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Equity in transit fare policy: a literature review

Matthew Bruno [a], Machiel Kouwenberg[b] and Niels van Oort [a]

[a]Department of Transport and Planning, Delft University of Technology, Delft, The Netherlands; [b]Policy Advisor for Mobility Research, Amsterdam Transport Region, Amsterdam, The Netherlands

ABSTRACT

This literature review examines 58 studies on equity in transit fare policy, addressing developments since the last comprehensive review in 1990. It divides the literature into seven categories: (1) fare equity calculation methods; (2) flat versus distance based fares (3) equity impacts of fare changes; (4) differentiated fares; (5) creating equitable fare policy for people with low incomes; (6) fare capping; and (7) free fare public transport. For each category, the review outlines the key findings and suggests areas for future research. Overall, the current literature shows that fare equity outcomes are highly context-dependent and shaped by system design, demographic patterns, and policy implementation. The literature suggests that direct subsidies to low income people result in better equity outcomes than subsidies to groups that collectively have a lower than average income. Additionally, free fare public transport has received considerable attention even as the literature suggests its benefits may be quite limited. In contrast, the limited attention given to fare capping has suggested that it has the potential to significantly improve equity outcomes with limited cost burdens to transit providers. Future research should focus on methods for identifying low-income users, best practices for implementing new payment structures such as fare capping, and different ways of using fares to increase transit accessibility.

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Fare equity; public transportation; fare pricing; fare policy; transportation policy

1. Introduction

Over 30 years ago, Cervero (1990) published a literature review on transit pricing, synthesising the insights from various North American systems on the effects of different payment policies on equity and ridership levels. In the intervening years, technological developments have changed how fares, are collected, monitored and analyzed (Dydkowski & Urbanek, 2023; Hickey et al., 2010). Further, the level of attention for issues surrounding equity and transportation has grown substantially. A UK study of social exclusion in 2002 led to a body of literature on transport disadvantage, examining the many different barriers that can exclude people from the transport system (Lucas,

CONTACT Matthew Bruno Bruno.ma@ymail.com Department of Transport and Planning, Delft University of Technology, Delft, The Netherlands

2012). A recent publication synthesising the ten different forms of transport related social exclusion noted that economic factors, including fare price, are one of the primary determining factors of accessibility (Bruno et al., 2024). An updated literature review is necessary to provide an overview of the results of numerous studies on fare equity that have been produced in the wake of changes in both how transit fares are paid and how fare equity is approached. This review will benefit both academics studying the role of fare policies in reducing transport disadvantage and transportation agencies that need an understanding of areas of consensus and contention before implementing fare policies that may have equity implications.

This review synthesises findings from 58 studies of equity in fare policy across seven thematic areas: (1) fare equity calculation methods; (2) flat versus distance based fares (3) equity impacts of fare changes; (4) differentiated fares; (5) creating equitable fare policy for people with low incomes; (6) fare capping; (7) free fare public transport. Each subsection summarises the current literature and identifies key gaps and points of contention. The review concludes with a discussion section that provides a synthesis of the findings and presents a research agenda that emphasises the need for more comparative studies across geographic contexts and better integration of income and spatial data in fare equity evaluations. Overall, the findings suggest that fare equity outcomes are highly context-dependent, shaped by regional demographics, land-use structure, and transit system design.

2. Methodology

The review follows the process outlined by Van Wee and Banister (2016). It uses the PRISMA method to identify potentially relevant scholarship and screen it for eligibility (Moher et al., 2009). The initial literature search was conducted in two stages. The first stage used the forward snowballing technique (Jalali & Wohlin, 2012) in which citations of a relevant older article are used to identify more recent scholarship. Specifically, all of the articles that cited the previous transit pricing review by Cervero (1990) were reviewed for relevance. The second stage applied a Scopus search of English language articles. A query was created using three sets of search terms: (1) terms related to public transportation, (2) terms related to fare policy, and (3) terms related to transport disadvantage. The search query for the third concept was adapted from a recent literature review on transport disadvantage and digital inequality that used an extensive query string to capture a broad range of literature related to transport disadvantage (Durand et al., 2022). The terms within each individual set were joined with a Boolean OR (see Table 1). The sets themselves were joined with an AND.

Table 1. The three search strings used to identify potentially relevant literature.

