

Abstract

Daily commuting and urban air pollution are closely connected. Motorised travel, particularly by private cars and motorised two-wheelers, contributes to vehicular emissions, while commuters using all travel modes may be exposed to the resulting pollution during their journeys. This is especially true in South Asian cities, where ambient air quality routinely exceeds safe limits and where many people travel in open or semi-open modes such as buses, auto-rickshaws, and two-wheelers that offer little protection from outside air. Long-term exposure to this air has been linked to respiratory illness, heart disease, and reduced life expectancy. Most of the existing research on the link between transport and air pollution has focused on emissions, that is, on what vehicles release into the air, while comparatively little attention has been paid to the behavioural side of the problem: how commuters perceive air pollution and how they change their travel choices in response. In particular, the standard models of travel behaviour do not include air pollution exposure as part of the commuter's decision, even though commuters in polluted cities clearly care about the air they breathe.

A close reading of the literature reveals three persistent gaps. Exposure is treated as the ambient concentration in the surrounding environment rather than as the perception that actually influences behaviour; behavioural evidence is drawn almost entirely from single-season cross-sections, so the seasonal stability of pollution-aware preferences has not been tested; and the existing work stops short of translating its insights into a deployable tool that commuters can use. A systematic review of the literature identifies the attributes through which commuters adapt to pollution, namely the mode of travel, the choice of route, and the timing of departure, and the moderators that shape the response, including air quality awareness, information channel, health condition, income, and commuting frequency. These attributes and moderators form the empirical scaffolding for the behavioural models that follow. Collecting the right kind of data required a survey instrument that off-the-shelf platforms could not deliver. An in-house, open-source dynamic survey platform was therefore developed with geo-coordinate capture, mode-conditional choice cards, automatic panel identifiers, and structured JSON output. A six-section questionnaire

combined revealed-preference items on trips, awareness, attitudes, and health symptoms with two D-optimal stated-preference experiments on mode and route choice. The instrument was deployed across two waves in the Kolkata Metropolitan Area, the high-pollution winter season and the moderate summer season. The matched-panel subsample of respondents who completed both waves supports the seasonal-stability analyses that follow. To the best of the author’s knowledge, this is the first two-season panel data collection on pollution-aware travel behaviour carried out in the Indian context.

The aim of the dissertation is to assess the impact of perceived air pollution exposure on urban travel behaviour and to translate the resulting insights into a decision-support tool that helps commuters reduce their personal exposure. The framing emphasises *perceived* rather than *ambient* exposure, on the grounds that a heavily exposed but unaware commuter does not adapt, while a moderately exposed but aware commuter often does. The aim is pursued through four objectives. The **first objective** validates the perceived-exposure construct against an independently estimated ambient air quality surface, establishing that what commuters report perceiving corresponds defensibly to what they actually breathe along their trip. The **second objective** models mode choice through a hybrid factor and latent class cluster analysis that recovers three behaviourally distinct segments of the population, a pooled mixed logit on the winter sample, and a panel mixed logit on the two-wave data; the air quality of a travel alternative is shown to enter the decision through its interaction with travel time, and the mechanism is qualitatively the same in both seasons but significantly amplified in winter. The **third objective** addresses the route margin through an interaction-only binary logit on the winter stated-preference data, triangulated through a tree-based machine-learning specification and a deep-learning specification with feature attribution; the three paradigms converge on the same top-tier features (route air quality, pre-trip information, travel cost), and a panel binary logit with seasonal interactions shows that commuters are willing to pay roughly three times as much for cleaner air in winter as in summer. The **fourth objective** translates these findings into the *Dynamic Routing for Urban Mobility* (DRUM) application, a multi-criteria routing tool that returns five route alternatives including a Least Exposure Path and a Least Energy Path; a Delhi demonstration shows that the exposure-aware route can cut on-route pollution intake by up to half at a modest travel-time cost. The tool is paired

with an evidence-linked policy agenda that extends the exposure-reduction logic to the mode-captive segment of commuters for whom routing-level adaptation is not available.

The dissertation makes four contributions. *Theoretically*, it formalises perceived air pollution exposure as a behaviourally meaningful construct on which discrete-choice models can be estimated and validated. *Methodologically*, it introduces a reusable dynamic survey platform, the first two-season panel data collection on this topic in the Indian context, and a three-paradigm logit–ML–DL triangulation framework. *Empirically*, it delivers the first systematic Indian evidence on pollution-aware mode and route choice under a seasonal contrast, including the seasonal amplification of willingness-to-pay for cleaner air and pre-trip information. *In policy and practice*, it delivers the DRUM tool and an evidence-grounded policy agenda.

The present work is based on a two-season panel collected over a single year, and its behavioural findings are derived from stated-preference experiments. Future research can extend the work in several directions. A multi-year panel would capture year-to-year variation in pollution levels and test the persistence of the seasonal amplification documented here. Stated-preference choice cards that incorporate real-time air quality information at the moment of the choice task would more closely mirror the information environment in which commuters actually decide. A daily travel diary study, in which the same respondents record their trips and perceived air quality every day for a sustained period, would allow the present cross-sectional and seasonal findings to be compared against revealed daily behaviour and would deepen the picture of how pollution-aware adaptation unfolds in everyday life. The broader ambition of the dissertation is that air pollution exposure should no longer be treated as an externality of the mobility system but should be recognised as one of its design variables.

Keywords: perceived air pollution exposure; urban travel behaviour; latent class cluster analysis; mode choice; route choice; decision-support tool.