

**Modelling Subjective Barriers to Public Transport
Adoption as a Holistic Network**

Paris Choi

Durham University

Department of Psychology

Submitted as part of the Laidlaw Research and Leadership Programme

Supervisor: Dr Michael L. Lengieza



Contents

Abstract	4
1. Introduction.....	5
2. Literature Review	6
2.1. Public Transport Adoption for Sustainable Development	6
2.2. Barriers to Public Transport Adoption	7
2.2.1. Service Quality.....	8
2.2.2. Infrastructure.....	11
2.2.3. Economic Factors	13
2.2.4. Psychological Factors	14
2.2.5. Demographic Factors	15
3. Network Analysis	16
4. The Present Research.....	17
5. Methods	18
5.1. Participants.....	18
5.2. Materials and Procedure	18
5.2.1. Scenario Description	18
5.2.2. Card Sorting Task.....	21
5.2.3. Demographic Questions.....	22
5.2.4. Exit Items	22
5.3. The Complete Network	23
5.3.1 Influence in Decision Making (Node size)	23
5.3.2. Barrier Perceptions (Ring Size and Colour)	24
5.3.3. Relationships Between Factors (Band Size and Colour)	24
5.3.4. Node clustering (Label Colour)	25
6. Results	26
6.1. Complete Network Analysis	26
6.1.1. General Influence (Node Size).....	26
6.1.2. Bearing on Choices (White Square vs Asterisk)	26
6.1.3. Centrality	27
6.1.4. Clustering	27
6.2. Discussion	28

6.2.1. Insights from the Complete Network	28
6.2.2. Practicalities (The Only Significant Factor)	28
6.2.3. Trip Duration as a Central Factor	29
6.2.4. Recommendations	30
6.2.5. Limitations	32
7. Conclusion	35
References	37

Acknowledgments

I would like to thank my supervisor, Dr Mike Lengieza, for his support throughout the research and writing process. This paper would not be possible without his support.

I would also like to thank the Laidlaw team at Durham University for their support and guidance, as well as the Laidlaw Foundation for their generous research stipend.

Abstract

Public transport (PT) adoption is essential for reducing greenhouse gas emissions and supporting sustainable urban development. While many studies identify barriers to PT use, little is known about their relative importance or how they interact. This study applies a novel network analysis to model subjective barriers as an interconnected system.

Participants (N = 101) completed an online survey featuring four hypothetical journey scenarios and a card-sorting task to indicate factors shaping their decisions to use or avoid PT. The resulting data were analysed to assess barrier centrality, clustering, and influence on mode choice.

Results showed that trip duration was the only factor with a significant direct effect on transport decisions, despite frequent mention of other barriers such as bus reliability, carbon footprint, and ease of payment. Network analysis revealed five central nodes – trip duration, ease of planning, route familiarity, walk from end, and bus stop wait – organised into five clusters: practicalities, cost/benefit, self-efficacy, bus pleasantness, and route characteristics.

These findings highlight the dominant role of practical constraints, particularly trip duration, in shaping PT adoption and demonstrate the value of network approaches for identifying policy targets to improve public transport uptake.

1. Introduction

During the Covid-19 pandemic, public transport (PT) ridership declined by up to 90% in some cities (SLOCAT, 2023). Although usage has gradually recovered, this recovery has been notably slower in high-income countries across North and South America and Europe, where ridership remains below pre-pandemic figures. This trend is concerning, given PT's critical role in sustainable urban development. For example, overreliance on private vehicles contributes to congestion and increased greenhouse gas emissions (Moavenzadeh et al., 2002); indeed, transportation accounts for 24% of direct CO₂ emissions from fuel combustion worldwide, with road vehicles accounting for nearly 75% of this total (IEA, 2020). It therefore remains crucial that research explores influential barriers to PT adoption to inform future policy aiming to encourage PT adoption.

While a substantial body of literature has explored factors influencing PT use, less is known about which barriers are most central – or how they influence one another. For example, while research has shown that service quality is a recurring barrier to PT adoption (e.g., Friman et al., 2020; Tyrinopoulos et al., 2013), there is less literature that explores the relationship between service quality and infrastructure-related issues. Addressing this gap is important for policymakers seeking to prioritise interventions to promote PT adoption. Crucially, research suggests that PT usage is rarely influenced by a single barrier but, instead, decisions are shaped by a web of interrelated factors, including infrastructure, service quality, psychological attitudes, and economic constraints (e.g., Javaid et al., 2020). For example, a bus lacking features for visually impaired passengers is not just an infrastructure issue – it also undermines perceived service quality and may trigger anxiety (e.g., Asplund et al., 2012), another psychological barrier (e.g., Schmitt et al., 2019). This is where the criticality of the current research can be seen: the network

approach allows for a complete analysis of the network of different barriers and their relationships, rather than an isolated focus on certain barriers.

Indeed, attempts to isolate a single “primary” barrier often oversimplify the underlying influences behind PT decision-making. Yet, many related disciplines still lack systematic approaches to aggregating knowledge (Beelmann, 2006; Minx et al., 2017). As such, this research takes a novel approach by modelling subjective barriers to PT adoption as a complex, interconnected network. This method captures how barriers influence each other and identifies those most central within the network, generating novel insights that can inform future policy.

2. Literature Review

2.1. Public Transport Adoption for Sustainable Development

In recent years, sustainability has emerged as a central objective for UK policymakers, with public transport (PT) adoption regarded as one of the most cost-effective strategies (IPCC, 2022). Buses and trains have been shown to reduce greenhouse gas (GHG) emissions by up to two-thirds per passenger kilometre compared to private vehicles (Ben Welle et al., 2023). The UN’s latest climate action report describes a shift to public transit as essential for mitigating climate change (FCCC, 2023), and PT adoption contributes directly to 14 of the UN’s 17 Sustainable Development Goals (IAPT, 2023). In this context, increasing PT use has become a key policy goal for sustainable development. Therefore, this research

contributes to sustainable urban development by identifying key barriers to public transport adoption, providing insights that can inform more effective policy interventions to increase its use.

2.2. Barriers to Public Transport Adoption

Given the importance of PT for sustainability, identifying and addressing the barriers to its adoption is critical. A review of the literature reveals several key obstacles, each of which is reviewed below. In brief, service quality, including reliability, cleanliness, staff friendliness, and similar factors, has consistently emerged as one of the most influential determinants of PT use (Ramos et al., 2019; Tyrinopoulos and Antoniou, 2019; Diab et al., 2015; Rasca et al., 2022). Infrastructure-related issues, such as walking distance to stops, accessibility – especially for people with disabilities – and limited network coverage, have also consistently emerged as key determinants of PT use (Mwaka et al., 2024; Asplund et al., 2012; Nielsen et al., 2021; Ramos et al., 2019). Economic and demographic variables (Dimitrios et al., 2017; Gudmundur et al., 2015), as well as psychological and normative factors (Rao et al., 2025; Vallee et al., 2024), add to the potential barriers to PT adoption.

Considering the number of barriers identified, taking a holistic approach is most appropriate, as it is unlikely that one barrier influences PT adoption alone, but instead, a network of barriers. While many factors influence PT use, this study will focus on subjective barriers amenable to direct policy intervention. First, it is essential to understand the nuances around these barriers; these are briefly reviewed below.

2.2.1. Service Quality

PT service quality is typically evaluated through a range of attributes, broadly divided into physical — measured without involving PT users — and subjectively perceived, which rely on the observation of PT user responses, either directly (e.g., Friman et al., 2001) or indirectly (e.g., Balcombe et al., 2004, Paulley et al., 2006). Table 1 lists and defines the attributes commonly studied. Some of these attributes overlap with infrastructure, such as ease of transfer and accessibility. These are best understood as hybrid elements, where physical design, e.g. station layout and step-free access, enables access, but operational factors, such as service scheduling and passenger assistance, determine the user experience (TfL, 2015).

