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Modelling residents' travel behaviour during a summer Olympics and Paralympics: Concepts, approaches and methods

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Abstract

Approximately sixty per cent of the tickets to the Brisbane 2032 Games are projected to be purchased by residents of South East Queensland. How residents travel, both to events and for other purposes during the Games, will be critical to their success. The aim of this paper is to develop the concepts, approach and methods for three inter-linked problem statements. The first determines the proportion of people who become 'resident spectators for non-ticketed events' per day during the Games, and their likely trip choices. The second explores likely changes to residents' usual travel behaviours under various Olympic travel demand management (TDM) scenarios. The third develops an agent-based model to represent this behaviour and predict travel flows. These are important inputs into the models being developed by the Queensland Department of Transport and Main Roads to forecast travel demands during the Games period. The first problem will be addressed using past event data from the Gold Coast Commonwealth Games, from previous Olympics, and from online stated preference panel surveys with existing SEQ residents. To address the second problem, on non-spectator travel during the Games, the main approach will be the same online panel surveys, capturing choices for changes in daily travel behaviours, including for commuting and work-from-home, leisure trips, and more. The third and final problem will be addressed through the development of an agent-based model, using inputs from the previous two problem statements. This research builds on previous studies on mega-events and host community travel choices but is also novel, partly due to the regional nature of the 2032 Games. With survey data collection underway, the future analysis will test hypotheses about how residents adjust their travel patterns in response to event-related disruptions and demand management measures.

1 Introduction

Mega events such as the Olympics significantly impact the host city's transportation network, with the capacity to create congestion, elongated travel durations, and shifts in travel patterns among both residents and visitors (Müller, 2015; Preuss, 2015). Forecasting travel behaviours during these events is vital for effective transport planning and management. Traditionally, these events have been concentrated in a single metropolitan area, which, while simplifying logistics, escalates infrastructure costs and the environmental footprint due to the need for new constructions to accommodate the event's various activities (Essex and Chalkley, 1998). Though Paris 2024 Olympics used mostly existing stadiums and this was thought as the leading approach for such events moving forward (Doustaly and Zembri-Mary, 2024), The International Olympic Committee's is now shifting towards a regional, inter-city model for

hosting the future Olympic Games (Raco and Di Vita, 2024). This approach leverages existing infrastructure across a broader area, enhancing sustainability by mitigating the need for new development. While transportation planning for such large-scale events is inherently complex, spreading the event across a region introduces additional complexities, increasing inter-city travel demand, and generating new logistical and coordination challenges. The Brisbane 2032 Olympics and Paralympics will see sporting events across three major urban centers in South East Queensland (Brisbane, Gold Coast, and Sunshine Coast) over 150km apart.

Host communities gain a range of economic, social, and infrastructural benefits of mega-events, but also are asked to behave in ways that help them succeed (Preuss, 2007). This is particularly so for transportation during mega-events, where local residents can enjoy travelling to and seeing events, but are asked to significantly restrain their non-event-related travel. These issues are situated at the intersection of the research (sub) fields of travel behaviour, transport planning, travel demand management (TDM) and events management. These issues are always a focus of intense speculation, research and planning activity in host cities, especially in those hosting the Summer Olympic and Paralympic Games. Though the region recently hosted the 2018 Commonwealth Games, the travel demands for a Summer Olympics are roughly six-times greater and robust predictions of travel patterns are necessary.

Olympic Games can generally be divided into two kinds of events. Ticketed events, which require attendees to purchase tickets in advance, tend to have more predictable travel patterns, as the time and location of these events are fixed. Such predictability allows for more effective transportation planning. The anticipation of higher travel demand at specific times can also lead to enhanced traffic management strategies around these venues .Non-ticketed events, on the other hand, may attract spontaneous attendance, leading to less predictable travel patterns (Davies et al., 2010). Most non-ticketed Olympic events, such as marathons, road cycling, triathlons, and race walking, typically feature a small ticketed area but the majority of the route remains free-to-view for the general public. These events often result in sudden surges in local traffic volume, challenging urban transportation networks. These events necessitate rolling or full road closures along the course, leading to widespread disruption of normal traffic flows and posing significant challenges for local travel and public transport operations. Effective management of non-ticketed events requires flexible transportation strategies that can adapt to rapid changes in demand, including the provision of additional public transport services and real-time traffic information to the public. Some examples of such events can be seen in the table below.

