Temporary Reduction in Road Supply: Traffic Congestion Adjustment and Travel Behavior Adaptation

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Abstract

This paper investigates the effects of a temporary reduction in road supply on traffic congestion and commuter behavior, using a natural experiment in São Paulo, Brazil. The unexpected closure of a 5 km section of the city's most important road—a ring road encircling the CBD—in 2018 provides an opportunity to assess short- and long-term traffic adjustments. Using a differences-in-differences (DiD) approach and a high-frequency dataset of identified vehicle counts from more than 1,000 traffic sensors, I show that the affected area lost approximately 5% of vehicles during the period when the overpass was blocked. I then investigate the possible mechanisms of traffic adjustment and commuter behavior following the reduction in road supply, building on Downs (1962). The road closure led to increased congestion and traffic dispersion to alternative routes (route shifting), with little evidence of departure time adjustments (scheduling shifting) or changes in mode choice—public transportation and cycling (mode shifting). When the affected road segment reopened, traffic did not fully return to its previous levels, indicating a persistent decline in vehicle flow. This effect is particularly strong on alternative routes, suggesting some degree of stickiness or commuters learning and adopting new routes. These findings contribute to urban transport policy discussions, highlighting that reductions in road supply, such as street pedestrianization, may not be an effective policy to reduce car dependence. Moreover, such policies can disperse traffic to other areas, and this dispersion effect should be carefully considered in policy design.

Keywords: road supply, traffic congestion, travel behavior, São Paulo.
JEL Codes: R41, C33.

1 Introduction

Urban transportation networks help shape economic activity, labor market accessibility, and urban development patterns. In an urban setting, individuals travel to access essential goods and services such as employment, recreation, shopping, and residential activities. Given the inherent unpleasantness of travel, transportation costs - both in terms of time and money - are typically modeled as a disutility in economic theory. Therefore,

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individuals are expected to minimize their travel costs while also considering factors such as comfort and safety (Small and Verhoef, 2007).

However, individuals typically do not internalize the negative externalities they impose on others, leading to excessive travel demand and traffic congestion. Congestion remains one of the most pressing issues in urban environments, not only limiting individual mobility but also causing various other adverse effects. In addition to increasing travel times, congestion is associated with air pollution, noise, public health concerns (Green et al., 2020; Levy et al., 2010; Zhang and Batterman, 2013), and higher road fatalities (Pasidis, 2019; Retallack and Ostendorf, 2019).

Addressing congestion has been a persistent challenge for policymakers and a constant theme of debate in the transport economics literature. Some strategies focus on pricing mechanisms, such as congestion pricing or subsidies for alternative transport modes like public transit. Another approach involves infrastructure investment, which can target either public and active transportation or the road network for private vehicles. In the first case, investments make these alternatives more attractive through increased availability, convenience, comfort, and safety (Litman, 2004; Wardman et al., 2018). Nevertheless, expanding road supply has been one of the main investment policies to deal with congestion since the second half of the twentieth century.

However, there is no clear consensus in the literature regarding the impact of road expansion on congestion. Theoretical models (Downs, 1962; Anas, 2024) predict that expanding road supply should reduce congestion in the short run, but also increase travel demand, a phenomenon often measured by vehicle-kilometers-traveled (VKT - how many kilometers each vehicle travels). Empirical studies provide conflicting results due to challenges in establishing exogeneity in the road supply-congestion relationship (see WSP (2018), Bucsky and Juhász (2022) and Hymel (2019) for extensive reviews and Duranton and Turner (2011)).

This paper exploits a natural experiment in São Paulo, Brazil. On November 15, 2018, a structural failure in an overpass on the Marginal Pinheiros expressway (a 46 km-long highway) resulted in the abrupt closure of a 5 km section. Thousands of commuters had to adjust their travel behavior in response to this road supply shock. The overpass remained closed for four months, reopening on March 16, 2019. This event provides exogenous variation to analyze short- and long-term effects of road capacity changes on traffic congestion and commuter adaptation. It also allows for empirical testing of Downs' Law (Downs, 1962) and Anas' (Anas, 2024) theoretical model.

2 Research Objectives and Contribution

This study seeks to answer the following key questions:

1. How do commuters respond to a sudden reduction in road supply?
2. What are the dominant adjustment mechanisms—route shifting, scheduling shifts, or mode substitution?
3. Do these behavioral changes persist after the affected road is reopened?
4. What are the policy implications for urban transport planning and congestion management?

By employing a differences-in-differences (DiD) empirical strategy, this paper contributes to the urban and transport economics literature by providing causal evidence on how road supply shocks impact congestion and modal choices. These findings are particularly relevant for urban sustainability policies, such as street pedestrianization or road diets, which seek to reduce car dependence but may lead to unintended congestion spillovers.

3 Data and Methodology

São Paulo features a comprehensive network of traffic sensors/cameras placed in most arterial and collector roads in the city. Since 2015, the city has been recording every vehicle that passes through these sensors, regardless of its speed. Approximately 70% of these records are successfully identified, adding the vehicle license plate to the observation. If the license plate is not identified, the vehicle is still counted and its speed recorded.

Accessing the entirety of records from 2015 to 2022, I obtained a comprehensive dataset comprising both identified and non-identified records[1]. Each observation within this dataset includes the license plate code, timestamp (including day, hour, minute, and second), traffic sensor identifier, vehicle type (ranging from passenger vehicles to buses, trucks, and motorcycles), and the recorded speed of the vehicle at the time of observation.

