned across the total labor participation rate for 2021, the direct economic cost for traffic congestion in Trinidad and Tobago was estimated at $TT2.26 billion for 2021 or roughly 1.37% of annual GDP (Table 5). From the analysis, it is apparent that time lost to professionals and technicians, results in the highest economic burden due to traffic congestion in the economy (figure 5).

Figure 5
Annual loss from traffic congestion by occupational category
(TTD Millions)



Source: Authors' estimation based on survey.

Table 3
Summary of traffic congestion time lost

Traffic congestion costs estimation								
Weekdays = Monday to Saturday								
Time of day	Average daily time loss (Mon – Fri- minutes)	Total time loss (5 days: Mon – Fri - minutes)	Average time loss (Sat - minutes)	Total daily time loss (Mon – Sat - minutes)	Average time loss (Sunday) baseline - minutes	Net time loss (weekly - minutes)	Net time loss (total weekly - hours)	Net time loss (total annual hours)
Early morning: 4 AM–9 AM	52.53	262.65	7.13	269.78	2.92	266.86	4.45	221.49
Mid-morning: 9 AM–11 AM	19.44	97.20	13.20	110.40	3.95	106.45	1.77	88.35
Lunch hour: 11 AM–1 PM	15.34	76.70	15.18	91.88	3.59	88.29	1.47	73.28

[8] Based on an **annual** total number of working hours of 1992, or 49.8 work weeks. Note that all working times were estimated for the 2021 calendar year, and a **40-hour** work week.

Traffic congestion costs estimation								
Weekdays = Monday to Saturday								
Time of Day	Average daily time loss (Mon – Fri- minutes)	Total time loss (5 days: Mon – Fri - minutes)	Average time loss (Sat - minutes)	Total daily time loss (Mon – Sat - minutes)	Average time loss (Sunday) baseline - minutes	Net time loss (weekly - minutes)	Net time loss (total weekly - hours)	Net time loss (total annual hours)
Early afternoon: 1 PM–3 PM	18.53	92.65	10.86	103.51	2.90	100.61	1.68	83.51
Late afternoon: 3 PM–6 PM	58.06	290.30	10.69	300.99	3.33	297.66	4.96	247.06
Evening: 6 PM–8 PM	15.49	77.45	5.31	82.76	2.61	80.15	1.34	66.52
Night/late night: 8 PM – Midnight	2.74	13.70	2.61	16.31	1.41	14.90	0.25	12.37
Totals	182.13	910.65	64.98	975.63	20.71	954.92	15.92	792.58

Source: Authors' calculations from survey data.

Table 4
Estimation of value of time lost
(Trinidad and Tobago Dollars)

Occupational group	No. of persons (CSO, 2021)	Average monthly income (CSO, 2021)	Average annual income (CSO, 2021)	Hourly wage rate	% Share of occupational category in survey[a]	Annual value of time lost ($TT)
Legal, senior officials and managers	60 100	7 050	84 600	42.47	9.47	191 580 173.27
Professionals	36 900	14 448	173 376	87.04	56.06	1 427 000 700.35
Technicians and associated professions	81 800	8 432	101 184	50.80	10.98	361 595 681.72
Clerks	55 300	5 365	64 380	32.32	9.85	139 530 156.65
Services (including defence) and sales	88 000	5 382	64 584	32.42	5.68	128 443 370.96
Agriculture and fisheries	20 300	3 674	44 088	22.13	0.38	1 353 180.6565
Craft and related workers	71 100	5 260	63 120	31.69	0.00	-
Plant and machine operators	43 200	6 641	79 692	40.01	0.00	-
Elementary worker	101 000	3 509	42 108	21.14	0.76	12 860 425.211
Total direct costs *($TT)*						2 262 363 688.81
Total direct costs *($TT Billions)*						2.26
Total direct costs *(USD)* [b]						0.33
Share of annual GDP (Current prices - 2021)						1.37

Source: Authors' calculations.
[a] Excludes students and unemployed persons, hence percentages do not sum to 100.
[b] Exchange Rate: 1 USD = 6.78 TTD.