Concept	Search string
Public Transportation	"transit" OR "public trans*" OR "PT"
Fare Policy	"fare*" OR "pric*" OR "cost"
Transport disadvantage	"social exclusi*"OR"inclusive*"OR"transport* accessibility"OR"accessible transport*"OR"social* *clusive transport*"OR"transport-related social*clusion"OR"transport* disadvantage" OR "unmet travel need" OR "transport*poverty"OR"mobility poverty"OR"mobility disadvantage"OR"mobility inequalit*"OR"transport* *equalit*"OR"unfulfilled mobility"OR"participation in mobility"OR"latent travel demand"OR"accessibility poverty"

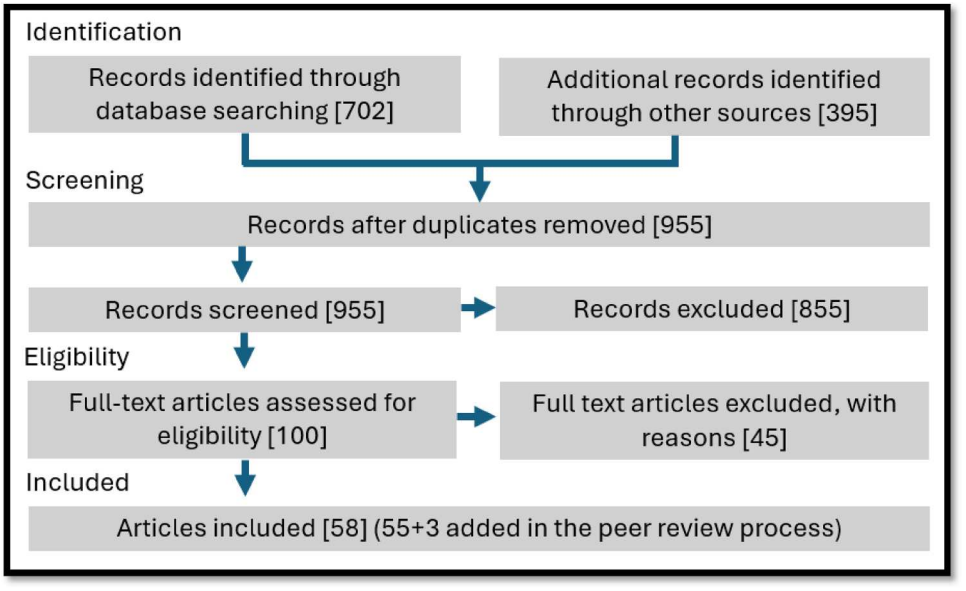

Figure 1. Flow of information through the different phases of a systematic review, adapted from Moher et al. (2009).

The forward snowballing technique produced 270 results through Google Scholar and 125 results through Scopus. Removing duplicates, non-English language articles, conference papers and non-academic sources left 253 results. The Scopus search shown in Table 1 produced 702 results. Combining the two lists and removing duplicates left 955 results that were screened for relevance. One hundred of these were determined to be within the scope of the literature review.

The titles, abstracts and keywords for each of these results led to the organisation of the literature into seven thematic categories (see the appendix for a summary table including methods, data, and geographic area for each category). The categories also include references to significant works found within the reviewed literature. These are only included as citations and not summarised as part of the literature review. After reviewing the full text of the literature, 45 articles were found to be outside of the scope of the review, narrowing the final selection of articles down to 55. Three additional articles were added during the review process (Figure 1).

3. Overview of the thematic categories

The sections below provide an overview of the literature in seven thematic categories related to fare equity. Each section begins with a brief synthesis of the reviewed literature and concludes with possible areas for potential future research.

3.1. Fare equity calculation methods

Defining what equity means and determining how best to measure it is one of the central challenges in evaluating fare equity in public transportation. Equity is generally discussed

in terms of horizontal equity (the equal distribution of benefits across equal members of society (Bandegani & Akbarzadeh, 2016)), and vertical equity (the distribution of benefits according to need across different income groups and social classes (Harmony, 2018)). One standard approach for calculating either type is an accessibility analysis combining fare data the variables of distance and time (Zhang, 2023). This section first looks at research that has incorporated fares into accessibility models and then examines research that also includes ability to pay. It continues with research evaluating equity using optimisation models, economic welfare frameworks, and value-based assessments. Finally, it presents literature that examines calculating equity within broader goals including travel-time savings and sustainability.