Service quality, then, is best understood as the extent to which the transport system meets or exceeds users' expectations and needs. It significantly influences behavioural outcomes by shaping perceptions of ease, trust, and satisfaction – core drivers of transport choice and habitual use (Friman, Lättman, & Olsson, 2020). These dynamics are central to this study's focus on subjective barriers to PT adoption, where “subjective barriers” are understood as personally reported reasons for avoiding PT, based on an individual's perceptions, experiences, and context.

Service quality attributes, including reliability, frequency, price, ease of transfer, and safety, have been demonstrated in numerous studies to substantially shape user decisions (Haboucha et al., 2023). Reliability reflects how closely the bus service matches the route timetable. According to a review conducted by Tyrinopoulos and Antoniou (2013), service reliability is one of the most essential factors in PT use, even more so than factors such as price, with other

studies also emphasising the importance of reliability to customer satisfaction (Diab et al., 2015; Hansson et al., 2020; Redman et al., 2013). Similarly, frequency, defined as how often a bus service runs in a set period, has been cited alongside reliability as one of the most important factors encouraging PT adoption (Goransson & Andersson, 2023), particularly in enhancing customer satisfaction. However, it remains unclear whether reliability and frequency alone are sufficient to influence overall loyalty and mode switching to PT.

Indeed, other attributes, such as price, transfers, and comfort, might be more significant in increasing loyalty and adoption. Price, defined in this study as the monetary cost of travel, influences individuals' decision to choose PT over private modes of transport – PT needs to be cost-competitive to be a strong alternative to the car (Goransson and Andersson, 2023). This picture is complicated by transfers, which commuters are largely negatively disposed towards; Guo and Wilson (2004) defined transfer penalty as a value which reflects the negative perceptions users have towards transfers. Further, service quality attributes that influence overall loyalty to the PT system are more associated with a trusting relationship between the user and the agency, including value for money, on-board safety, cleanliness, and interaction with personnel (van Lierop et al., 2018). PT service quality represents a multifaceted subjective barrier, crucial for understanding user behaviour and its interplay with other factors in a holistic network approach.

Table 1. Definitions of public transport (PT) service quality attributes.

	Attribute	Definition
Operational Attribute	Reliability	How closely the actual service matches the route timetable

	Attribute	Definition
	Frequency	How often the service operates during a given period
	Speed	The time spent travelling between specified points
	Price	The monetary cost of travel
	Information provision	How much information is provided about routes and interchanges
	Ease of transfers/ interchanges	How simple transport connections are, including the time spent waiting
	Vehicle condition	The physical and mechanical condition of vehicles, including the frequency of breakdowns
Experiential Attribute	Comfort	How comfortable the journey is regarding access to seat, noise levels, driver handling, air conditioning, and cleanliness.
	Safety	How safe passengers feel from traffic accidents passengers feel during the journey, as well as their personal safety

Attribute	Definition
Convenience	How simple the PT service is to use and how well it adds to one's ease of mobility.
Aesthetics	Appeal of vehicles, stations and waiting areas to users' senses

Note: Table adapted from Redman et al., 2013, with minor modifications.

2.2.2. Infrastructure

It is also important to consider the role of infrastructure in influencing PT decisions. If service quality is primarily related to user experience, infrastructure refers broadly to the physical design elements of PT. Its impact on PT use is significant. An international review found that investments in infrastructure, such as Bus Rapid Transit (BRT), Light Rail Transit (LRT), and commuter rail, can shift up to 40% of car users toward PT (Ingvardson & Nielsen, 2018).

First, intermodal connections regularly surface in analyses as primary influencers to PT adoption. Complicated or poorly coordinated networks, where transfers are frequent or disjointed, discourage use (Ramos et al., 2019). Simplifying routes and improving transfer efficiency may therefore be key to increasing adoption.

Further, network density and spatial coverage are also critical. Studies show that sparse stop spacing and limited service areas depress ridership even when service quality is high (Ingvardson &

Nielsen, 2018; Ulfarsson et al., 2015). Poor ‘first-mile/last-mile’ connections, such as long walks to stations or inadequate feeder services, reduce the effective catchment of public transport and deter potential users.

Yet, coverage alone is insufficient if stations and stops themselves are poorly designed. Features such as lighting, shelter, seating, and barrier-free access directly affect both the physical feasibility of trips and passengers’ perceptions of safety and comfort (Hansson et al., 2019; van Lierop et al., 2018). Well-distributed routes, therefore, need to be complemented by high-quality stop environments that make waiting and transferring both convenient and secure. Together, these spatial and design elements determine the real catchment of the system and shape whether potential users perceive public transport as a viable alternative to private cars.

This is deepened when considering potential accessibility issues, particularly for people with disabilities (PWD). Across 15 studies, physical barriers such as inadequate ramps, steep gradients, or inoperable features were frequently cited as critical impediments to PT access (1, 7, 9, 10, 15, 23, 43, 47, 48, 50, 54, 56, 61, 65, 66). Of 34 studies reviewed, 9 specifically noted problems with ramp deployment and slope (2, 5, 9, 17, 24, 40, 54, 61, 65). These issues not only limit access but may also create anxiety or risk for passengers, particularly those with mobility or sensory impairments.

In summary, infrastructure in this study broadly refers to the physical design elements of public transport, and its impact, particularly regarding effective intermodal connections and accessibility for people with disabilities, is a significant barrier to PT use. However, infrastructure is understood to intersect with other

perceived factors, such as convenience, safety, and accessibility, as a complex network.

2.2.3. Economic Factors

In its broadest sense, economic factors can be understood as the financial conditions, incentives, and constraints that influence individual and collective decisions about PT use. Studies that examined PT use during recessions found slower PT growth, indicating a relationship between unemployment/reduced income and reduced PT use (Gudmundur et al., 2015; Paulley et al., 2006; Taylor et al., 2009). For example, during the 2008/09 recession, the growth of PT stagnated at around 0% where growth had previously been sustainable (Cordera et al., 2015). Given this, it is valuable to consider wider economic contexts as a factor in PT use.

Beyond absolute fares, the *perceived* value of public transport depends on how costs interact with service quality. Even when ticket prices are low, poor reliability, long waits, or uncomfortable journeys can reduce perceived value and discourage use (Paulley et al., 2006; Redman et al., 2013). Hidden costs such as the time lost to delays or multiple transfers function as an “opportunity cost,” meaning that longer or more complex journeys feel economically unattractive even without a fare increase (Guo & Wilson, 2004). In the present network, factors such as trip duration, ease of transfer, and reliability connect directly to these economic evaluations, highlighting that financial and operational barriers are intertwined rather than independent.

Traditional economic theory frames transport choice as a rational decision-making process based on utility maximisation. In this view, individuals weigh the financial and time costs of PT against alternatives (Javaid et al., 2020). However, given that there are numerous alternatives, this should generally result in a global evaluation of whether PT is perceived as good value for money (London TravelWatch, 2022).

2.2.4. Psychological Factors

Psychological factors, especially attitudes, norms, and prejudices, can influence PT use. Crucially, environmental awareness has been cited as a significant factor in PT use (Vallee et al., 2024; Nilsson and Kuller, 2000), as well as norms and prejudices disfavouring PT (Murray et al., 2010). For this reason, our study examines attitudes towards carbon footprint. Further, car ownership and use are associated with a unique set of values (such as freedom and care for others) and social identity that is lacking in PT (Sheller, 2004; Gartman, 2004; Cairns et al., 2014). This reduces the allure of PT compared to private transport.