D. Spatial impacts

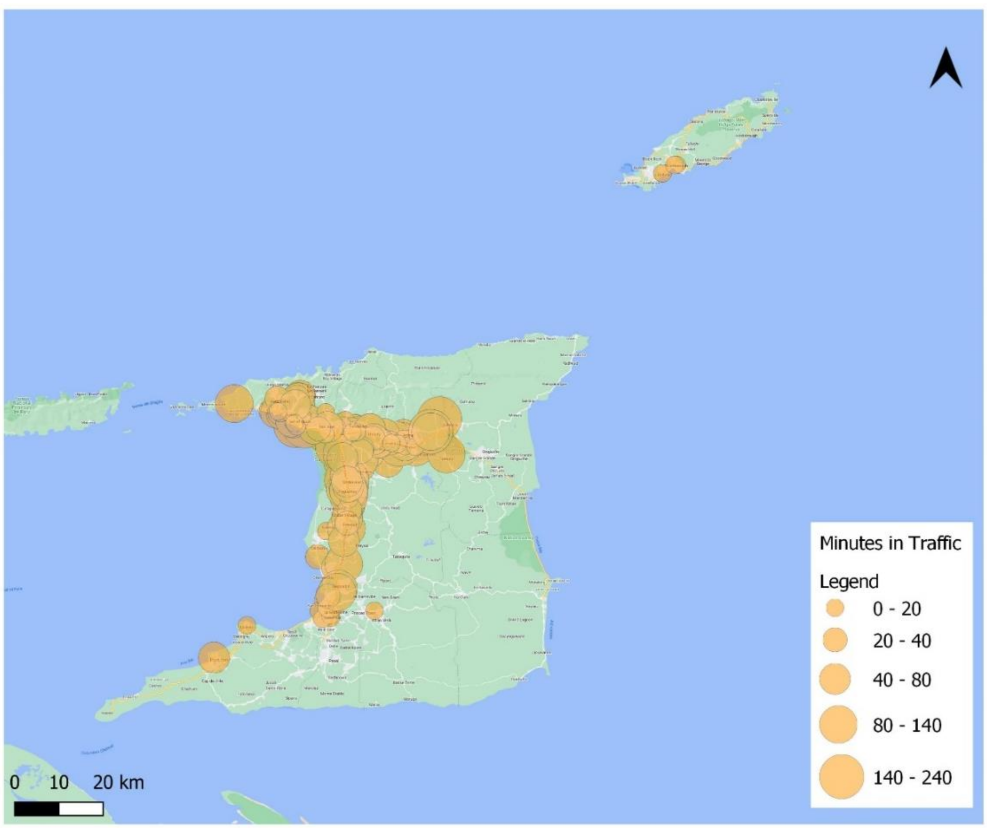
From the survey, commuters reported an average of two (2) locations where they faced significant traffic congestion in their daily commute. Consistent with the distribution of population and the evolved transportation network as discussed above, the most intense traffic congestion is experienced in the more densely populated areas of the country. Taking a regional perspective, transit routes along the main North-South highway (Uriah Butler Highway), and the main roadways of the East-West corridor

(Churchill Roosevelt Highway, Eastern Main Road, Audrey Jeffers Highway and Western Main Road) endure the brunt of the traffic congestion on the island of Trinidad. A significant, level of congestion also occurs along the main arterial roadways of the southwest peninsula which connect to the southern industrial city of San Fernando. Among the specifically recognized intensely congested transit routes are Chaguanas to Port of Spain; Chaguanas to Couva; Arima to Port of Spain; Port of Spain to Diego Martin; and San Fernando to Point Fortin. Less intense, but equally significant traffic congestion, also occurs in regional towns and municipalities such as Sangre Grande in the North-East; and Penal; Siparia; Debe, and Princes Town in the South-Central regions of Trinidad.

In the case of Tobago, while traffic congestion is comparatively less compared to Trinidad, most traffic congestion is experienced in the South-West of the island along Milford Road, and the connecting Claude Noel Highway.

These two roadways form the main arterial connection of the more densely populated southwest, with the island's capital at Scarborough. Additional traffic congestion is also routinely observed on main suburb connecting routes such as Scarborough to Calder Hall, and Scarborough to Mount Marie. A heat map showing the spatial distribution of traffic congestion based on the survey is presented in map 2.

Map 2
Graduated map showing spatial distribution of traffic congestion – Trinidad and Tobago