Multiple researchers have focused on the need to incorporate fares into accessibility evaluations. For example, a study of transit in Kunming City, China, used an accessibility analysis to measure horizontal equity. It combined door-to-door travel time with fare prices to create a generalised travel cost (Li et al., 2023). When comparing traffic analysis zones, the method found that accessibility levels differed by a factor of almost 2.5 across the city. Similarly, Herszenhut et al. (2022) determined that not including monetary costs in accessibility calculations leads to an overestimation of accessibility levels but the complex relationship between fare policies, spatial organisation, and transit structure means that different ways of including fare in accessibility calculations can lead to different determinations of what is equitable. Another group of researchers analyzed vertical equity by creating what they described as "an algorithm-based fare calculation approach that is flexible, scalable, fast, and accurate" (Da Silva et al., 2022, p. 2). The algorithm takes data found within the General Transit Feed Specification (GTFS) and uses it to evaluate all the different travel options for people on a limited travel budget and identifying the locations where having a limited ability to pay has the greatest impact on accessibility (Da Silva et al., 2022).

Other researchers have treated the variables of distance and fare as an optimisation problem, calculating which set of distance-based fares would minimise the system's Gini-coefficient. They found that fares based on Euclidean distances rather than the distance traveled had better equity results (Huang et al., 2021). This result was also reflected in case study of the Amsterdam transit system that showed that people living in higher income areas travelled on less circuitous routes than lower income people, as higher income people often have access to more direct metro connections (Dixit et al., 2021). This results in lower income people both traveling longer distances and paying higher fares, an equity issue that could be addressed by switching to fares based on Euclidean distance rather than distance traveled.

Other researchers have extended this discussion by incorporating income and population differences when assessing equity in accessibility evaluations. El-Geneidy et al. (2016) highlight that conventional accessibility measures often focus solely on the number of jobs reachable within a time threshold, overlooking affordability. Their study of socially disadvantaged neighbourhoods in Montreal used a model that combined travel times, fares, and local minimum wage. With wages included in the model, overall job accessibility decreased, but the lowest income groups experienced smaller reductions. Building on this approach, Conway and Stewart (2019), using the case of greater Boston, developed an algorithm that adds a monetary cutoff to the cumulative opportunities metric that traditionally only has a travel time cutoff. Liu and Kwan

(2020a) argue that fare price needs to a part of accessibility models when evaluating which jobs are available to low-income people using public transportation and describe a method for including this in accessibility calculations. In a related article, Liu and Kwan (2020b) added complexity to the model of El-Geneidy et al. (2016) in their analysis of the Chicago Metropolitan Area by converting travel time, median income per census tract, and transit fares into a unified measure of total travel cost expressed as a percentage of income. As in the other studies reviewed here, they found that not including income in fare-based accessibility evaluations resulted in an overestimation of accessibility for low-income people.

Further studies have refined these approaches to examine how fare structures interact with transport investments and spatial inequalities. Yu and Cui (2023) observed that rail investments often prioritise travel time savings, but the resulting higher fares can offset benefits, particularly for residents in peripheral, low-income areas where travel times may not improve while costs rise. Similarly, Chen et al. (2022) evaluated the equity implications of rail expansion by comparing the number of opportunities reachable under different combined bus – rail cost thresholds. Their results emphasise that evaluating accessibility across varying fare levels is essential for understanding the equity impacts of infrastructure investments.

Some fare equity research does not use accessibility as a starting point. One study looked at the bus fare paid by older adults in Beijing public transport system using the lens of economic welfare (Zhang, 2023). The study used a stated preference survey of 500 people between the ages of 60 and 69 to compare the difference between what passengers were willing to pay and the actual fare and found that a fare increase would have a differential impact on passengers. The study recommended fares based on income rather than age. Xiao et al. (2021) examined the transit fare and benefit mismatch (TFBM) of transit users through a comparative analysis of Hong Kong's heavy rail, light rail, buses, trams, taxis, and ferries. They analyzed travel distance and relative travel time between systems and then used transit fare in relation to not only income but also estimated housing costs to determine the relative cost of transit. The results showed that TFBM reduces transit usage in peripheral areas of the city and leads to equity issues in transit dependent socioeconomically vulnerable neighbourhoods.