For this paper, I've specifically focused on data spanning from August 1^{st}, 2018, to June 30^{th}, 2019, despite having access to a broader dataset covering the years 2015 to 2022. This time-frame allows for a detailed analysis with approximately three months of individual records both before, during, and after the event. Using this dataset, I construct the following measures:

- **Vehicle counts** per hour and per day at each camera, allowing for flow analysis.
- **Average vehicle speeds** per hour, enabling the study of congestion dynamics.
- **Hypercongestion classification**, based on the speed-flow relationship per hour and per camera.
- **Individual trip reconstruction**, using license plate tracking to identify control areas and route changes.

[1]Freedon of Infomation Acts 65772 from 20/05/2022, 72853 from 12/04/2023 and 85588 from 03/12/2024 requested to the City of São Pulo by Tainá Souza Pacheco relative to the access of ST1714 - Volumetria de Radares hosted by PRODAM.

Additionally, I incorporate:

- **Cycling counts**, collected from official bicycle counters.
- **Public transport ridership data**, sourced from official agencies, to assess mode substitution effects.

The affected area is divided into four zones: (i) upstream section (before the blocked overpass), (ii) downstream section (after the blocked overpass), (iii) alternative 1 (local lanes of the expressway), and (iv) alternative 2 (a parallel arterial road further east). A control area, unaffected by the closure, is identified by analyzing vehicle trips before the event to determine which traffic cameras were not connected to the affected road segment. The DiD strategy compares traffic conditions before, during, and after the event in both the affected and control areas to isolate the causal impact of the road closure.

4 Main Findings

My findings are divided into general traffic congestion adjustments, and the mechanisms behind the general adjustment. When I look at the flow in the whole day, I see that the affected area (downstream, upstream, alternative 1 and alternative 2) has lost about 5% of vehicles per day. Therefore, it seems that a small share of vehicles have stopped using the region, either because individuals (i) stopped traveling, (ii) found routes besides Alternative 1 and Alternative 2, (iii) changed transport modes.

I do not find an impact in the number of passengers of public transport, nor in cycling counts, so I can discard the third alternative (mode shifting). From the 5% lost in the total vehicles using the affected area, my data does not allow me to say how much was due to stopping travelling and how much was due to drivers finding other routes besides Alternative 1 and Alternative 2.

The effect for the whole day masks adjustments mechanisms related to route change and departure time change. When I investigate the rush-hours, I see that people adapt via route change, with an increase in the flow of Alternative 2, and reduction of speed and increased probability of hypercongestion in Alternative 1 and Alternative 2, 16% and 66% increase respectively. Counterintuitively, I see a decrease in flow in Alternative 1, but this can be explained by the fact that Alternative 1 was already operating at its optimal capacity, so it had no room to accommodate more vehicles. In the hypercongestion state, the reduction in flow is a result of an increased density.

These findings suggest that congestion did not disappear but was redistributed to other parts of the network, consistent with Downs' Law (1962), which predicts that traffic demand expands or contracts to fill available road capacity.

The last travel behavior adaptation mechanism I investigate is the departure time change. I compare the total flow of vehicles in the hours just before or just after rush-hours. If individuals have flexibility in their scheduling decisions, they might change their departure time to avoid the most congested hours (rush-hours). I do not find evidence of this adaptation mechanism.

Finally, I investigate what happens to flow, hypercongestion and speeds after the overpass reopening. Although the reopening is not exogenous, it helps us understand how drivers respond to an increase of road supply. When the overpass reopened, traffic did not return to pre-closure levels: traffic in the downstream section remained 7% lower than before the event; Alternative 1 absorbed some of the permanent changes, with a 5% increase in flow post-event; Alternative 2, which had absorbed most of the diverted traffic, saw a gradual decline in use but remained slightly above pre-event levels. These results indicate some stickiness in commuter behavior, as drivers who had learned alternative routes continued using them even after the expressway was fully operational.

5 Policy Implications

The findings of this paper highlight important implications of road supply for urban transport planning. First, reducing road supply does not necessarily reduce car use—in this case, congestion was displaced rather than eliminated. At least in the short run, it seems that people do not have much scheduling flexibility to adapt their travel behaviors, so they search for new routes.

Second, pedestrianization or road diet policies should consider spillover effects—reducing lanes or closing streets can redistribute congestion rather than eliminate it. Therefore, infrastructure investments that take away space from cars must be accompanied by incentives for mode and scheduling shifts (e.g., improved public transport or cycling infrastructure, and allowing for flexible working times).

6 Conclusion

This study provides empirical evidence supporting Downs' Law in the context of a temporary road supply shock. Drivers adjust their routes until the road reaches its maximum capacity. Adaptation mechanisms such as mode shifts and scheduling adjustments play a secondary role compared to route shifting.

While temporary disruptions may encourage individuals to explore alternative travel options, this alone does not necessarily lead to a reduction in car dependence. Policy interventions should capitalize on these moments by providing attractive and efficient alternatives, such as enhanced public transportation and improved cycling infrastructure.

Ultimately, this study highlights the complexity of congestion dynamics, emphasizing that reducing road supply alone is insufficient to curb car use - it must be part of a comprehensive mobility strategy.

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