A popular approach in PT research is the adoption of the Theory of Planned Behaviour (TPB) to gain knowledge into the specific psychological factors that influence mode switch from cars to PT. TPB frames these influences through:

- Attitudes: Evaluation of PT
- Subjective Norms: Social Expectations about PT use
- Perceived Behavioural Control: Confidence in one's ability to use PT effectively.

While TPB is valuable for understanding mode-switching behaviour, this study excludes psychological variables from its network model. The primary reason is policy applicability: psychological attitudes are harder to intervene upon than service quality or infrastructure. Unlike fare reductions or increased frequency, attitude change requires long-term cultural or educational strategies. This does not diminish the importance of these factors, but positions them as the subject of future, specialised research.

Although the present network excludes psychological variables for policy reasons – attitudes are less directly modifiable than fares or service frequency – they remain closely intertwined with service quality and infrastructure. For example, station design and service reliability can heighten or reduce anxiety, influencing confidence in using PT (Friman et al., 2020). A well-lit, sheltered stop with clear information can improve perceived safety and thereby strengthen positive attitudes, illustrating how physical features translate into psychological comfort.

In short, while psychological factors are not modelled here, the network findings can still inform them indirectly, highlighting how improvements in service quality and infrastructure may foster the attitudes and perceived control that encourage PT adoption.

2.2.5. Demographic Factors

The literature indicates a relationship between demographic factors and likelihood to use PT. Notably, women have a slightly lower probability of using cars, lower average travel distances, and are more likely to favour PT for trips (Best and Lanzendorf, 2005; Rosenbloom, 2004; Kuhnimhof et al., 2006). Likewise, PT seems

more popular for certain age groups, with young people (under 25) and elderly tending to be more PT-oriented (Coogan et al., 2018, Ding et al., 2017, Ha et al., 2020, Litman, 2004, O’Fallon et al., 2004). Having children in a household reduces the likelihood of PT pass ownership (Vance and Peistrup, 2012), which reflects findings that having a person in care reduces PT usage.

Despite these patterns, this study does not include demographic segmentation in its analysis. The decision is guided by practical considerations: while demographic trends can indicate general usage likelihood, they offer limited guidance for actionable policy. This research aims to uncover barriers applicable across diverse users, with future studies encouraged to explore targeted demographic insights in more depth.

3. Network Analysis

The present research, which uses network analysis, is unique in its approach to modelling the factors that influence PT adoption. Unlike traditional approaches (e.g., the simple use of regressions), the present approach explicitly models both the importance of any individual PT barrier for PT adoption, as well as the association it has with other barriers in the network. This allows for a more holistic understanding of how the barriers studied here ultimately form the decision-making network surrounding PT adoption.

The strength of this approach is derived from three qualities. First, this approach is generative. There is high potential for identifying new associations between different barriers that can be investigated in future research (Lengieza et al., 2025). Put succinctly, it can generate new hypotheses and potentially instigate new lines of research.

Secondly, it is an exploratory approach. Rather than attempting to confirm previously identified connections, this approach is aimed at uncovering new connections for the subject of future study. Finally, this approach is flexible, requiring no a priori knowledge or expectations surrounding patterns in the data. This is particularly useful for this area, where there is a potential gap in the literature.

In summary, the outputs from this approach do not confirm associations. Rather, the outputs indicate a set of potential associations that should be tested in future studies.

4. The Present Research

The purpose of this paper is to explore the subjective barriers to PT adoption as a network. As such, the ultimate goal is to identify the most influential barriers to switching from private to public transport, and the existing connections between barriers. In this context, a connection refers to the degree of co-occurrence between a pair of barriers (i.e., the correlation between two barriers). To answer our research questions – i.e., what are the most influential factors in PT decisions, and what are the relationships between different factors – we released an online survey in which participants imagine they are going to four different locations. Given each location, they were asked how likely it is that they would take the bus and then completed a card sorting task (adapted from Lengieza, 2025) used to identify the factors that influence their hypothetical PT decision. The data was then analysed as a network to model the identified barriers to PT adoption.

5. Methods

5.1. Participants

Participants were asked to complete a survey, which was visible through two streams: Prolific and Environmental Action Durham. For the purposes of this study, a sample of 101 participants was used for data collection and analysis. All participants were recruited from Durham County; data collection is from Durham County exclusively.

5.2. Materials and Procedure

5.2.1. Scenario Description

The procedure closely followed that of Lengieza et al. (2025). After providing informed consent in accordance with institutional ethical approval, participants were presented with an introductory briefing outlining the upcoming tasks (see Fig. 1). After spending as much time as needed on this page, participants advanced to a second page. Here, they were then shown a scenario prompt and asked to indicate how likely they would be to take the bus in that situation (see Fig. 2). For example, one scenario asked participants to consider the likelihood of using the bus for a journey from home to a GP appointment. The order of scenarios was randomised to control for sequence effects.

Each participant completed four scenarios in total, designed to capture variability in public transport (PT) decision-making across different journey contexts. After being presented with the scenario,

participants were asked how likely they were to take the bus for this imagined journey. The scenarios included the following (presented in randomised order to participants):

- 1) Imagine that, tomorrow (or the next most reasonable day), you need to travel from home to go to work on a normal workday (at the time that you normally tend to do such things).
- 2) Imagine that, tomorrow (or the next most reasonable day), you need to travel from home to go to the GP for a routine appointment (at the time that you normally tend to do such things).
- 3) Imagine that, tomorrow (or the next most reasonable day), you need to travel from home to go to the shop to get groceries for the week (at the time that you normally tend to do such things).
- 4) Imagine that, tomorrow (or the next most reasonable day), you need to travel from home to meet a friend at their favorite pub or restaurant (at the time that you normally tend to do such things).

This approach enabled meaningful comparisons and increased the richness of the resulting network data, allowing us to identify which barriers to PT use were most influential across diverse situations.

Fig. 1. Introductory Briefing of Survey Tasks

In a few pages, you will be asked to drag and drop items based on whether they were part of your decision-making process. By (un)attractive, we mean that the feature pushes you toward or away from taking the bus for the specific journey identified. Ultimately, we are interested in your impression of these factors—your reasonable assumptions based on the information you have available *are* valid impressions.

- Some of the factors will make taking the bus seem **very attractive**. You should place them in the **green category**.
- Some of the factors will make taking the bus seem **sort of attractive**. You should place them in the **blue category**.
- Some of the factors will make taking the bus seem **sort of unattractive**. You should place them in the **grey category**.
- Some of the factors will make taking the bus seem **very unattractive**. You should place them in the **red category**.
- any factor that was not relevant or influential for any reason you can remove by clicking the red X icon.

Fig. 2. Scenario Description

Imagine that, tomorrow (or the next most reasonable day), you need to travel from home to **go to the GP for a routine appointment** (at the time that you normally tend to do such things).

How likely are you to take the bus to get there?

Please take a moment to think carefully about all of the things you would normally consider when deciding how to get to your destination before indicating your decision.