Varghese et al. (2023) broaden the context of fare equity, noting that achieving sustainability goals that depend on a mode shift from private auto use to transit often requires building transit systems that meet the comfort demands of high income riders. These systems can price out low-income riders. In modelling the ridership effects of a system with increased comfort at higher fare prices, they found a trade-off between equity and sustainability.

A review of the literature on defining fare equity shows different approaches for how the concept can be approached. Some researchers have looked at fare equity largely from an accessibility perspective (Chen et al., 2022; Dixit & Sivakumar, 2020; El-Geneidy et al., 2016; Liu & Kwan, 2020a) while another approaches it by examining the benefits received by passengers in relation to their costs (Varghese et al., 2023; Xiao et al., 2021; Zhang, 2023). More research is needed on how to combine these approaches and to determine if applying a different approach in the same context yields complementary of contradictory results.

3.2. Flat vs distance based fares

Comparing the equity effects of flat versus distance-based transit fares is a common theme in fare equity research. While distance-based fares have often been considered more equitable (Brown, 2018; Cervero, 1981) – especially in contexts where wealthier riders travel longer distances – more recent research suggests that the relationship between fare structure and equity is highly context-dependent (Rubensson et al., 2020; Tiznado-Aitken et al., 2020; Zhao & Zhang, 2019). This section reviews studies that investigate how urban form, socio-economic geography, and transit usage patterns shape which fare structures best serve low-income and transit-dependent populations. It also reviews several case studies on how fare policy affects suburban and peripheral areas, highlighting the trade-offs between different equity goals.

Some studies have shown that from a vertical equity perspective, distance-based fares are more equitable than flat fares where the price is the same regardless of the distance travelled (Brown, 2018; Cervero, 1981). These studies argued that distance-based fares were more equitable because under a flat fare system wealthier people who travelled long distances from the suburbs had their trips partially subsidised by lower income people taking trips within the urban core.

Researchers looking at the issue within a European context, however, argued that the previous studies used U.S. examples and were reflective of a specific U.S. suburban development pattern (Rubensson et al., 2020). Their work, along with additional research from South America (Tiznado-Aitken et al., 2020) and Asia (Zhao & Zhang, 2019), found that flat fares were more equitable in places where the urban core remained the most desirable place to live and lower income workers often had to commute long distances from more affordable housing outside of the city center.

Studies have looked at the specific impact of switching from flat to distance-based fares. Researchers looking at the Utah Transit Authority created a method that included income, race, ethnicity, age, employment status, education, ability to drive, physical ability, care ownership, home ownership, home type and residential location in the analysis (Farber et al., 2014). They found that low-income, elderly, and non-white populations benefited from the change but benefits were not evenly distributed geographically, with some on the urban fringe even being impacted negatively. Bandegani and Akbarzadeh (2016) used the Gini co-efficient to analyze the degree to which passengers cross subsidised each other in a flat versus distance-based fare system for the city of Esfahan. They found that changing from a flat to distance-based fare system would result in a 50% improvement in horizontal equity. When examining the impacts of switching from a flat to a zone based system in Haifa, Israel, researchers found the change resulted in a greater overall variance of the price paid to use transit but had a positive impact on vertical equity, with people living in low-income areas, the unemployed, and retired riders all experiencing a significant reduction in fare (Nahmias-Biran et al., 2014). In contrast, a study focused on the area around Stockholm concluded that flat fares reduce the geographic disparity in public transport costs, making transit more attractive to those who drive (Kholodov et al., 2021).

Collectively, these studies show that the equity of distance based versus flat fares is dependent on historical development patterns and the cultural and geographic context in which the fares are implemented. In areas in which flat fares are determined

to be better than distance based fares in terms of vertical equity, an understanding of the trade-offs when the opposite is true for horizontal equity is critical. Additional research could provide more support for which factors are the key determinants of equity across diverse geographic areas.

3.3. Equity impacts of fare changes

An overview of 265 urbanised regions in the U.S. concluded that two factors have the greatest influence on transit use: service frequency and fare levels (Taylor et al., 2009). A large body of literature has explored how changes in the price of fares results in changes in ridership (Bresson et al., 2003; Davis, 2021; de Grange et al., 2013; Deb & Filippini, 2013; Guzman et al., 2020; D. A. Hensher, 2008; Kholodov et al., 2021; Zeng et al., 2021). This section reviews the research around price elasticity that has specifically addressed the equity implications, examining whether some groups are more heavily impacted by changes in price than others.