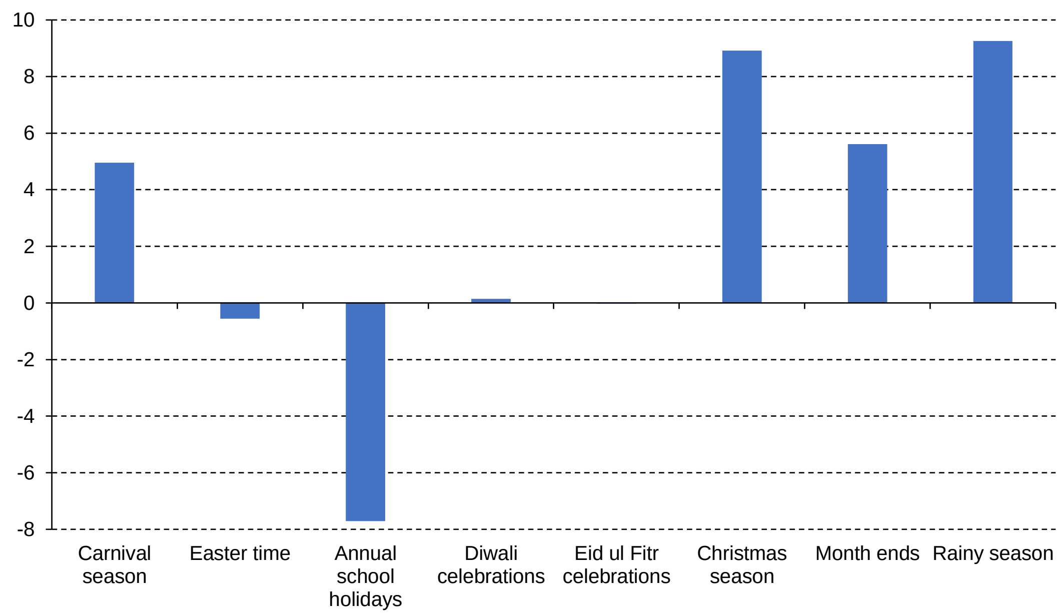


Source: Generated in QGIS by authors from survey spatial data.
Note: The boundaries and names shown on this map do not imply official endorsement or acceptance by the United Nations.

E. Seasonal impacts

Several seasonal events also impact traffic congestion in Trinidad and Tobago. Among them, the rainy season, and Christmas holidays generate *increases* in annual *per capita* traffic delays of 9.3 and 8.9 hours respectively, while the annual school closures *reduce* traffic delays by roughly 7.7 hours annually. The annual carnival season (5.0 hours), as well as month ends (5.6 hours) also significantly *increase* traffic congestion during the year (figure 6).

Figure 6
Seasonal traffic delay change per year
(Hours)



Source: Authors' compilation based on survey data.

F. Averting behaviour and other costs

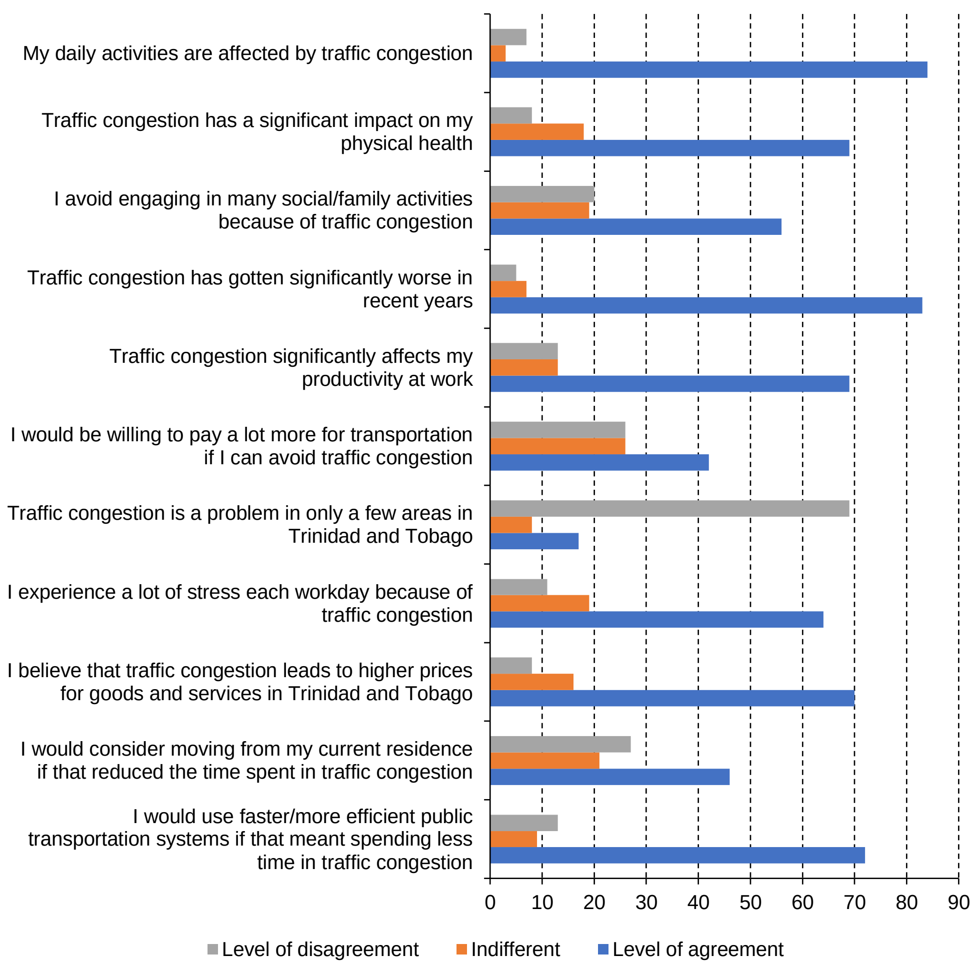
In the face of enduring traffic congestion, commuters typically adopt coping strategies to mitigate impacts. Such averting behaviour may result in additional expenditure such as food, supervisory care for children, communications, or afterwork activities. In the case of Trinidad and Tobago, survey respondents reported an average *monthly* additional costs of $TT558 in order to meet such expenses. This amounts to an additional annual expense of $TT6,696 per capita and represents a further economic burden of traffic congestion in the country.