Very Unlikely to take the bus

Unlikely to take the bus

A Bit Unlikely to take the bus

Neither one way or the other

A Bit Likely to take the bus

Likely to take the bus

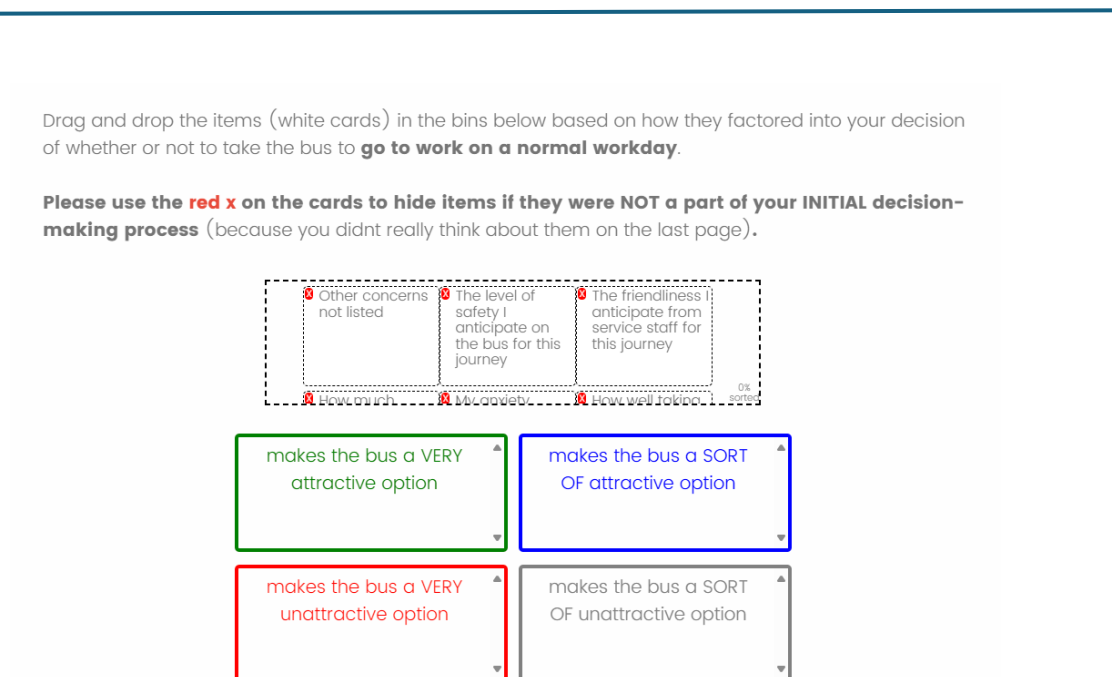
Very Likely to take the bus

5.2.2. Card Sorting Task

Participants then advanced to the next page, which featured a drag-and-drop sorting task, adapted from Lengieza (2025). In this task, they were presented with a series of cards reflecting the network factors of interest. They were asked to drag each item into one of four categories depending on its attractiveness for PT use. Participants were also given the option to delete a card if it was not a consideration in their decision-making. Prior to starting this task, participants were presented with instructions presented in Fig. 1.

The appearance of the actual task page can be found in Fig 3. The item pool only displayed a portion of the entire set at a time – to accommodate smaller-sized devices. The drop-bins were coded from 0 (“very unattractive”) to 3 (“very attractive”).

Fig. 3. Drag-and-Drop Sorting Task

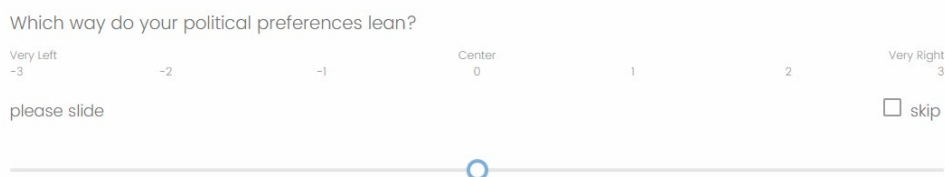


5.2.3. Demographic Questions

After sorting for each scenario, participants completed some demographic questions. This inquired about the following: gender, ethnic group or background, age, physical/mental illnesses that have lasted or are expected to last for 12 months and would impact their ability to use PT. Participants were then shown an image of a ladder, the top of which represented the people with the “most money, most education, and the best jobs”, and the bottom of which represented those with the “least money, least education, and worst or no job”. Participants were asked to rank themselves, on a scale of 1-10, according to where they believed they placed on the ladder.

Following this, participants were also asked to move a slider according to their political preferences, with the prompt “Which way do your political preferences lean?”. Left on the slider represented the political left, and the right, the political right. Figure 4 is taken from this page.

Fig. 4. Political Preferences Slider



5.2.4. Exit Items

At the end of the survey, participants were asked whether any other infrastructural changes would make them more likely to take the bus. Following this, participants were presented with a series of items designed to assess data quality (see Lengieza, Aviste, & Swim, 2023b). Participants reported whether they rushed, were distracted, or did not take the survey seriously. Prior to answering these questions, participants were explicitly informed that their answers would not affect their credit. Responses were used to identify and exclude low-quality responses, as noted in the participant's section.

5.3. The Complete Network

5.3.1 Influence in Decision Making (Node size)

Node size (the white inner portion) indicates the level of influence a given node exerted on decisions of whether to take the bus. This was based on a multi-level regression predicting bus choice ratings from all nodes at once, when controlling for journey type. Nodes with a non-significant or trivial influence are depicted with an asterisk in the centre. Nodes with a significant, non-trivial effect are depicted with a square. Larger nodes (with larger white inner circles) indicate that the given barrier was more predictive of bus choice scores. Small inner circles indicate that the factor did not predict choice scores when controlling for all of the other factors.

5.3.2. Barrier Perceptions (Ring Size and Colour)

Ring size and colour reflect the valence of the average perception of the given barrier. This was calculated by taking the average of the raw item ratings. Items that were rated more often as “unattractive” appear with a red ring. The more unattractive they were, the thicker the ring. Items that were rated more often as “attractive” appear with a green ring. The more attractive they were, the thicker the ring. Items with thin rings were neither rated as notably unattractive or attractive.

5.3.3. Relationships Between Factors (Band Size and Colour)

Most relevant to the research aim of modelling subjective barriers as a complex network, we modelled the associations between the factors within the network. Thicker green lines indicate a positive relationship between two nodes (i.e., when one node appeared as a factor in the survey, another node was also frequently observed). The thickness of the line indicates the strength of this relationship. Absence of lines indicates no meaningful relationship between two nodes. We should note that we used thresholding to filter out trivial (i.e., $|r| < .10$) associations.

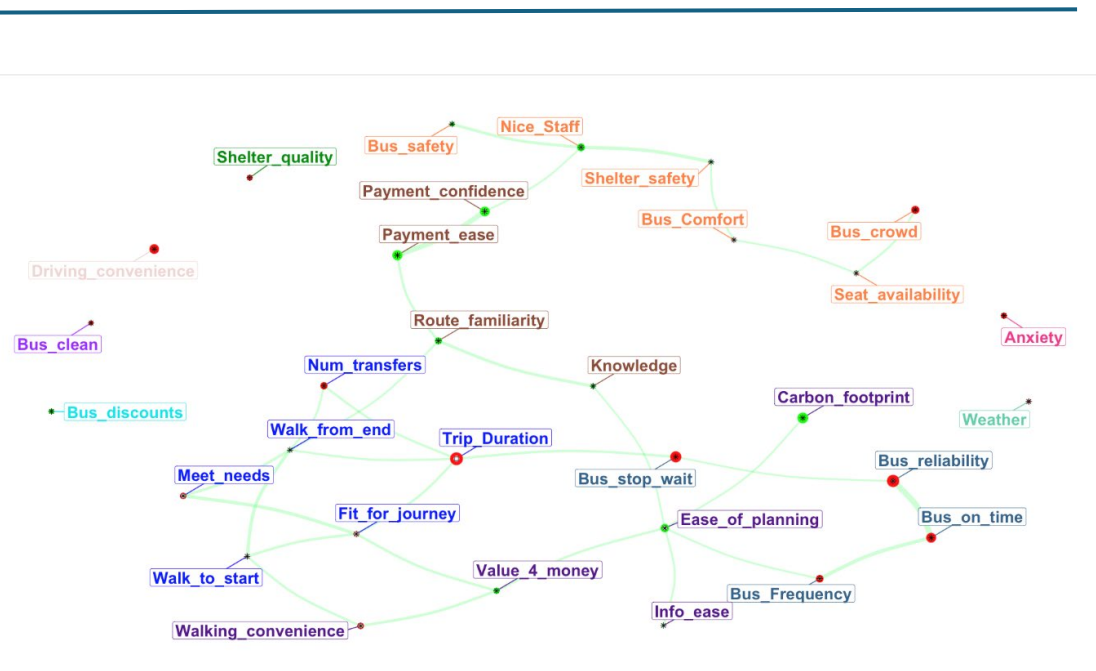
Further, consistent with (Lengieza, Richardson, & Aviste, 2025; Lengieza, Richardson, & Hughes, 2025), we calculated centrality, by summing the weights of edges connected to the node (with higher numbers reflecting a greater number of strong connections in the network) after further weighting the edges by the influence of the connected node. This effectively captures whether a given node is

highly connected to important positive members of the network or important negative members of the network.