Table 1: Ticketed and Non-Ticketed Events

Ticketed Events	Non-Ticketed Events
Athletics	Marathon
Swimming and Diving	Road Cycling
Gymnastics	Triathlon
Basketball	Open Water Swimming
Tennis	Sailing
Equestrian etc.	Race Walking etc.

The issues confronting Brisbane 2032 have their own unique characteristics because of the new regional approach. Whereas most previous Summer Games cities have built a bespoke Games Precinct, the Brisbane 2032 event will almost entirely use existing stadia and transport systems across a much larger city-region. The Queensland Government's 100-Day Review, conducted by the Games Independent Infrastructure and Coordination Authority (GIICA), has outlined a strong commitment to a regional strategy for Brisbane 2032. While the main stadium will be built in Victoria Park, the Games will feature a widely distributed venue model, with

events such as rowing in Rockhampton, sailing in the Whitsundays, and football matches in Cairns. Approximately one-third of all events are on the Gold Coast and Sunshine Coast and not in Brisbane, separated by over 150km travel distance. This approach aims to maximize community benefit across Queensland. The Gold Coast also hosted the 2018 Commonwealth Games where a very effective TDM campaign reduced non-Games travel well below the levels required for a successful event (Powell, 2019). It is not known whether using similar techniques again will have the same effect. Having some insights into the travel behaviours we are likely to see is critical to Games transport planning.

This paper develops the approach and methods for three problem statements, in order: First is the non-ticketed event travel behaviour for the residents. Second is the base line travel behaviors of residents under the games TDM measures. Third is the creation of an agent based model based on above two studies. This requires predicting travel choices of residents during the event, distinguishing between regular daily travel and event-related travel, and identifying the propensity to travel, the peak travel times and modes of transportation to popular non-ticketed events. Predictor variables include socio-demographic variables, residential proximity to event venues, the availability of transportation options, and the transportation policies applied during the Games. This research is part of an industry-embedded PhD being carried out in collaboration with the Queensland Department of Transport and Main Roads. Five PhDs are conducting independent and collaborative research on different aspects of Transport for Games. The panel survey for this study is currently underway and is expected to be completed before the conference. This methods paper is presented independently of the survey results, which will be available for presentation at the conference.

2 Background

2.1 Travel demand management and event travel behaviour

Travel Demand Management (TDM) refers to a set of strategies aimed at influencing travel behaviour to optimize the use of transportation network. It encompasses a range of measures intended to reduce congestion by encouraging alternatives to single-occupancy vehicle use, such as carpooling, public transit, and non-motorized travel (Aytekin et al., 2024). TDM emerged primarily in response to the challenges of traffic congestion and environmental concerns. Additionally, the concept has evolved to focus more on operational strategies to manage travel demand effectively and adapt to changing urban dynamics (Coulombel et al., 2023). The TDM approach often applies the “4R” behavioural framework to describe how individuals respond to interventions: Reduce (avoiding the trip), Retime (shifting the time of travel), Reroute (taking an alternative path), and Remode (switching travel mode) (Parkes et al., 2016).

There is also the concept of the "social contract" in the context of large events which highlights a set of unwritten agreements and expectations among the government, event organizers, and the host community (Mair et al., 2023). This social contract is predicated on the notion of being "good hosts" which involves not only hospitality but also specific behavioral adjustments to ensure the smooth execution of the event. The host community's cooperation is essential for the success of any major event. This often means that residents are asked to avoid certain activities, such as unnecessary travel on specific roads or areas to reduce traffic congestion and enhance security measures. The community's willingness to adjust their routines can be seen as part of their contribution to the broader benefits the event is expected to bring.

