# Congestion impacts of shopping using vehicle tracking data

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ABSTRACT

Shopping and retail trade play an important role in the economy, yet shopping activities and associated on-street parking and disruptions to traffic could substantially contribute to congestion in the megacities of the developing and emerging countries. This research investigates and quantifies the effects of shopping and related road-side frictions and disruptions on congestion in a city. We make use of minute by minute GPS tracking data of vehicles and a unique policy of different shopping closure days in different areas of the city, which allows the separation of shopping related congestion effects from commute and other effects. Results show that average speed increased by 18.5% on weekdays when shopping centres were closed. The differences in speed in the different zones can also be qualitatively related with the density of shopping centres in those zones.

## 1. Introduction

The retail trade (high street shopping, food and restaurants) plays a very important role in the economy. They generate large direct and indirect benefits to the economy through employment, income generation and contribution to the GDP. The contribution of shopping and similar retail services to the local or urban economy is even larger, and local shops and shopping centres often provide character to an area. Shopping is also a popular leisure activity. In the USA the retail sector is estimated to provide 16.1% of all jobs and 7.7% of GDP (Price Waterhouse Coopers, 2014). In the EU, the retail trade is responsible for every 1 in 11 jobs (International Council of Shopping Centres, 2015). However, these studies on the impact of shopping or retail trade on local, regional or national economy do not include the potential negative impacts of generating additional traffic and associated congestion and air pollution related health effects – possibly because of the essential nature of retail trade and shopping in modern economy.

Shopping is clearly a major traffic generator, e.g. in England nearly one-fifths of all car trips are shopping trips (Department for Transport, 2016). While it is not uncommon to evaluate the traffic implications of a *new* shopping centre (e.g. through Transport Impact Assessment, TIA) as part of a planning approval process, the overall contribution of shopping related activities to traffic and congestion in an area or a city is often overlooked in the benefit or impact calculations. This research aims to address this important gap, by quantifying the contribution of shopping on traffic congestion at a city or local area scale. In order to achieve this aim, we make use of GPS tracking data of vehicles in Dhaka, the capital of Bangladesh, and the uniqueness of its shopping scene, where different shopping districts are closed on different days of the week. The research is especially unique because shopping related activities in a developing country megacity do not only generate traffic but also aggravate congestion through other means such as unauthorized on-street parking, and we consider these additional means in our effect estimate too. To our knowledge, this is the first study of this kind.

The paper is organized as follows. Section 2 provides a brief background of Dhaka, its chronic traffic congestion and how shops and shopping related activities aggravate it further. Section 3 provides a brief review of relevant literature. Section 4 describes the methods of analysis, data and hypotheses. Section 5 presents the results, while Section 6 draws conclusions.

## 2. Background on Dhaka

Dhaka is the 11th largest city in the world in terms of population (United Nations, 2017) and is one the most densely populated as well. Greater Dhaka is a megacity of > 18 Million people and home to more than a third of the country's urban population. The city is the hub of all economic, political, administrative and cultural activities of the country, and has seen rapid growth since the independence of Bangladesh in 1971. Based on current trends, the city is expected to grow further and accommodate 35 million people by 2035 (Fan and Rama, 2017). Unfortunately, because of poor planning and poor enforcement of existing plans and regulations, the provisions of infrastructure, basic services and amenities in Dhaka could not keep up with the rapid growth of the city, resulting in poor living conditions.

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Transportation provides an important lens in understanding the rapid growth and deterioration of service provisions in the city. During a ten year period between 1995 and 2005, the population in Dhaka grew by 50% and road traffic by a massive 134%, yet the only accompanying improvements in infrastructure provision was a mere 5% increase in road surface (Fan and Rama, 2017). Dhaka is also one of the few cities of similar size which does not have a mass rapid transit, bus rapid transit or suburban railway.[1] The result is not unexpected: the city is consistently ranked among the most congested cities in the world, with concomitant high air pollution adversely affecting human health. In the last 10 years, the average traffic speed has dropped from 21 kph to 7 kph, not too far from average human walking speed of 5 kph. A recent survey of car and bus commuters shows that around 48% of the respondents had a commute time of above 1 h, each-way for their most recent trips, while 22% of the bus commuters travel for > 2 h, each way (Wadud and Huda, 2018).[2] Congestion results in a loss of around 3.2 million hours of productivity every day and is estimated to cost the city several billions USD every year.

Land use in Dhaka has become truly mixed over the last three decades of continuous growth. Previous regulations about commercial activities such as shopping centres, retail trade, restaurants and offices in residential areas were relaxed to accommodate the pressures for these amenities, resulting in a mixed land use. While such mixed land-use is encouraged to reduce traffic (Ta et al., 2016), residential location choice in Dhaka is often based on schooling of children, and not the commute distances or local amenities (Choudhury and Ayaz, 2015), which calls into question the advantages of mixed land use. Especially, the proliferation of unplanned shops and shopping centres throughout the city is thought to be a major contributor to congestion. In a city like Dhaka, shopping activities can contribute to congestion in several ways as described below, although different combinations of these may be at play in different locations.