Wang et al. (2021) used smart card data in Brisbane, Australia, to evaluate how fare changes effected horizonal and vertical equity, looking at the impacts across the system and within individual travel zones. They found vertical equity variations when comparing across passenger types of concession card users, adults, children and seniors, with concession card holders having the lowest Gini Index both before and after the fare change. The evaluation, however, also found horizontal equity improvements, with the Gini Index lower for each type after the fare change (except for a minor increase for children likely due to a policy change allowing free travel on weekends). They identified specific instances where equity may be negatively impacted even when overall equity is improved. Chen and Zhou (2022) took a longitudinal approach, using data before and after a fare increase in the Wuhan Metro system to compare the travel behaviour of specific user groups. The results showed the fare increase had significant impacts on travel patterns and that socioeconomic indictors were a better predictor of decreased trip taking than spatial variables. The authors conclude that offering discounted tickets to those who are transit dependent could allow for revenue increases while mitigating the impact on low-income users.

A case study looking at a northern California transit system examined the impacts of five different fare change proposals for increasing revenue while minimising the equity impacts on riders (Nuworsoo et al., 2009). The proposals included a combination of fare increases, base fare reductions, removal of free transfers, and elimination of periodic passes. The study estimated elasticities for different subsets of riders, including lower income riders, youth and minorities. Because the lowest income groups made more trips with more frequent transfers, options that maintained periodic passes and reduced transfer fees were the most equitable.

Another group of researchers examined the impacts on job accessibility after a direct fare increase in Kelowna, British Columbia, Canada (Ma et al., 2017). They used a logit mode choice model to estimate the monetary value of travel time and then measured changes in accessibility. They found that when fares increase in a flat fare system, the number of jobs available at a given distance decreases proportionally, with the layout of the city, the organisation of the transit network, fare structure, and the distribution of jobs effecting the impacts of the fare increase. Specifically, the researchers found

that the accessibility impact for the central area was substantially greater for short trips than long trips but the flat fare structure did not allow for a differentiation between these trip types. They recommend alternative fare structures, such as a zone-based fare system, that would mitigate the negative impact of fare increases where the change had the greatest impact on job accessibility.

The literature on fare increases shows that measuring the elasticity effects of price changes is different from measuring the equity impacts on specific groups of riders. Even when the overall impact of a fare increase on ridership might be limited, certain groups might be significantly effected. This presents two different challenges: identifying the most impacted groups and developing policies to mitigate that impact. As with many aspects of fare equity, more research is needed on the context dependent elements that should be taken into account, including the fare structure, system configuration, and population distribution.

3.4. Differentiated fares

Differentiated fare policies, fare pricing schemes in which specific groups pay reduced fares, are often implemented as a means to improve transit equity. The literature in this area explores two main dimensions: the effectiveness of targeted fare discounts in improving equity outcomes, and the institutional and societal challenges of implementing fare systems where different users pay different prices. Even when equity benefits are clear, efforts to implement differentiated fare systems often face resistance due to political, financial, or public perception barriers. This section reviews research that evaluates both the impact and the implementation challenges of differentiated fares.

Wang et al. (2022) noted that some studies showed clear benefits from subsidising groups that might have a lower ability to pay (Guzman & Oviedo, 2018; Myung-Jin et al., 2018) and other studies showed differentiated fares primarily benefited the wealthy with limited benefit to the targeted groups (Arranz et al., 2022; Serebrisky et al., 2009). Cadena et al. (2016) also found a lack of adequate research on evaluating the equity implications of subsidised travel. They developed a method of evaluating the vertical equity impact of subsidised travel passes provided to low income people and found that it effectively supported accessibility for low income groups, resulting in less inequality between residents.

Arranz et al. (2022) examined whether providing lower fares for people over 65 created a more equitable transportation system. They noted that the assumed correlation between being over 65 and being low-income does not exist in many places. Their study found that subsidising trips for people over 65 did produce equitable outcomes because low and medium income households benefitted, but the subsidies produced the largest positive impact for households in the top earning quartile, calling into question the use of age in fare pricing. A study of free subway fares for elderly people in Seoul determined that the scheme provided substantive net social welfare benefits without burdening the transit system (Myung-Jin et al., 2018).