2.2 Travel demand management at the 2018 Commonwealth Games

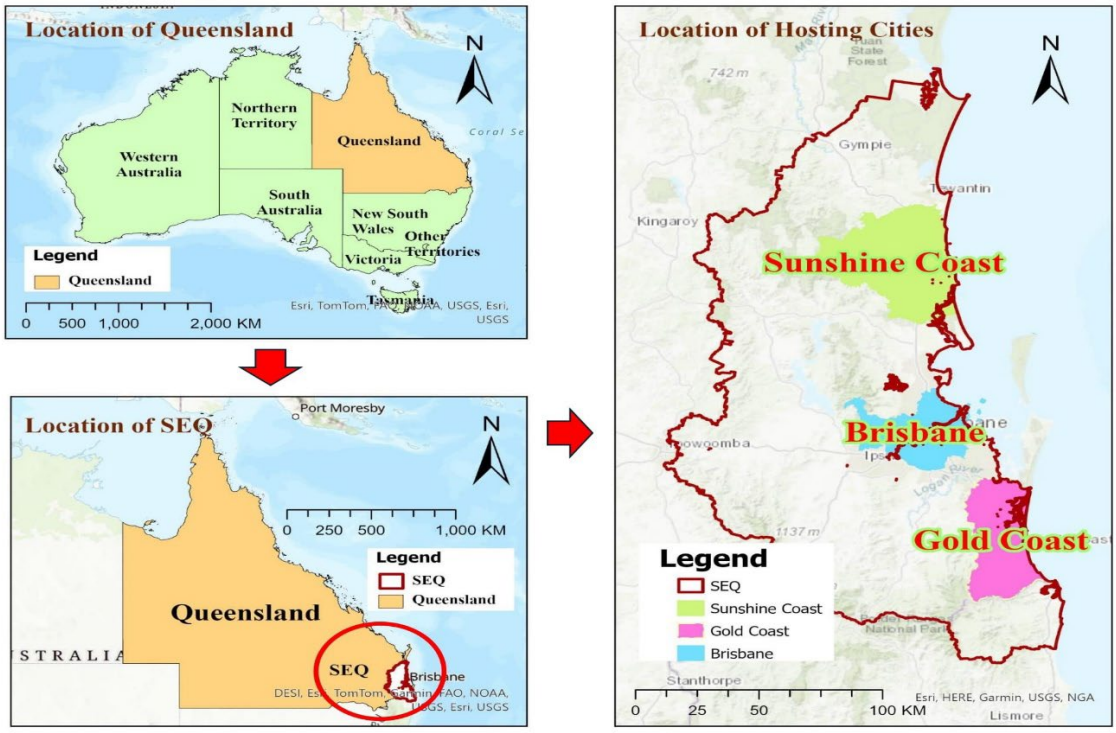
An example of these TDM measures in effect in the region can be seen in the 2018 Commonwealth Games on the Gold Coast. The Gold Coast 2018 Commonwealth Games demonstrated effective TDM with over 1.2 million spectators and participants utilizing enhanced public transit systems and facing minimal transport difficulties, indicating a well-prepared TDM approach for large-scale events. This effort contributed to the overall success

of the Games, ensuring that transport issues did not overshadow the sporting events. Similar strategies were observed in other major international events, providing valuable lessons in urban planning and transport management (Currie and Delbosc, 2011). Several key transportation demand management measures were implemented to manage and optimize the use of transport infrastructure effectively during the event. The number of daily public transport services was increased and a special 24/7 shuttle service was established to connect sports, accommodation, and entertainment precincts. The M1 motorway saw several traffic management initiatives including reduced speed limits and temporary ramp metering to maintain traffic flow. Additional Traffic Response Units were deployed to ensure rapid incident clearance during the games. Extensive public engagement activities were conducted to prepare residents and they were asked to stay off the road as much as possible sighting congestion blocking. These measures were part of a comprehensive strategy to ensure that the transportation system could handle the increased demand efficiently and sustainably, minimizing disruptions while enhancing the experience for both locals and visitors during the games. These measures were very effective and congestion on the roads was even less than normal during the games period. This speaks for the effectiveness of these TDM measures applied but can also be a double-edged sword. Residents who were warned off the road and saw the conditions afterward may have a subconscious aversion to follow these recommendations in the future undermining the importance of the process (Powell, 2019).

2.3 Residents' travel and Brisbane 2032

Brisbane Olympics 2032 will be the first regional summer Olympics to be ever held. Brisbane was announced as the host city for the 2032 Summer Olympics and Paralympics on July 21, 2021. While Brisbane will host the majority of ticketed events, the Gold and Sunshine Coasts will accommodate popular non-ticketed events (i.e. the marathon), as shown in Figure 1, and provide the majority of formal visitor accommodation. Some Olympic events will be held in locations as far north as Cairns, highlighting the unprecedented regional spread of Brisbane 2032. Planners need to predict intra- and inter-city travel on limited rail and road corridors during peak Games periods, for both residents and visitors. From a time geography perspective, Hägerstrand's space-time prisms constrain which sessions residents can feasibly attend after accounting for work, childcare and return-trip windows (Miller, 2017).