5.3.4. Node clustering (Label Colour)

Cluster_optimal() from the igraph package was used to identify clusters in the data based on the weighted connections between each node. Such clustering procedures are used to identify communities in networks based on the ties between them (M. Neuman et al., 2022). This function only accepts positive values for weights. Since the weights in our network could range from -1 to 1, we used the absolute value of the connection instead of the raw weight. Nodes sharing the same text colour belong to the same cluster based upon the network ties.

Fig. 5. The detailed network of factors that influence public transport adoption.



Note: The following explains how to interpret the visual network.

Nodes: Larger nodes indicate greater importance; Green nodes had a positive importance for PT adoption; Red nodes had a negative importance for PT adoption. **Edges:** Bands indicate relationships between nodes; no bands indicate no relationship after controlling for other nodes; No bands indicate no relationship between other nodes in the network. **Label colour:** The colour of labels was determined by the cluster assignment derived from the network community structure. **White square and Asterisk:** An asterisk indicates no bearing on decision-making. A white square indicates bearing on decision-making, with the size indicating influence.

6. Results

6.1. Complete Network Analysis

6.1.1. General Influence (Node Size)

The complete network is depicted in Figure 5. The five most important factors for transport decision were “trip duration”, “bus reliability”, “bus stop wait”, “carbon footprint”, and “payment ease”. However, it is interesting to note that “trip duration” is the only factor that is significant in influencing decision-making, based on regression analysis. Despite other factors clearly being perceived negatively, there is no indication that they are substantial in influencing choices to take the bus.

6.1.2. Bearing on Choices (White Square vs Asterisk)

There were several factors that seemed to have no bearing on decision-making, including “bus safety”, “shelter safety”, “bus comfort”, “seat availability”, “weather”, “bus clean”, “walk to start”, and “info ease”. These were all rated as equally attractive and unattractive regarding the bus as a PT option. Therefore, these factors were poor differentiators of PT or non-PT decisions; as such, they were unlikely to have been influential.

6.1.3. Centrality

The most central nodes for PT decisions were “trip duration”, “ease of planning”, “route familiarity”, “walk from end”, and “bus stop wait”. Further, the following nodes were moderately connected: “bus reliability”, “fit for journey”, and “payment confidence”. Of the central nodes, both positive and central nodes were present.

6.1.4. Clustering

The network was formed from five clusters altogether, as determined by the clustering algorithm: *bus pleasantness* (e.g., nice staff, shelter safety, bus comfort), *self-efficacy* (e.g., payment confidence, payment ease, route familiarity), *cost/benefit* (e.g., value for money, ease of planning, walking convenience), *practicalities* (e.g. walk from end, trip duration, fit for journey), and *route characteristics* (bus reliability, bus on time, bus frequency). Some nodes were ignored by the clustering algorithm and, therefore, not sorted into a cluster, such as driving convenience, anxiety, and weather. *Bus pleasantness* was situated on the opposite wing of the network to *cost/benefit*, *practicalities*, and *route characteristics*.

6.2. Discussion

6.2.1. Insights from the Complete Network

Decision factors clustered into five groups, which are depicted visually using colour: self-efficacy (brown), bus pleasantness (orange), route characteristics (blue), practicalities (dark blue), and cost/benefit (purple) – each differed in their level of importance for decision-making.

6.2.2. Practicalities (The Only Significant Factor)

Practicalities were the only cluster that was decidedly important for PT decision-making within the simplified network. This suggests that, when people are deciding whether to take the bus or another mode of transport, the only factors that were able to explain their decision-making were practicalities. The practicalities cluster (See Figure 5) includes factors such as trip duration, fit for journey, walk from end, number of transfers, meet needs, and walk to start. Yet, of these, it was only trip duration that seemed to affect decision-making.

This finding initially appears to diverge from the extant literature, for example, studies highlighting service quality (Tyrinopoulos & Antoniou, 2013; Diab et al., 2015) or transfer penalties (Guo & Wilson, 2004) as decisive. However, several strands of research suggest that these apparently distinct attributes often operate through perceived journey efficiency. For instance, Redman et al. (2013) and Goransson & Andersson (2023) both show that reliability and frequency primarily influence satisfaction by

shortening perceived travel time. In this sense, the ‘practicalities’ cluster, particularly trip duration, may represent a higher-order construct that encapsulates the downstream effects of reliability, transfers, and scheduling. This interpretation aligns with Paulley et al. (2006), who argue that time cost is the dominant component of perceived value even when fares remain stable.

6.2.3. Trip Duration as a Central Factor

Trip duration emerged as the only factor with a statistically significant influence on mode choice, underscoring its importance as a central determinant of public transport adoption. Within the network, it was also one of the most highly connected nodes, linked to “number of transfers”, “bus stop wait”, “walk from end”, and “fit for journey”. It was also one of the most negative perceptions: trip duration emerged as not only the most important node, but also the most negatively influential. This position suggests that trip duration does not function in isolation but acts as a proxy for a broader set of practical barriers. In other words, when participants evaluate a journey as “too long,” they may also be responding to the waiting, transferring, or additional effort involved.

Unlike other central nodes, which can sometimes have a positive framing (e.g., ease of planning can attract people towards PT if well designed), trip duration is almost always perceived negatively. This asymmetry highlights an important behavioural tendency: time loss acts as a strong deterrent, while positive attributes may not exert a comparable pull.

These findings diverge slightly from much of the existing literature. For example, reliability and frequency have frequently been

identified as decisive factors (Diab et al., 2015; Tyrinopoulos & Antoniou, 2020), yet in this study, they were central but not directly significant. This suggests that users may conceptualise reliability and waiting primarily in terms of their contribution to total journey length, rather than as standalone considerations. The classic notion of a “transfer penalty” (Guo & Wilson, 2004) also aligns with this interpretation: transfers are disliked because they inflate both the actual and perceived duration of a trip.

Trip duration, therefore, appears to capture the cumulative impact of several different types of barriers, both objective (e.g., longer travel distances, additional transfers) and subjective (e.g., frustration from waiting, uncertainty when planning routes). As such, it functions as a summary indicator of journey efficiency. From a policy perspective, this suggests that interventions should not only aim to reduce absolute travel times but also target the components that inflate perceived duration. Reducing unnecessary transfers, minimising waiting times through coordinated scheduling, and improving last-mile connections would all serve to reduce the perception of “long” journeys and thereby lower the most significant barrier to PT adoption.

6.2.4. Recommendations

As explored in the introduction, this study aimed to identify the barriers to public transport (PT) use that are most influential and interrelated, in order to guide policy for sustainable urban mobility. The network analysis highlighted trip duration, ease of planning, route familiarity, number of transfers, bus stop wait, and reliability as central factors in the system of barriers.