Other research on differentiated fares has examined the political challenges of providing targeted subsidies to specific groups. Different studies have examined proposed plans to subsidise specific groups and identified the key reasons that these programmes were never implemented. Zolnik (2007) looked at a failed effort to provide discounted travel to

students and certain employees and found the programme had clear goals but not a clear financial structure to support those goals. Another study of a similar programme found that those advocating for it could not convince the community that different people should pay different fares based on need (Butler & Sweet, 2020).

The multiple case studies on differentiated fares shows that, in some instances, the targeted groups may contain people with a lower than average income but people with higher than average incomes within the group receive the greatest benefits from the subsidies. For this reason, other researchers have proposed providing subsidies directly to people with low-incomes, rather than to groups that collectively have a lower than average income. The section that follows provides an overview of that literature.

3.5. Creating equitable fare policy for people with low incomes

As an inability to pay is one of the most significant barriers to transit use (Bruno et al., 2024), creating fare policies that support low income people can have a significant impact on reducing transport related social exclusion. Recent research has shifted from broad demographic-based discounts to more targeted approaches that prioritise income as the key determinant for fare subsidies (Harmony, 2018). This section explores the growing body of literature on low-income fare programmes, highlighting how they are designed, implemented, and evaluated. Studies reviewed here emphasise the importance of clearly defining and verifying income eligibility (Harmony, 2018), the need for tiered pricing structures that differentiate between low and very low incomes (Darling et al., 2021), and the broader implications of unaffordable fares, including fare evasion (Perrotta, 2017) and reduced mobility for vulnerable groups (Cooke et al., 2022). This section also examines aspects of pricing that include the financial burden of transportation expenses (Olvera et al., 2004) and the integration of first – and last-mile services (Reck & Axhausen, 2020), highlighting the many different aspects of transit affordability and the different approaches for directly addressing it.

Researchers examining 61 transit programmes in the United States that provided free or reduced fares to low-wage earners found that many transit agencies had moved from programmes that addressed the problem indirectly – providing free transit connections from low-income communities, placing caps on transfer fees, or providing discounted fares to certain demographics – to programmes that addressed the issue directly by providing discounts to people with low incomes (Harmony, 2018). They used their findings to develop a four step process for creating an equitable low-income fare policy: (1) Create a definition for what low-income means; (2) Develop a method for determining if someone meets that definition; (3) Give the people that meet that definition lower fares; (4) Reduce fraud. The authors give examples of the methods used by different agencies for each step.

Research that looked at the 50 largest transportation providers in the US noted that while people who qualify for reduced fares spend on average 2% – 6% of their annual income on transportation, people with very low-income may spend more than 10% (Darling et al., 2021). They conclude that providing tiers of discounts based on income would greatly improve equity outcomes for the lowest income riders.

Cooke et al. (2022) use the capabilities approach to frame the relationship between fare policy and low income people, noting those evaluating transportation systems often confuse proximity with access. The authors note that if people cannot afford the

fare, they cannot use the system. They note that quantitative data on those who travel does not include data on those who cannot travel. Their interviews showed that many who are walking or cycling do so because they cannot afford public transportation, not because it is the best alternative.

Loukaitou-Sideris et al. (2023) reviewed a programme that provided free transit to passes to unhoused people and noted that transit agency did not expect to lose substantial revenue because the target group had low fare compliance. Further, the agency hoped that applying for the pass would create an opportunity to connect unhoused people with additional city services.

Through a qualitative study based on interviews with low-income residents, transportation planners, and social service professionals, Perrotta (2017) examined strategies used by people who could not afford to use transit but still relied on it for travel. The author noted that transportation professionals are often unaware of how their transit systems are subsidised by other government agencies that provide fare support to riders and that fare evasion is often a consequence of not being able to afford a trip that is seen as necessary. A study of transit use in three major cities in France complemented these findings by showing that the cost of transport can limit the mobility of all low-income households, including those with access to a car, and many of these low-income households are not eligible for transportation benefit programmes because they do not meet the specific income requirements or are not registered in the unemployment system (Olvera et al., 2004). The authors recommend progressive pricing policies based on household incomes and providing broader access to steeply discounted monthly passes.