Figure 1: Brisbane 2032 Regional Distribution



This geographical distribution of events poses significant challenges in terms of travel arrangements when many events occur simultaneously in different locations. The population in the SEQ region is unevenly distributed, with dense urban centers and sparser suburban and rural areas. Residents in less densely populated or suburban areas might face challenges such as longer travel times and fewer direct public transport routes. These limitations will affect their ticket purchase and travel choice behaviours.

A series of TDM measures will be essential to manage the increased transportation demands effectively during games. Closure of schools and universities, public sector leave, Adjustment of office and shift timings, and Working from Home are some of the measures proposed for this purpose. For the researcher confronting these problems, the key decisions are around what approaches and methods should be selected, and the key variables required for data collection.

3 Approach and methods

Both non-Games 'base layer' travel and non-ticketed event travel require a two-stage methodological approach, beginning with stated-preference discrete choice surveys. For this study, SurveyEngine will be used for survey design, and to recruit a diverse panel that matches the demographic profile of typical Olympics attendees, and ensure the panel is large enough to provide statistically significant data. For the 'base layer' travel, Ngene software is being used to design an efficient discrete choice experiment; cross-sectional panel surveys will then be conducted to gather data about changes in travel behaviour for residents under Games travel condition. The results will feed into an agent-based modelling (ABM) framework, which uses the discrete choice survey data to simulate individual travel behaviours within a dynamic, multi-city transportation network. The ABM will be structured around several core components to ensure an accurate representation of the complex travel interactions expected during the Olympics.

A very similar approach will then be applied for the non-ticketed event travel, but with separate panel surveys of residents, prospective interstate visitors and prospective international visitors. The agent decision-making will be modelled based on survey responses, allowing for realistic simulation of travel choices under varying conditions. Dynamic routing algorithms will be integrated to enable agents to respond to simulated network conditions, including constrained inter-city transit options, which are crucial for optimizing flows between Brisbane, Gold Coast, and Sunshine Coast. Transport capacity constraints will be modelled to reflect the limits of public transport infrastructure, simulating potential peak load stresses during high-demand periods. Additionally, the ABM incorporates behavioural adaptation mechanisms, enabling the agents to adjust their travel patterns in response to evolving transportation network demands. This dynamic approach will allow the model to reflect the unique pressures of a multi-city Olympic event on the network.

A literature review has already been conducted to identify factors related to residents' change in travel behaviour and non-ticketed event choices during mega-events. Based on the literature review and data availability, several variables have been identified for questionnaire preparation, data analysis, and traffic simulation development as seen in the tables below.

Table 2: Factors affecting the change in travel behaviour

Factors affecting the change in travel behaviour	
(Zhao and Gao, 2022)	This research examines the factors influencing individuals' change in behaviour to use public transit in the aftermath of the COVID-19 pandemic. Using the extended Theory of Planned Behaviour (TPB) as a framework, the study integrates additional constructs to better understand the complexities of travel behaviour changes due to the pandemic. The research employs a quantitative approach, collecting data through and Structural Equation Modelling (SEM) to analyze it.

(He, n.d.)	The study utilized a series of continuous Beijing residents household travel surveys and supplementary surveys to investigate travel behaviour changes during the Beijing Olympics 2008. Demographic, Traveller diary record, Daily vehicle parking information, Drive route and Games-related attitudes were the main factors covered in these surveys.
(Parkes et al., 2016)	In this study, multi wave longitudinal panel surveys were used to examine travel behaviour changes during the London 2012 Games. Demographic, current travel behaviour and travel behaviour during and after games factors were used to examine various travel behaviour changes, including reducing, re-timing, re-moding, and re-routing journeys during the games.

Table 3: Factors affecting the event choice behaviour

Factors affecting the event choice behaviour	
(Kruger et al., 2012)	This paper investigates the socio-demographic and behavioural determinants that influence visitor attendance and expenditure at the Two Oceans Marathon in South Africa, based on a participant and spectator survey conducted at the race in 2011.
(Rizi and Granitzer, 2019)	The research paper focuses on modelling social influence to predict event attendance.
(Cianfrone et al., n.d.)	In this paper we can see How event attractiveness, economic consideration, local attractiveness, and venue accessibility are the factors that significantly influence attendance at high school basketball tournaments.
(Serrano et al., 2015)	This study explores the Rottemberg Hypothesis to determine the positive relationship between the expected quality of the event and attendance at the European football stadiums. The quality of the event, including the presence of star players and competitive teams, greatly impacts attendance. High-profile matches or events featuring well-known athletes tend to attract larger crowds.