Among these, trip duration was the only factor with a statistically significant direct effect on mode switching, confirming it as the primary target for policy intervention. The remaining nodes, although not individually significant, are important because their network connections indicate that they contribute to trip duration and shape perceptions of PT. While more research could be conducted into psychological and demographic factors, and more targeted research is necessary for insights into the accessibility of PT for different social groups, this research does broadly support a few policy suggestions regarding the factors that are most likely to influence the likelihood of adopting PT.

First, given the centrality and influence of trip duration, future policy should aim to reduce overall trip duration. Although the physical distance of a trip cannot always be shortened, the *experienced* duration can be reduced by lowering the number of transfers, minimising transfer waiting time, and providing more direct or express routes. The strong edges linking trip duration to transfers and bus stop wait support interventions such as synchronised timetables, coordinated intermodal connections, and infrastructure that shortens walking distances between modes. Considering that trip duration is often extended by transfers (Guo and Wilson, 2004), improving intermodal connections would make PT more attractive. Equally, planners could synchronise timetables to reduce waiting at bus stops, and invest in infrastructure (covered walkways, shorter transfer distances, clearer signage) to make connections smoother.

Interventions to improve the reliability and frequency of services are also supported by the present research. While not significant in regression analysis, reliability and frequency occupy central positions in the network and are linked to trip duration. Targeted improvements in areas where long waits or unreliable services inflate total trip time would likely have a substantial impact

on people's willingness to switch to PT. Practical steps include integrated scheduling software, data-sharing agreements between operators, and publishing real-time journey planning apps (Brakewood et al., 2015; Watkins et al., 2011).

Finally, this study also supports policy interventions to improve ease of planning and accessibility. Ease of planning and route familiarity were also central nodes, indicating that psychological effort, e.g., planning complexity and uncertainty, acts as a barrier even when physical service is adequate. The network shows these factors are connected to practical nodes (transfers, trip duration), suggesting that better planning support can reduce both perceived and actual journey costs. Policy should therefore prioritise accessible digital tools (multimodal journey planners, real-time apps) and clear analogue aids (standardised signage, simplified maps), which directly target these nodes by lowering uncertainty and cognitive load.

Together, these recommendations reflect the core insight of this research: trip duration is the critical determinant of PT adoption, and the most promising interventions are those that either shorten actual journey times or weaken the connected factors that inflate them. As such, policies that simultaneously address transfers, waiting time, reliability, and planning complexity are most likely to reduce the dominant barrier to PT adoption identified by this study.

6.2.5. Limitations

The first and foremost limitation of this research is the limited sample size. Due to restrictions in the data collection window, only 101 participants took part in the survey, forming the completed

network. With a larger sample size, more insights might have been revealed from the network, and the accuracy of the network would have improved significantly. Yet, this study has been invaluable in demonstrating the value of future research in this area and the generative potential of a network approach. A future study with a larger sample size could generate novel insights for policymakers in sustainability spaces.

Another significant limitation is that the relationships identified within the network are not causal relationships and, therefore, require further experimental investigation to determine causality. This methodology, however, does represent a useful and highly generative tool (Lengieza, Richardson, & Aviste, 2025; Lengieza, Richardson, & Hughes, 2025) for identifying potential factors for future investigation with higher-cost methods (e.g., RCTs). It is also practically untenable to use causal paradigms while still considering all the decision-making factors as holistically as we do here. Following from this research, future studies could explore causality in more depth.

In terms of the survey design, there were a couple of limitations. First, the survey relied on self-report measures – that is, participants were required to self-report on how much different factors were important in their decision-making. This reliance on self-reported sorting tasks risks social desirability effects (e.g., sorting carbon footprint as a very attractive factor when, in reality, this does not feature in the participants' decision-making). Second, the study was designed around hypothetical scenarios, which may distort survey responses. Participants were asked to respond based on imagined journeys, not actual behaviour. This introduces hypothetical bias, where reported barriers may not align with real-world choices.

Equally, the imagined scenarios do not consider participant proximity to the destination. For example, one scenario asks participants to imagine that they are going to a GP appointment. However, this journey could greatly vary between participants based on their proximity to a local GP practice. This makes the results more difficult to generalise due to different routes participants might take. To address these concerns, future research could incorporate field experiments or naturalistic studies in which barriers are manipulated (e.g., reduced fares, improved bus frequency, enhanced journey-planning information) and subsequent mode choice is observed.

It is also worth addressing some limitations of the scope of factors included in this study. This study has focused only on factors that are informative for future policy. As such, psychological and demographic factors have been excluded from the survey. However, this has likely reduced ecological validity, as decisions about PT are influenced by more than subjective service/practical barriers, which this study has focussed on. Future research could extend the network to include demographic and psychological factors, including attitudes, norms, and identities, to see how they interact with practical barriers. Such a study could give a unique, nuanced insight into subjective barriers and their relationships. However, given that this study was specifically for the purpose of informing policy, the decision to exclude psychological and demographic factors is justified based on a lack of immediate applicability of these findings. This is not to suggest that they are not significant, nor that they should be excluded from future research.

Finally, it is worth noting that this data is from a Western, English-speaking country (i.e., the UK, County Durham). We selected this context due to convenience (being based in Durham) and a research focus on barriers to PT adoption in UK contexts. The goal of this research was to aid in actionable UK sustainable policy.

However, it should be noted that these findings may not generalise to other cultural contexts or countries, as the quality and experience of public transport varies widely between nations. The public transport data mentioned in this paper are largely UK-specific. Further, this research is limited even for UK insights; the data collection was exclusively from the Durham area, which will not necessarily be reflected across different UK counties. Accordingly, future research could consider a greater geographic range of samples to explore issues surrounding PT more holistically, encompassing a greater range of perspectives.

7. Conclusion

This research is the first to attempt to model the subjective barriers affecting public transport adoption using a network approach. The most visible finding was that trip duration was the most central and influential determinant of transport mode choice. This indicates a negative bias towards PT adoption on the basis of practicality. Equally, trip duration is well-connected to many other factors within the network, including the number of transfers, bus stop waiting time, fit for journey, and walk from the end. This indicates that trip duration is significant as a factor, not only individually, but also due to its connection with many other factors. This is particularly important for policymakers; while trip duration itself is not something that can be controlled with policy, influencing factors such as ease and number of transfers and bus waiting times, for example, can be improved with targeted policy. Further, this research does seem to be consistent with much of the extant literature under this analysis. While trip duration is the only factor that seems significant in decision-making, this is likely only the

biggest consideration due to other features of PT that it is connected to within the network.

References

1. Almada JF, Renner JS. Public transport accessibility for wheelchair users: a perspective from macro-ergonomic design. *Work*. (2015) 50(4):531–41. 10.3233/WOR-131811
2. Asplund, K., Wallin, S., & Jonsson, F. (2012). Use of public transport by stroke survivors with persistent disability. *Scandinavian Journal of Disability Research*, 14(4), 289–299.
<https://doi.org/10.1080/15017419.2011.640410>
3. Beelmann, A. (2006). *Review of systematic reviews in the social sciences: A practical guide*. Routledge.
4. Best, H., & Lanzendorf, M. (2005). Division of labour and gender differences in metropolitan car use: An empirical study in Cologne, Germany. *Journal of Transport Geography*, 13(2), 109–121.
<https://doi.org/10.1016/j.jtrangeo.2004.04.008>

5. Bezyak JL, Sabella SA, Gattis RH. Public transportation: an investigation of barriers for people with disabilities. *J Disabil Policy Stud.* (2017) 28(1):52–60. 10.1177/1044207317702070

6. Brakewood C., Gregory S. Macfarlane, Kari Watkins, The impact of real-time information on bus ridership in New York City, *Transportation Research Part C: Emerging Technologies*, Volume 53, 2015, Pages 59-75, ISSN 0968-090X, <https://doi.org/10.1016/j.trc.2015.01.021>.