G. Social impressions

While the study does not attempt to estimate the social impacts of traffic congestion, it recognizes the significant social costs associated with the phenomenon. In order to gauge commuters' sentiment, respondents were asked to rate their feelings with respect to several related statements using a Likert summated ratings scale.

Among the statements rated, there was an overall level of agreement of 84% with the statement "My daily activities are affected by traffic congestion". Moreover, as many as 56% of respondents generally agreed with the statement "I avoid engaging in many social/family activities because of traffic congestion", reflecting the foregoing of social, and possibly related economic activity on account of traffic congestion. Many commuters also recognize the possible health related impacts of long-term traffic congestion as evidenced by their overall agreement with the statements "Traffic congestion has a significant impact on my physical health" (69%), and "I experience a lot of stress each workday because of traffic congestion" (64%). Commuters also manifested an awareness of the potential productivity losses due to traffic congestion by their overall level of agreement with the statement "Traffic congestion significantly affects my productivity at work" (69%). Finally, many commuters regard efficient public transportation systems as a key strategy for overcoming the challenges of traffic congestion. This is apparent in the general agreement of 72% of respondents with the statement "I would use faster/more efficient public transportation systems if that meant spending less time in traffic congestion". Overall levels of agreement or disagreement with each statement is summarized in figure 7.

Figure 7
Summary of social impressions
(Percentages)



Source: Authors compilation based on survey data.

V. Policy implications and conclusions

The most important policy implication which arises from the study findings is the level of public sector investment that would likely be necessary to mitigate the vehicle traffic congestion challenge in Trinidad and Tobago. An opportunity cost, measured in this instance as a direct economic burden of 1.37% of annual GDP is not trivial, and represents a considerable economic benefit that the country routinely foregoes each year because of vehicle traffic congestion. This is brought into sharper relief if it is considered that the estimate closely approaches the GDP contribution (current prices) of the Agriculture, Forestry and Fishing subsector (1.5%), and is 12% of the GDP contribution for the Petroleum and Chemical Products subsector (11%) in 2021 (CSO, 2023). Moreover, in the context of the prevailing dynamics discussed above, it is reasonable to expect that these costs would continue to increase over the medium to long term.

All of the above notwithstanding, a closer examination of the minutiae of the study findings suggests the following main policy options for consideration over the short to medium term:

- Continuing efforts to strengthen public transportation services, including strategies to make public transportation services more accessible and attractive to commuters. In this regard, an examination of the prospects for enhancing the role of paratransit service providers; initiatives to enhance first and last mile transportation options; and efforts to improve public safety of both commuters and service providers are critical.
- Wider adoption of telecommuting as an option to reduce the need for physical commuting especially among the professional categories of workers for whom this may be feasible.
- Further investment in a school bus service which could mitigate the school-generated traffic congestion associated with the daily parental delivery and pick-up of school children.
- Application of better spatial planning and traffic management tools when planning for annual and/or seasonal events.

Naturally, the principal long run strategy of implementation of an *efficient, reliable, and multi-modal* public transportation system, along with decentralization of public services remains key to solving the vehicle traffic congestion problem in Trinidad and Tobago. Such a strategy should be seen to be moving persons off the physical roadway, and onto the digital highway. In this regard, digitally supported analytics for scheduling, tariffing, fleet maintenance, and intermodal connectivity are critical. Finally, efforts to enhance public safety and security would be central to supporting and encouraging the widespread use of public transportation that would be a key requirement for alleviating the vehicle traffic congestion problem.