Based on these studies, a tentative list of attributes to be considered in this research was selected as seen in table 4.

Table 4: List of Attributes

Change in travel behaviour	**Event choice behaviour**
Age	Age
Gender	Gender
Employment status	Income
Household Structure	Solo/Group Attendance
Income	Nationality
Vehicle Ownership	Trip Origin
Trip Purpose	Trip Destination
Mode of Transportation	Venue Accessibility
Travel Frequency	Mode of Arrival
Departure Time	Event Type
Travel Time	Medal Chance

Flexibility of working hours	Media Promotion
Flexibility of working place	Duration of Stay
Trip Origin	Weather
Trip Destination	Event Location

One of the primary obstacles in ABM applications is the scarcity of accurate and comprehensive real-life data to inform agent behaviours and validate the model (Collins et al., 2024). In this project, we will meet this challenge by accessing multiple high-quality datasets as mentioned in Table 5.

Table 5: Data Sources

Data sources for ABM	
Panel Survey Data	Information on individual travel behaviours, and socio-demographic characteristics, collected through discrete choice panel survey using survey engine platform.
Traffic Network Infrastructure and Operational Data	GIS-based representations of the transportation network, including road networks, public transport routes, service frequencies, capacities, and operational schedules obtained from industry partner.
Location-Based Big Data	Anonymized, aggregate information on population movements and activity patterns collected from social media applications and mobile network location data facilitated by the industry partner
Previous Olympic Games Data	Inputs from the recent Olympic games guided by the IOC's new sharing policy, obtained from the Queensland Government.

The integration of these diverse datasets will create a rich data environment, enhancing the ABM's fidelity and predictive capabilities. Figure 3 and 4 show the ABM agent profile and model framework. The ABM will be implemented using AnyLogic, chosen for its flexibility and capacity to handle complex, large-scale simulations. Given the scale and complexity of the model, computational efficiency is paramount. Cloud Based GPU-Accelerated Data Transformation will be employed to enhance performance. The use of NVIDIA GPU accelerated cloud network allows for parallel processing of big data, significantly reducing computation times. This provides scalable resources for data processing and simulation runs, enabling the handling of large agent populations and extensive network scenario analyses.