7. Broome K, Worrall L, Fleming J, Boldy D. Evaluation of age-friendly guidelines for public buses. *Transportation Research Part A: Policy and Practice.* (2013) 53:68–80. 10.1016/j.tra.2013.05.003

8. Cairns, S., Harmer, C., Hopkin, J., & Skippon, S. (2014). Sociological perspectives on travel and mobilities: A review. *Transportation Research Part A: Policy and Practice*, 63, 107–117. <https://doi.org/10.1016/j.tra.2014.02.002>

9. Carlsson G. Travelling by urban public transport: exploration of usability problems in a travel chain perspective. *Scand J Occup Ther.* (2004) 11(2):78–89. 10.1080/11038120410020548
10. Chowdhury, S., & Ceder, A. (2016). Users' willingness to ride an integrated public-transport service: A literature review. *Transport Policy*, 48, 183–195. <https://doi.org/10.1016/j.tranpol.2016.03.007>
11. Cordera, R., Canales, C., dell'Olio, L., & Ibeas, Á. (2015). Public transport demand elasticities during the recessionary phases of economic cycles. *Transport Policy*, 42, 173–179. <https://doi.org/10.1016/j.tranpol.2015.05.012>
12. Diab, E. I., Badami, M. G., & El-Geneidy, A. M. (2015). Bus transit service reliability and improvement strategies: Integrating the perspectives of passengers and transit agencies in North America. *Transport Reviews*, 35(3), 292–328. <https://doi.org/10.1080/01441647.2015.1005034>

13. Dorbritz, R., Lüthi, M., Weidmann, U., & Nash, A. (2009). Effects of onboard ticket sales on public transport reliability. *Transportation Research Record, 2110*(1), 112–119. <https://doi.org/10.3141/2110-13>
14. Efthymiou, D., & Antoniou, C. (2017). Understanding the effects of economic crisis on public transport users' satisfaction and demand. *Transport Policy, 53*, 89–97.
<https://doi.org/10.1016/j.tranpol.2016.09.007>
15. Enginöz EB, Salvi H. Examination of accessibility for disabled people at metro stations. *Iconarp Int J Archit Plan.* (2016) 4(1):34–48.
10.15320/ICONARP.2016120307
16. Friman, M., Lättman, K., & Olsson, L. E. (2020). Public transport quality, safety, and perceived accessibility. *Sustainability, 12*(9), 3563. <https://doi.org/10.3390/su12093563>
17. Frost KL, Bertocci G, Smalley C. Ramps remain a barrier to safe wheelchair user transit bus ingress/egress. *Disabil Rehabilitation:*

Assist Technol. (2020) 15(6):629–36.

10.1080/17483107.2019.1604824

18. Gartman, D. (2004). Three ages of the automobile: The cultural logics of the car. *Theory, Culture & Society*, 21(4–5), 169–195.
<https://doi.org/10.1177/0263276404046060>
19. Göransson, J., & Andersson, H. (2023). Factors that make public transport systems attractive: A review of travel preferences and travel mode choices. *European Transport Research Review*, 15, 32.
<https://doi.org/10.1186/s12544-023-00609-x>
20. Guo, Z., & Wilson, N. H. M. (2004). Assessment of the transfer penalty for transit trips: Geographic information system-based disaggregate modeling approach. *Transportation Research Record*, 1872(1), 10–18. <https://doi.org/10.3141/1872-02>
21. Haboucha, C. J., Ishaq, R., & Shiftan, Y. (2017). User preferences regarding autonomous vehicles. *Transportation Research Part C*:

Emerging Technologies, 78, 37–49.

<https://doi.org/10.1016/j.trc.2017.01.010>

22. Hansson, J., Pettersson, F., Svensson, H., & Wretstrand, A. (2019). Preferences in regional public transport: A literature review. *European Transport Research Review*, 11, 38. <https://doi.org/10.1186/s12544-019-0374-4>
23. Hess DB. Access to public transit and its influence on ridership for older adults in two US cities. *J Transp Land Use*. (2009) 2(1):3–27
24. Hidalgo D, Urbano C, Olivares C, Tinjacá N, Pérez JM, Pardo CF, et al. Mapping universal access experiences for public transport in Latin America. *Transp Res Rec*. (2020) 2674(12):79–90.
10.1177/0361198120949536
25. International Association of Public Transport. (2023, November 24). *Why public transport is key to achieve the SDGs*.
<https://www.uitp.org/news/why-public-transport-is-key-to-achieve-the-sdgs/>

26. Intergovernmental Panel on Climate Change. (2022). *Climate change 2022: Mitigation of climate change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (P. R. Shukla, J. Skea, R. Slade, et al., Eds.). Cambridge University Press. <https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/>
27. International Energy Agency. (2020). *Tracking transport 2020*. IEA. <https://www.iea.org/reports/tracking-transport-2020>
28. Ingvardson, J. B., & Nielsen, O. A. (2018). How urban density, network topology and socio-economy influence public transport ridership: Empirical evidence from 48 European metropolitan areas. *Journal of Transport Geography*, 72, 50–63. <https://doi.org/10.1016/j.jtrangeo.2018.07.002>
29. Javaid, A., Creutzig, F., & Bamberg, S. (2020). Determinants of low-carbon transport mode adoption: Systematic review of reviews.

Environmental Research Letters, 15(10), 103002.

<https://doi.org/10.1088/1748-9326/aba1d7>

30. Kuhnimhof, T., Chlond, B., & von der Ruhren, S. (2006). Users of transport modes and multimodal travel behavior: Steps toward understanding travelers' options and choices. *Transportation Research Record*, 1985(1), 40–48.
<https://doi.org/10.1177/0361198106198500106>

31. Lengieza, M. L., Richardson, M., & Aviste, R. (2025). Situation networks: The emotions and activities that are central to nature-connectedness experiences. *Journal of Environmental Psychology*, 101, 102491. <https://doi.org/10.1016/j.jenvp.2024.102491>

32. Lengieza, M. L., Richardson, M., & Hughes, J. P. (2025). Feature networks: The environmental features that are central to nature-connectedness experiences. *Landscape and Urban Planning*, 259, 105362. <https://doi.org/10.1016/j.landurbplan.2025.105362>

33. London TravelWatch. (2022, February 5). *Research on passenger perceptions of value for money*.
<https://www.londontravelwatch.org.uk/research-publications/>
34. Minx, J. C., Callaghan, M., Lamb, W. F., Garard, J., & Edenhofer, O. (2017). Learning about climate change solutions in the IPCC and beyond. *Environmental Science & Policy*, 77, 252–259.
<https://doi.org/10.1016/j.envsci.2017.08.002>
35. Moavenzadeh, F., Hanaki, K., & Baccini, P. (Eds.). (2002). *Future cities: Dynamics and sustainability* (Vol. 1). Springer.
36. Murray, S. J., Walton, D., & Thomas, J. A. (2010). Attitudes towards public transport in New Zealand. *Transportation*, 37(6), 915–929.
<https://doi.org/10.1007/s11116-010-9312-7>
37. Mwaka, C. R., Best, K. L., Cunningham, C., Gagnon, M., & Routhier, F. (2024). Barriers and facilitators of public transport use among people

with disabilities: A scoping review. *Frontiers in Rehabilitation Sciences*, 4, 1336514. <https://doi.org/10.3389/fresc.2023.1336514>