Reck and Axhausen (2020) argue that fare policy extends beyond the transit trip itself. They document the challenges faced by transit operators looking to subsidise first and last mile trips to transit stations and conclude that integrating these segments into existing fare structures would be the most equitable approach to subsidising feeder services.

Collectively, the literature reveals a consensus on equity outcomes being improved through policies that directly target low-income people rather focusing on groups with a below average income. Making this shift in policy requires a better understanding of how to identify low-income people, how to differentiate between those with low and very low-incomes, and how to provide financial support not only to use public transport but also to access it.

3.6. Fare capping

The transition to card-based payment systems created the possibility of innovative fare structures, including fare capping, which automatically limits how much a rider pays within a set timeframe or trip count. This section outlines the main types of fare capping and explores their equity benefits, reviewing how transit agencies have implemented these systems in practice. It also highlights how fare capping supports riders with irregular travel patterns and reduces the financial burden of upfront pass purchases for low-income users.

Chalabianlou et al. (2015) describe the key elements of fare capping and detail the different variants. In value based caps, people no longer pay after a certain monetary amount. In trip based caps, a fare is only charged for a certain number of trips within a time period. Transit operators could also discount fares after a certain threshold is

crossed or apply differentiated fares based on mode or operators. They note that from an equity perspective, fare capping provides two key advantages: it guarantees that the passenger pays the lowest possible fare and simplifies the payment system so all users can benefit without needing to understand the system.

Hightower et al. (2022) examine how fare capping works in practice through a review of the fare capping policies of 21 transit agencies in the United States. They note that fare capping can increase equity without revenue losses for the transit agencies, as the cap amounts can be adjusted to keep the policy revenue neutral. The system itself allows for improved equity evaluations as reaching the fare cap reveals which passengers are benefitting from the system. They note no systems sets the daily cap level below two trips, directing the benefits away from commuters and towards transit-dependent riders, tourists, and frequent users. They also observed that many transit systems used nested capping systems – systems with multiple capped time periods. These increase the equity of the system by benefiting people with irregular travel patterns and allows the benefits to accumulate.

In a study of fare pass use in Montreal, Verbich and El-Geneidy (2017) found that fare vendors in low-income neighbourhoods and neighbourhoods with high employment rates sold higher levels of weekly transit passes than high income neighbourhoods, even though the weekly passes cumulatively cost more. A fare capping system removes this issue by taking away the burden of paying the full cost of a pass up front (Hightower et al., 2022).

These findings demonstrate the potential of fare capping for advancing equity in public transit systems. By eliminating enrolment requirements and removing large one-time payments, fare capping provides clear equity benefits without necessarily incurring increased costs for transit providers. Additional research could help clarify how best to implement a fare capping programme. This could include research on specific cost neutral fare capping strategies and research on the benefits and drawbacks of increased complexity in nested fair capping systems.

3.7. Free fare public transport

The equity argument for Free Fare Public Transport (FFPT) focuses on its ability to directly increase transit accessibility for people with low incomes and underprivileged groups. In presenting the equity argument for FFPT, Kębłowski (2020) draws on scholarship that views public transportation as a common good rather than a commodity, comparing transit systems to other fare-free transportation infrastructure such as bicycle lanes or streetlights. FFPT also resolves issues related to racial profiling by removing the process of controls entirely. This section examines the different forms, goals, and equity impacts of fare-free public transport. It distinguishes between full and partial FFPT systems and looks at critiques of generalising from schemes implemented within specific political contexts and under financial constructions not possible in many places.

In an overview of the nearly 100 cities offering some form of FFPT, Kębłowski (2020) found most cases were in areas with less than 100,000 inhabitants. The overview makes a distinction between full FFPT with fully subsidised routes across the system over an extended period of time, and partial FFPT that is only free during limited hours, for a limited period, to a limited number of people, or on limited routes. The underlying goal of FFPT also varies significantly by system, with arguments based on how transit

should be funded, sustainability arguments, and equity arguments. While the first two are outside the scope of this paper, the equity arguments are central to a broader discussion of the role of transit fares in equitable transportation policy.