Figure 2: ABM model framework

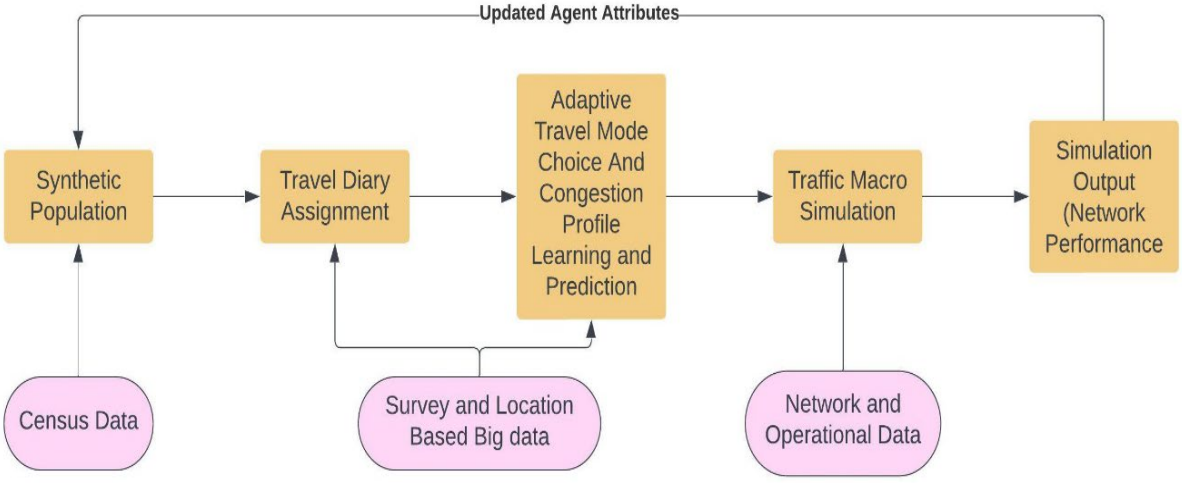
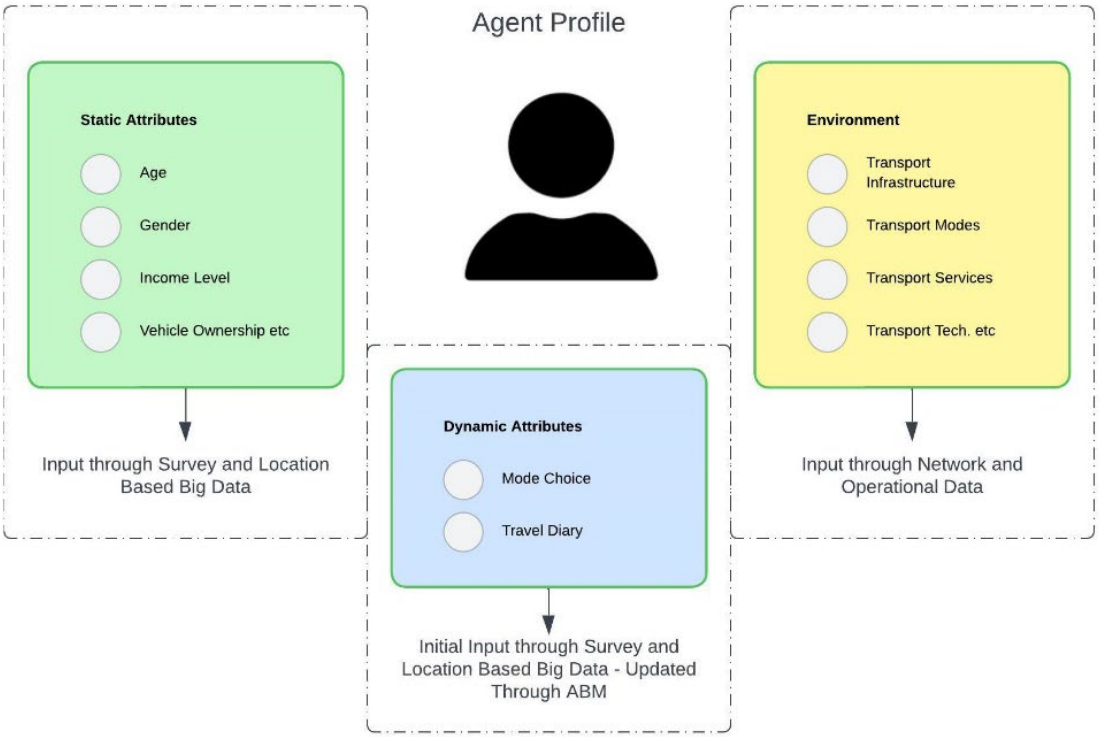


Figure 3: ABM agent profile



4 Limitations

The approach and methods provided here have some limitations. The data from past Olympics suffers from being in cities using a clustered Games Precinct, rather than the dispersed inter-city Games that Brisbane is pursuing. Second, the online panel surveys suffer from coverage bias (digitally excluded seniors, newly arrived migrants and very-low-income households are under-represented), self-selection bias (sport enthusiasts are more likely to respond) and hypothetical bias (respondents may over-state their willingness to avoid travel eight years in advance). These gaps risk under-estimating special-needs transport and over-predicting TDM compliance. Third, the agent-based model simplifies behaviour by hard-coding static utility rules, yet crowding aversion, social influence and last-minute ticket resale can alter routing in ways the model may miss; calibration is further hampered by the absence of revealed-preference data so far from the event, and extreme-scenario sweeps are computationally expensive.

5 Conclusion and way forward

This paper has detailed the methodological design and modelling approach for studying travel behaviour changes during the Brisbane 2032 Olympics. Survey data collection is in progress, and this data will be analyzed using statistical and simulation-based techniques. Several key hypotheses will be tested, including but not limited to: residents with flexible work arrangements will be more likely to reduce or time-shift their trips during the Games; proximity to non-ticketed venues increases the likelihood of spontaneous attendance, especially among younger and lower-income residents; and past exposure to TDM campaigns influences how individuals respond to future campaigns. This analysis will inform transport modelling and the design of effective TDM measures, and will support traffic management, public transport planning, and infrastructure coordination for the Brisbane 2032 Olympics.

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