Traffic Congestion

Subjects: Economics | Public Administration | Development Studies

Contributor: Felipe Bedoya-Maya

Traffic congestion is ubiquitous in large cities around the world; where it leads to increased air pollution, vehicle noise, and travel time for private and public transportation. These challenges reduce the well-being of both road users and urban populations.

traffic accidents congestion big data Latin America

1. Introduction

Congestion costs in Europe were estimated at over €200 billion in 2016, which was equivalent to 1.4% of the region's GDP [1]. In the United States, such costs amounted to as much as US $160 billion in 2015 in wasted time and fuel [2] and it was expected to grow steadily to US $186.2 billion by 2030 [3]. Recent studies focusing on developing countries showed that in 2019, direct congestion costs in Sao Paulo were equivalent to the annual amount that the city invested in healthcare and twice the annual amount that Buenos Aires and Mexico City invested in education [4]. Mitigating congestion is therefore among the main goals of transportation policy [5].

Along with direct economic costs, the time lost on a congested road that could be spent on other activities, urban congestion is also associated with increased indirect costs, including adverse health effects on individuals [6]. For example, Wang et al. found that ten additional minutes of commuting time due to congestion is associated with a 0.8% higher chance of suffering from depression [7]. More broadly, the World Health Organization (WHO) suggests that congestion is related to higher levels of fatigue, alterations to social behavior (increased anxiety, for example), communication difficulties, and sleep disruption, ultimately impeding societies' sustainable development [8].

Among the indirect costs of congestion, extant literature has analyzed the relationship between congestion and accidents. Indeed, traffic accidents are one of the main challenges in achieving sustainable mobility [9]. Various studies have shown mixed results on this relationship. Based on a comprehensive literature review of more than 70 studies between 1937 and 2019, Retallack and Ostendorf [10] suggest four types of relationships: (i) A positive linear relationship between the volume of traffic and the total number of accidents [11]; (ii) a positive U-shaped relationship where higher levels of accidents are found with both low and high congestion levels [12]; (iii) an inverse U-shaped relationship where the highest level of accidents is reached with an average level of congestion [13]; and (iv) a negative relationship between congestion and fatal accidents, where the effect caused by the speed reduction on accidents outweighs the effects attributed to a higher number of cars on the road [14].

Despite being a long-dated topic of interest in academic literature, there is still no agreement on the way that the amount of congestion and quantity of accidents are related. Scholars have faced two main barriers in addressing this question: (i) The relationship between congestion and quantity of accidents is influenced by a number of circumstantial factors such as weather conditions [15], urban or rural environment [16], travelers' attributes [17], and road design [18]; and (ii) the relationship is bidirectional, meaning that while it is expected that congestion influences the number of accidents, similarly accidents also create congestion (also known as reverse causality) [19]. The absence of temporally and spatially disaggregated data on congestion, the number of accidents, and the various factors influencing the relationship have made it difficult for previous studies to address endogeneity challenges in their methodological strategies [20]. The approaches most widely adopted use indicators to control for specific effects, including the volume-to-capacity ratio (v/c). However, the effect is still influenced by other circumstantial factors, and mixed results have been reported by the literature (see for instance [14][15][21]).

Novel technologies for traffic management such as Automated Vehicle Identification (AVI), Remote Traffic Microwave Sensors (RTMS), Bluetooth traffic sensors, and mobile navigation platforms are now generating large amounts of data to explore congestion and accident patterns at an unprecedented level of granularity [22]. Particularly, the widespread adoption of GPS-equipped mobile phones and the development of mobile applications for trip planning make them a plausible option for collecting massive amounts of traffic and other related information at a relatively lower cost, with higher update frequency, and broader coverage [23]. Despite this potential, to our knowledge, there is little research that leverages this data to explore the relationship between urban congestion and the number of traffic accidents.

2. Understanding the Effect of Traffic Congestion on Accidents Using Big Data, Take Latin America as an Example

Our findings suggest that congestion and accidentality are highly correlated. The overall correlation is 0.81, and it is statistically significant. Moreover, congestion has a significant effect on accidentality rates. According to our estimations, 1,000 additional hours of delay will increase accidentality rates by 0.4%. This result is not negligible, since a 10% decrease in congestion would reduce traffic accidents by 3.4%. This effect is estimated by taking into account the cities' specific traffic conditions and instrumenting the endogeneity between congestion and accidentality. By doing so, we overcome the twofold challenge faced by extant literature when assessing the effect of urban congestion on accidentality. In particular, the granularity of the database allowed us to construct a temporal-spatial partitionable database and apply a Poisson panel data model with an instrumental variable to account for the simultaneous effect of congestion and accidentality in the model.

Results show a positive non-linear effect of traffic delays on road accidents, also after controlling for hazards and roads closed. As such, the effect marginally decreases when delays increase. These findings are related to those of the most recent studies on this subject, which suggest an inverted U-shaped relationship between congestion and accidentality, where the highest level of accidents is reached with an average level of congestion [13].

Analyzing the results obtained for each city in the sample, we find that Sao Paulo and Mexico City would be the cities benefiting the most if congestion decreased by 10%. The number of accidents taking place annually in Sao Paulo and Mexico City would decrease by 5.4% and 4.7%, respectively. Instead, San Salvador, the city with the largest per capita accidentality rate among the ones analyzed in this paper, would obtain a reduction of just 0.3% in the number of accidents. When considering the absolute number of annual accidents, Mexico City would be the area more positively impacted: A 10% reduction in congestion would reduce the number of accidents by 26,000. This reduction would be equivalent to 17 days without accidents in Mexico City. Next in line is Sao Paulo, with a reduction of 23,000, followed by Bogota (11,000); Lima (4000); Rio de Janeiro (3000); Santiago and Buenos Aires (2000); San Salvador (193); Santo Domingo (143); and Montevideo (115).

Our findings are particularly relevant if we take into account the mobility trends in emerging economies and especially in Latin America. The region already holds 4 of the 10 most congested cities in the world (Bogota, Mexico City, Rio de Janeiro, and Sao Paulo) [24]. By 2030, motorization rates are expected to increase by almost 40% [25]. In turn, higher product demand from a growing urban population, together with the boom in e-commerce, is expected to trigger more freight traffic on urban roads [7]. Moreover, while the medium and long-term impacts of Covid-19 are still uncertain, recent studies show short-term changes in modal preferences, increasing private vehicle usage. For example, Basu and Ferreira [26] found that in Boston, 18% of zero-car households intended to purchase a car because of Covid-19, and 26% of them within the following year. In this context, bolder public policies are needed to revert the negative mobility trends, particularly regarding congestion growth [25].

The linkage between congestion and accidentality rates evidenced here can help increase the acceptability of traffic demand policies, particularly when their goal is to reduce car usage. Congestion charging, parking pricing, and low-traffic neighborhoods, among others, are often hard to implement due to the resistance of private vehicle users, residents, and business owners. In these contexts, our findings can aid policymakers in implementing such policies by providing an additional factor that justifies their implementation: Congestion mitigation policies can also help create safer environments.

Likewise, our results help advance research on the relationship between congestion and public health. As mentioned earlier, Wang et al. [7] found that ten additional minutes of commuting time due to congestion is associated with a 0.8% higher chance of suffering from depression. More broadly, the WHO suggested that congestion was related to higher levels of fatigue, alterations to social behavior (more anxiety, for example), communication difficulties, and sleep reduction, ultimately impeding societies’ sustainable development [8].

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