VI. Limitations of the research

Several important limitations attend the conduct of this study. Firstly, the analysis seeks to measure direct economic costs only. The assessment therefore is not complete and should be seen as at best a lower bound estimate of the cost of vehicle traffic congestion, given that it does not include the social welfare impacts, health effects or environmental costs associated with additional fossil fuel burn, and related green house gas emissions. With respect to the latter issue, Trinidad and Tobago provides a considerable fuel subsidy to motorists, estimated at between 2%-3% of annual GDP for the years 2012–2014 (IMF, 2016). The excessive fuel burn related to vehicles routinely standing idle in congested traffic further exemplifies the extent of the economic costs to the country's economy on account of traffic congestion. But this impact has not been captured in the analysis.

Secondly, it does not attempt to quantify the additional marginal costs related to stochastic impacts on traffic such as vehicle accidents, law enforcement operations or extreme weather events.

A third important challenge as alluded to above relates to the use of the non-probabilistic snowball sampling method for accessing potential respondents via social media. While recent literature (Schneider and Harknett, 2022), suggests strategies for enhancing representativeness, non-probability sampling still limits the researcher's ability to measure the likelihood of each survey respondent being selected.

Bibliography

Atkinson, R., & Flint, J. (2001). Accessing hidden and hard-to-reach populations: Snowball research strategies. Social research update, 33(1), 1-4. https://www.researchgate.net/publication/46214232_Accessing_Hidden_and_Hard-to-Reach_Populations_Snowball_Research_Strategies.

Borneo M. and Townsend T. (2023), "Port of Spain Commuter Patterns and Satisfaction Levels", The West Indian Journal of Engineering, Vol. 45, No. 2, January 2023, pp. 14 – 24.

Brickman Bhutta, C. (2012). Not by the book: Facebook as a sampling frame. Sociological methods & research, 41(1), 57-88.

Button K. (2014) "Transport Economics 3rd Edition" Edward Elgar Publishing Inc. UK.

Central Statistical Office of Trinidad and Tobago (2023), "Annual Gros Domestic Product at Current Prices", Ministry of Finance, Government of the Republic of Trinidad and Tobago - https://cso.gov.tt/subjects/national-accounts/ Accessed September 28th, 2023.

______(2022) "Labour Statistics of Trinidad and Tobago, 2022", Ministry of Finance, Government of the Republic of Trinidad and Tobago.

Dolcy K. and Townsend T.(2022), "Challenges to Alternative Fuel Vehicle Usage in Trinidad", The West Indian Journal of Engineering, University of the West Indies, St. Augustine.

Dusek, G., Yurova, Y., and Ruppel, C. P. (2015). Using social media and targeted snowball sampling to survey a hard-to-reach population: A case study. International Journal of doctoral studies, 10, 279. http://ijds.org/Volume10/IJDSv10p279-299Dusek0717.pdf.

Economic Commission for Latin America and the Caribbean.(ECLAC) (2003).https://www.cepal.org/en/publications/37898-traffic-congestion-problem-and-how-deal-it.

European Conference of European Ministers of Transport (ECMT) (1999), *Traffic Congestion in Europe*, ECMT Round Tables, No. 110, OECD Publishing, Paris, https://doi.org/10.1787/9789264180048-en.

Fattah Md. A., Morshed S. R. and Kafy A. (2022), "Insights into the Socio-Economic Impacts of Traffic Congestion in the Port and Industrial Areas of Chittagong city, Bangladesh, Transportation Engineering, Vol 9, Elsevier.

Fulponi J.I.(2023), "Traffic Congestion in Buenos Aires: diagnosis and public policy recommendations for a more sustainable city", Transportation Research, Procedia, Elsevier, Science Direct.

Gajjar R. and Mohandas D. (2016), "Critical Assessment of Road Capacities on Urban Roads – A Mumbai Case Study" Transportation Research Procedia, Science Direct.

Griffiths, M. D., Kuss, D. J., & Demetrovics, Z. (2014). Social networking addiction. In *Elsevier eBooks* (pp. 119–141). https://doi.org/10.1016/b978-0-12-407724-9.00006-9.

Harriet T.,Poku K. and Emmanuel A. K. (2013), "An Assessment of Traffic Congestion and Its Effect on Urban Ghana", International Journal of Business and Social Science, Vol 4, No. #, Centre for Promoting ideas, USA.

International Organization of Motor Vehicle Manufacturers (2019) "Trinidad and Tobago registered motor vehicles" https://www.ceicdata.com/en/indicator/trinidad-and-tobago/motor-vehicle-registered.

InterAmerican Development Bank (2021) "Urban Road Congestion in Latin America and the Caribbean – Characteristics, Costs and Mitigation", IDB Washington.

International Monetary Fund (2016), "Trinidad and Tobago – Selected Issues: Fuel Subsidies in Trinidad and Tobago - Fiscal, Distributional and Environmental Impacts", IMF, Washington.