38. Nilsson, M., & Küller, R. (2000). Travel behaviour and environmental concern. *Transportation Research Part D: Transport and Environment*, 5(3), 211–234. [https://doi.org/10.1016/S1361-9209\(99\)00034-6](https://doi.org/10.1016/S1361-9209(99)00034-6)
39. O’Fallon, C., Sullivan, C., & Hensher, D. A. (2004). Constraints affecting mode choices by morning car commuters. *Transport Policy*, 11(1), 17–29. <https://doi.org/10.1016/j.tranpol.2003.08.001>
40. Olawole MO, Aloba O. Mobility characteristics of the elderly and their associated level of satisfaction with transport services in Osogbo, Southwestern Nigeria. *Transp Policy (Oxf)*. (2014) 35:105–16. [10.1016/j.tranpol.2014.05.018](https://doi.org/10.1016/j.tranpol.2014.05.018)

41. Park J, Chowdhury S. Investigating the barriers in a typical journey by public transport users with disabilities. *J Transp Health*. (2018) 10:361–8. 10.1016/j.jth.2018.05.008

42. Paulley, N., Balcombe, R., Mackett, R., Titheridge, H., Preston, J., Wardman, M., & White, P. (2006). The demand for public transport: The effects of fares, quality of service, income and car ownership. *Transport Policy*, 13(4), 295–306.
<https://doi.org/10.1016/j.tranpol.2006.09.001>

43. Putranto LS, Putri DA. Satisfaction level of the blind on urban transportation system in Greater Jakarta. *Int J Integr Eng*. (2018) 10(2):37–42. 10.30880/ijie.2018.10.02.008

44. Ramos, S., Vicente, P., Passos, A. M., Costa, P., & Reis, E. (2019). Perceptions of the public transport service as a barrier to the adoption of public transport: A qualitative study. *Social Sciences*, 8(5), 150. <https://doi.org/10.3390/socsci8050150>

45. Rao, P., Quddus, M., & Ochieng, W. Y. (2025). From autonomy to community: Advancing the role of psychological factors in sustainable mobility decisions. *Transportation Research Interdisciplinary Perspectives*, 31, 101394.
<https://doi.org/10.1016/j.trip.2025.101394>
46. Rasca, S., & Saeed, N. (2022). Exploring the factors influencing the use of public transport by commuters living in networks of small cities and towns. *Travel Behaviour and Society*, 28, 249–263.
<https://doi.org/10.1016/j.tbs.2022.03.007>
47. Ravensbergen L, Newbold KB, Ganann R, Sinding C. ‘Mobility work’: older adults’ experiences using public transportation. *J Transp Geogr.* (2021) 97:103221. 10.1016/j.jtrangeo.2021.103221
48. Ravensbergen L, Van Liefferinge M, Isabella J, Merrina Z, El-Geneidy A. Accessibility by public transport for older adults: a systematic review. *J Transp Geogr.* (2022) 103:103408.
10.1016/j.jtrangeo.2022.103408

49. Redman, L., Friman, M., Gärling, T., & Hartig, T. (2013). Quality attributes of public transport that attract car users: A research review. *Transport Policy*, 25, 119–127.
<https://doi.org/10.1016/j.tranpol.2012.11.005>
50. Risser R, Lexell EM, Bell D, Iwarsson S, Ståhl A. Use of local public transport among people with cognitive impairments–A literature review. *Transp Res Part F: Traffic Psychol Behav.* (2015) 29:83–97.
10.1016/j.trf.2015.01.002
51. Schmitt, L., Delbosc, A. & Currie, G. Learning to use transit services: adapting to unfamiliar transit travel. *Transportation* **46**, 1033–1049 (2019). <https://doi.org/10.1007/s11116-018-9880-9>
52. Sheller, M. (2004). Automotive emotions: Feeling the car. *Theory, Culture & Society*, 21(4–5), 221–242.
<https://doi.org/10.1177/0263276404046063>

53. SLOCAT. (2023). *Global status report on transport, climate and sustainability* (3rd ed.). SLOCAT Partnership on Sustainable, Low Carbon Transport. <https://www.tcc-gsr.com>
54. Stjernborg V. Accessibility for all in public transport and the overlooked (social) dimension—a case study of Stockholm. *Sustainability*. (2019) 11(18):4902. 10.3390/su11184902
55. Taylor, B. D., Miller, D., Iseki, H., & Fink, C. (2009). Nature and/or nurture? Analyzing the determinants of transit ridership across US urbanized areas. *Transportation Research Part A: Policy and Practice*, 43(1), 60–77. <https://doi.org/10.1016/j.tra.2008.06.007>
56. Tennakoon V, Wiles J, Peiris-John R, Wickremasinghe R, Kool B, Ameratunga S. Transport equity in Sri Lanka: experiences linked to disability and older age. *J Transp Health*. (2020) 18:100913. 10.1016/j.jth.2020.100913
57. Transport for London. (2015). *Exploring the Bus CSS metrics*. <https://content.tfl.gov.uk/exploring-the-bus-css-metrics.pdf>

58. Tyrinopoulos, Y., & Antoniou, C. (2020). Review of factors affecting transportation systems adoption and satisfaction. In C. Antoniou, D. Efthymiou, & E. Chaniotakis (Eds.), *Demand for emerging transportation systems* (pp. 11–36). Elsevier.
<https://doi.org/10.1016/B978-0-12-815018-4.00002-4>
59. Ulfarsson, G. F., Steinbrenner, A., Valsson, T., & Kim, S. (2015). Urban household travel behavior in a time of economic crisis: Changes in trip making and transit importance. *Journal of Transport Geography*, 49, 68–75. <https://doi.org/10.1016/j.jtrangeo.2015.10.012>
60. United Nations Framework Convention on Climate Change. (2023). *Technical dialogue of the first global stocktake: Synthesis report by the co-facilitators* (FCCC/SB/2023/9 ADV).
https://unfccc.int/sites/default/files/resource/sb2023_09_adv.pdf

61. Unsworth C, So MH, Chua J, Gudimetla P, Naweed A. A systematic review of public transport accessibility for people using mobility devices. *Disabil Rehabil.* (2021) 43(16):2253–67.
10.3390/ijerph20206952
62. Vallée, J., Ecke, L., Barthelmes, L., & Vortisch, P. (2024). Drivers and barriers to public transport usage: Insights from psychographic profiles using latent class analysis. *Transportation Research Record*, 2678(10), 459–470. <https://doi.org/10.1177/03611981241233580>
63. Vance, C., & Peistrup, M. (2012). She’s got a ticket to ride: Gender and public transit passes. *Transportation*, 39(5), 1105–1119.
<https://doi.org/10.1007/s11116-011-9378-7>
64. van Lierop, D., Badami, M. G., & El-Geneidy, A. M. (2018). What influences satisfaction and loyalty in public transport? A review of the literature. *Transport Reviews*, 38(1), 52–72.
<https://doi.org/10.1080/01441647.2017.1298683>

65. Velho R., Holloway C, Symonds A, Balmer B. The effect of transport accessibility on the social inclusion of wheelchair users: a mixed method analysis. *Soc Incl.* (2016) 4(3):24–35. 10.17645/si.v4i3.484
66. Velho R. Transport accessibility for wheelchair users: a qualitative analysis of inclusion and health. *Int J Transp Sci Technol.* (2019) 8(2):103–15. 10.1016/j.ijtst.2018.04.005
67. Watkins, K. E., Ferris, B., Borning, A., Rutherford, G. S., & Layton, D. (2011). Where Is My Bus? Impact of mobile real-time information on the perceived and actual wait time of transit riders. *Transportation Research Part A: Policy and Practice*, 45(8), 839–848.
<https://doi.org/10.1016/j.tra.2011.06.010>