1. Presence of a shopping mall or a series of roadside shops naturally increases traffic (both motorized and non-motorized) in nearby roads to accommodate the additional trips generated by potential shoppers. This is the typical generated traffic, which is often modelled ex-ante in a TIA process in many developed countries.
2. Nearly in all cases there is a shortage or a complete lack of parking in the shopping centres and roadside shops. This combined with the lack of adequate parking control and enforcement on the roads leads to cars, rickshaws (human-powered tricycle) or autorickshaws (three-wheeler taxi service) being parked on the streets, creating a bottle neck (Photo 1).
3. Lack of adequate drop-off and pick-up points also leads to bottlenecks from vehicles dropping off or picking up shoppers. This is especially visible for para-transits such as rickshaws and autorickshaws, which can be seen taking up road space near the entrances of major shopping centres – competing for passengers (Photo 2).
4. The pedestrian footpaths near some shopping hubs can often be occupied by street vendors forcing pedestrians to walk on the roads, either increasing side friction or creating bottlenecks, both reducing speed and flow (Photo 2). In some areas, the vendors' make-shift stalls could extend onto the road, too, further aggravating the conditions.
5. Loading and unloading of goods for the shops also create bottlenecks. However, only light commercial vehicles are allowed in the city during the day, while larger trucks (above 5 t payload) are allowed to enter after 8 pm.

The importance of shopping on congestion is especially visible during the weeks before the biggest festival on the calendar, the Eid-ul-Fitr, when traffic comes to a near standstill. The area of New Market and Elephant Road, a major retail shopping district, had always appeared to be less congested during Tuesdays, when the shops were closed. Learning from this observation, the authorities devised an innovative plan to manage congestion in February 2010. The city was divided into seven different zones, and the shops and shopping centres in these regions were assigned five different pairs of weekly closure days: one day when the shopping centres will be fully closed, and one day when they will be open only half-a-day and will close at 2 pm. Compliance is excellent for the full-closure days, but half closures are observed less strictly. There was an immediate relief in traffic congestion in the regions where shops were closed, yet there was never an evaluation of the policy either at local or at the city level in terms of quantifying the effect. However, the policy offers a unique opportunity to understand the overall effects of shopping on road congestion.

Fig. 1 shows these different shopping closure zones in Dhaka, while Table 1 presents the days when they are fully and half closed. Note that Fridays and Saturdays are weekends in Bangladesh, although many private offices and businesses may remain open on Saturdays.

## 3. Literature

There is little literature on the impact of shopping on traffic and congestion. While there are some studies on the interaction between shopping and transportation, they are primarily trip based: e.g. trip generation for shopping purposes (Department for Transport, 2016), mode choice for shopping trips (Ibrahim, 2005), effects of congestion charge on shopping trips (Schmocker et al., 2006) or reduction in carbon emissions from shopping trips (Li et al., 2015). There are planning guidelines and regulations in most developed and many developing countries, which regulate the quantity of parking to be made available in a new shopping facility (e.g. in the UK, USA). TIA is also mandatory in several countries, which requires ex-ante modelling of the impact of new shopping (or other large construction) projects on traffic and congestion level as part of the planning permission process. TIA is not applied during the planning process of a new shopping centre in Dhaka, however, the number of parking in any *new* proposed shopping centre has to follow the city's planning codes, but this does not apply to individual shops. Also, the TIA approach is not applicable here since we are interested not on the trips generated by each shopping centre (or many shopping centres), rather on the collective congestion impacts from the additional shopping trips as well as other shopping related frictions and disruptions outlined earlier.

The effects of e-shopping on traffic is an active research area within the transport community, with a growing literature (e.g. Braithwaite and LCP Consulting, 2017, Cairns, 2005, Rotem-Mindali and Weltevreden, 2013). However, the primary focus of this strand of research is the trade-off between the reduced trips or traffic generated by the shoppers versus the increased trips or traffic generated by the delivery services, again making them not very useful here. License plate based bans on cars during different weekdays directly ration the road space and appear to have some similarity with the policy in Dhaka, yet, these are quite distinct policies. Car bans on alternate days or different days of the week, as implemented in Mexico City, Bogota, Beijing or Athens, have primarily been implemented to control air pollution. Different shopping closure days in Dhaka allocate road space only indirectly, and was primarily a traffic management tool. As such the metric of evaluation is quite different and not comparable.[3]

The use of GPS based vehicle tracking for decision making

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[1] The construction of the first mass rapid transit track has started recently, and is due to be completed in 2025

[2] This number has not been published in Wadud and Huda (2018), but derived from the raw survey responses used in that study.

[3] For example, a quick literature search shows that most of the literature on the effect of Mexico City's "Hoy No Circula" programme, which is one of the earliest of its kind, focus on emissions or ambient air quality before and after the policy.