Jayasooriya, S. A. C. S., & Bandara, Y. M. M. S. (2017). "Measuring the Economic costs of traffic congestion." In *2017 Moratuwa Engineering Research Conference (MERCon)* (pp. 141-146). IEEE, May2017.

Kim J. (2019), "Estimating the Social Cost of Congestion Using the Bottleneck Model", California State University, Long Beach, USA.

Library of Congress (2023), "Railroad Map of Trinidad (https://www.loc.gov/resource/gdcwdl.wdl _11332/?r=0.004,0.114,0.881,0.551,0) Accessed September, 27th, 2023.

Ministry of Planning and Sustainable Development, Government of Trinidad and Tobago (2013). National Spatial Development Strategy for Trinidad and Tobago: Surveying the Scene: Background Information and Key Issues https://tcpd.gov.tt/wp-content/uploads/2020/10/NSDS_ Surveying-the-Scene.pdf.

______(2013). National Spatial Development Strategy for Trinidad and Tobago: A Planning Framework to Government Physical Development – Core Strategy and Regional Guidance https://www. planning.gov.tt/OurTnTOurFuture/documents/Core_Strategy_Regional_Guidance_web.pdf.

Ministry of Works and Transport (2023). "What we Do". https://www.mowt.gov.tt/Divisions/Highways-Division/What-We-Do.

______(2023), "Draft Policy Discussion Paper on : The Introduction of a Checkered Band Maxi Taxi System for the Servicing of Suburban and Rural Communities Across Trinidad and Tobago", Government of the Republic of Trinidad and Tobago.

Mohammed, A. Balbosa-Phillip A. (1999). The impact of urban management on access to public transportation in Port of Spain, Trinidad. Caribbean Geography ProQuest Central.

Muneera C. P. and K. Krishnamurthy (2019), "Economic Evaluation of Traffic Congestion at Intersection: Case Study from an Indian City", Transportation Research, Procedia, Elsevier.

Naderifar, M., Goli, H., & Ghaljaie, F. (2017). Snowball sampling: A purposeful method of sampling in qualitative research. Strides in development of medical education, 14(3). https://sdme.kmu.ac.ir/ article_90598.html.

Newsday (2021). Sinanan: 728,000 commuters used public transport. https://newsday.co.tt/ 2021/03/16/sinanan-728000-commuters-use-public-transport/.

Nikolopoulou, K. (2022, August 17). What Is Snowball Sampling? | Definition & Examples. Scribbr. https://www.scribbr.com/methodology/snowball-sampling/.

Ortiz-Ospina, E. (2023,). *The rise of social media*. Our World in Data. https://ourworldindata.org/rise-of-social-media#.

Oxford Business Group (2020). Ramp Logistics https://oxfordbusinessgroup.com/online-reader ?id=145026.

Schneider and Harknett (2022), "What's to like? Facebook as a Tool for Survey Data Collection" Sociological Methods and Research, Vol.51, Sage Journals.

Statista. (2023). *Trinidad and Tobago: motor vehicle unit sales 2010-2019*. https://www.statista.com/statistics/880454/motor-vehicle-unit-sales-trinidad-tobago/.

Stephen J. and Townsend T. (2020), "Estimation of Value of Trave Time in Trinidad and Tobago", Faculty of Engineering, University of the West Indies, Trinidad and Tobago.

Townsend, T. Wright, L. (2020). Mode Choice Modelling of Paratransit modes in Trinidad. https://doi.org/10.47412/VSAZ9280.

William S. Vickery (1969), "Congestion Theory and Transport Investment", American Economic Review, Vol 59, No. 2. JSTOR.

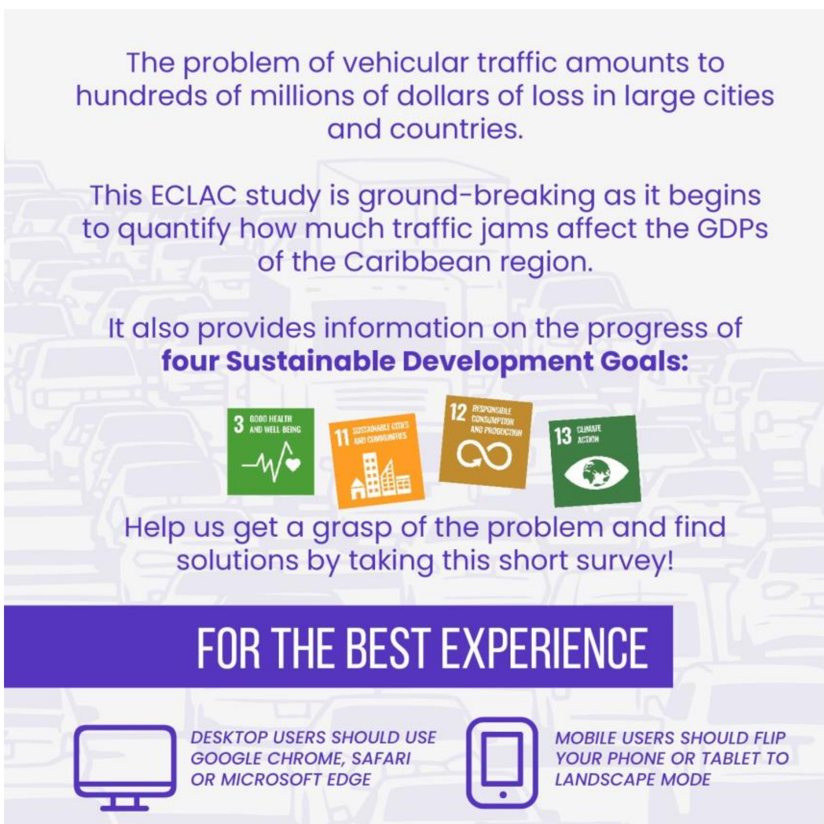
World Bank (2012a), "Estimation of Direct Economic Costs of Congestion in Cairo", World Bank, Washington.

______(2012) "Egypt - Traffic Congestion in Cairo - An Overview of Causes as well as Possible Solutions", Doc # 71852, World Bank, Washington.

Wright L. and Townsend T. (2020), "Sociodemographic Characteristics as it Relates to Travel Behaviour in SIDS: A Case Study of Trinidad and Tobago", Faculty of Engineering, University of the West Indies, Trinidad and Tobago.

Annex

Vehicle traffic congestion survey - Trinidad and Tobago, 2023



1. Do you live in Trinidad and Tobago? Yes [ ] No [ ]

2. If 'Yes', please indicate the Region in which you live (this is your Regional Corporation or Tobago):

Diego Martin	[ ]	Port of Spain	[ ]
San Juan/Laventille	[ ]	Tunapuna/Piarco	[ ]
Arima	[ ]	Sangre Grande	[ ]
Chaguanas	[ ]	Couva/Tabaquite/Talparo	[ ]
San Fernando	[ ]	Princes Town	[ ]
Penal/Debe	[ ]	Siparia	[ ]
Point Fortin	[ ]	Mayaro/Rio Claro	[ ]
Tobago	[ ]		

3. Please indicate on the map the general area where you live:

[*tap on map to specify*]

4. What is your age category?

a) Less than 18 years [ ]
b) 18 – 30 years [ ]
c) 31 – 45 years [ ]
d) 46 – 55 years [ ]
e) 56 – 65 years [ ]
f) Over 65 years [ ]

5. What is your gender? Male [ ] Female [ ] Prefer not to say [ ]

Commuting Experience

6. How often do you commute for work, school, or other social activities *(Regular commute means at least 3-times per week)*?

a) Very often (No less than 12 times per month) [ ]
b) Often (between 8 to 11 times per month) [ ]
c) Occasionally (between 3 – 7 times per month) [ ]
d) Rarely (less than 2 times per month) [ ]

7. How do you commute?

a) Self-driven private vehicle [ ]
b) As a passenger in a private vehicle [ ]
c) By public transport (bus/maxi taxi/taxi/ride share) [ ]
d) By Water Taxi (POS/San Fernando) [ ]
e) By self-driven motor cycle [ ]

8. For self-driven private commuters, please indicate how many passengers typically accompany you on your usual commute: ________________________________

Traffic Congestion Experience - Location

9. In how many locations do you generally face traffic congestion on your usual commute? *(You can specify up to FIVE (5) locations. Enter '0' if you do not experience traffic congestion)* ______________________

10. Please indicate on the map the **main locations** and **total amount of time (minutes)** that you spend in traffic at each location on your usual commute: (*Note: You can specify up to FIVE (5) locations*): *[tap on map to specify]*

Location	Time in Traffic (Minutes)

11. Please indicate on which of the following **routes** you face traffic congestion on your usual commute *(select all that apply)*:

a) Arima/Port of Spain [ ]
b) Arima/Sangre Grande [ ]
c) Calder Hall/Scarborough [ ]
d) Chaguanas/Cunupia [ ]
e) Chaguanas/Port of Spain [ ]
f) Chaguaramas/Port of Spain [ ]
g) Claxton Bay/San Fernando [ ]
h) Couva/Chaguanas [ ]
i) Couva/San Fernando [ ]

j) Cunupia/Piarco [ ]
k) Debe/Penal [ ]
l) Diego Martin/Chaguaramas [ ]
m) Diego Martin/Port of Spain [ ]
n) Gasparillo/San Fernando [ ]
o) Glen Road/Scarborough [ ]
p) Marabella/San Fernando [ ]
q) Maraval/Santa Cruz [ ]
r) Mason Hall/Scarborough [ ]
s) Mt. St. George/Scarborough [ ]
t) Piarco/St Helena [ ]
u) Plymouth/Scarborough [ ]
v) Point Fortin/Icacos [ ]
w) Point Lisas/San Fernando [ ]
x) Port of Spain/Chaguanas [ ]
y) Port of Spain/Maraval [ ]
z) Princes Town/Rio Claro [ ]
aa) Princes Town/San Fernando [ ]
bb) Rio Claro/Mayaro [ ]
cc) San Fernando/Debe [ ]
dd) San Fernando/Point Fortin [ ]
ee) San Fernando/Port of Spain [ ]
ff) Sangre Grande/Mayaro [ ]
gg) Santa Cruz/San Juan [ ]
hh) Scarborough/Carnbee [ ]
ii) Scarborough/Crown Point [ ]
jj) Scarborough/Mt. Marie [ ]
kk) Signal Hill/Scarborough [ ]
ll) Siparia/Penal [ ]
mm) Valencia/Sangre Grande [ ]
nn) Within my neighborhood or town [ ]

Traffic Congestion Experience - Delays

12. Please indicate how many **minutes** you spend in traffic **on an average weekday** for various times of the day:

Time of Day	Average time in traffic (minutes)
Early Morning: 4AM – 9AM	
Mid-Morning: 9AM – 11AM	
Lunch Hour: 11AM – 1PM	
Early Afternoon: 1PM – 3PM	
Late Afternoon: 3PM – 6PM	
Evening: 6PM – 8PM	
Night/Late Night: 8PM - Midnight	

13. Please indicate how many **minutes** you spend in traffic **for an average weekend day** for various times of the day:

Time of Day	Average time in traffic (minutes)	
	Saturdays	Sundays
Early Morning: 4AM – 9AM		
Mid-Morning: 9 AM – 11 AM		
Lunch Hour: 11AM – 1 PM		
Early Afternoon: 1PM – 3PM		
Late Afternoon: 3PM – 6PM		
Evening: 6PM – 8PM		
Night/Late Night: 8PM - Midnight		

14. On average, by how many **minutes** does your usual commute time change (increase/decrease) for the following seasons/periods/events during the year?

Season/Period/Event	Increase/Decrease?	Change of Time in Traffic (Minutes)
Carnival Season		
Easter time		
Annual School Holidays		
Diwali Celebrations		
Eid ul Fitr Celebrations		
Christmas Season		
Month Ends		
Rainy Season		

15. How much do you spend on transportation (vehicle fuel/bus or taxi fares) **per month** $___________

16. On average, how much **additional expenses** do you incur **on a monthly basis** in order to avoid or minimize the impacts of traffic congestion? *(eg. extra meals; child day care; entertainment; health care)*
$____

Employment

17. In which of the following occupations do you work?

a) Legal, senior officials and managers [ ]
b) Professionals [ ]
c) Technicians and associated professions [ ]
d) Clerks [ ]
e) Services (including defence) and sales [ ]
f) Agriculture and fisheries [ ]
g) Plant and machine operators [ ]
h) Elementary worker [ ]
i) Student (does not work) [ ]
j) Unpaid work (family care?)* [ ]
k) Other [ ]
l) Unemployed [ ]

(NB: Occupational categories from Trinidad and Tobago Central Statistical Office's Occupational Groups by Income)

(*Includes, family/home care providers, retirees, home schoolers etc.)

Social Impressions

18. Please indicate your agreement/disagreement with each of the following statements

	Strongly Disagree	Disagree	Neither Agree/ Disagree	Agree	Strongly Agree
1. My daily activities are affected by traffic congestion					
2.Traffic congestion has a significant impact on my physical health					
3. I avoid engaging in many social/family activities because of traffic congestion					
4.Traffic congestion has gotten significantly worse in recent years					
5. Traffic congestion significantly affects my productivity at work					
6. I would be willing to pay a lot more for transportation if I can avoid traffic congestion					
7. Traffic congestion is a problem in only a few areas in Trinidad and Tobago					
8. I experience a lot of stress each workday because of traffic congestion					
9. I believe that traffic congestion leads to higher prices for goods and services in Trinidad and Tobago					
10. I would consider moving from my current residence if that reduced the time spent in traffic congestion					
11. I would use faster/more efficient public transportation systems if that meant spending less time in traffic congestion					

This is the end of the Questionnaire. Thank you very much for your time!

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