Štraub (2020) argues that one of the primary equity rationales for FFPT in low-population areas is that it allows for the financing of public transportation independent of ridership, allowing transit access for people who live in areas that operators would otherwise not serve, which is separate from the impact of the fare on ridership. A survey of over a thousand people in suburban Poland with access to both free and paid transit found that connection frequency, accessibility, and safety were the most important factors for choosing public transport with the cost of fares being of limited concern in both free and paid areas (Fiedeń & Štraub, 2023). When looking only at cost, however, two studies of public transport fares in Australia that both found that public transport fares in suburban areas made it challenging for public transportation to compete with private cars (Hensher & Chen, 2011; Li et al., 2015)

In cities, FFPT has the potential to improve general mobility. A study in Santiago, Chile, that involved giving free travel passes to a select number of participants found no increase in peak hour trips but a significant increase in off-peak trips (Bull et al., 2020). These behaviour changes were attributed to the free pass allowing for an increase in leisure activities and errands.

Tomeš et al. (2022) examined one of the few non-local cases of FFPT, analyzing the costs and benefits of policies in Slovakia and the Czech Republic that provided 100% and 75% fare reductions respectively for children, students and pensioners. These discounts applied to local travel and some long distance transport. The study found an increase in train use by disadvantaged groups, which led to more frequent service, benefitting all groups. The study also noted, however, that the exclusion of busses from the programme led to a shift from bus to rail transport, decreasing bus service and reducing accessibility for some.

Tallinn, Estonia, is the largest system to adopt FFPT and several case studies have examined the system. A study a year after implementation argued that the Tallinn case is useful for three reasons: its implementation in a major city, its openness to all demographic groups, and its long-term structure (Cats et al., 2017). It also noted limitations: the scheme is limited to residents and funded by an increase in people who changed their registration city from their hometown to Tallinn, increasing Tallinn's tax base. Tallinn also already provided free fares to approximately one third of residents, lessening the impact of moving entirely to FFPT. The study concluded that the FFPT led to an additional 20% trip generation by low-income and unemployed residents but without an increase in employment opportunities for these groups.

Hess (2017) argues that generalising from the Tallinn case is difficult for four reasons: (1) the unusual financing scheme is both context specific and not likely to be sustainable over the long term; (2) the policy was implemented alongside other fare related policies including a new ticketing and payment system, making the effects of FFPT difficult to isolate; (3) the city itself has produced no official reports or systematic evaluations; and (4) riders frequently fail to validate their cards when using the system, creating reliability issues with the data. Other researchers have acknowledged these limitations of the Tallinn case and used them to argue that the political context of any FFPT programme needs to be taken into account when evaluating its effectiveness (Kębłowski et al., 2019). As most

of the other FFPT programmes were implemented in areas with low transit ridership (Kębłowski, 2020), the question of FFPT's long term viability in transit systems with high ridership and traditional funding systems remains open.

4. Discussion and conclusion

A review of 58 articles reveals that fare equity is influenced by factors far beyond fare structure alone. Similar fare structures can have different equity outcomes depending on where low-income people are concentrated in a given region (Herszenhut et al., 2022), the demographics of transit use (Dixit & Sivakumar, 2020), the structure of the transit system (Rubensson et al., 2020), the manner in which fares are calculated (Zhang, 2023), how discounts are applied (Hightower et al., 2022), and the degree of transit dependency experienced by passengers (Xiao et al., 2021). Research on the equity impact of fare changes shows that higher fares reduce ridership, but their equity impacts vary across user groups and urban contexts (Chen & Zhou, 2022; Taylor et al., 2009; Wang et al., 2021). Studies reveal that fare increases disproportionately affect low-income and transit-dependent riders, emphasising the importance of context-sensitive pricing and targeted mitigation measures to balance revenue needs with equity goals (Ma et al., 2017; Nuworsoo et al., 2009).

This literature review examined the literature across seven different topics and presented key findings for each topic. In examining fare equity calculation methods, studies have integrated fare, time, distance, and income to evaluate how costs shape mobility opportunities across socioeconomic groups. While some research emphasises optimising fare structures for equitable access (Da Silva et al., 2022; Huang et al., 2021), others assess the balance between cost, perceived benefit, and broader goals such as sustainability (Varghese et al., 2023; Xiao et al., 2021; Zhang, 2023). Research comparing flat and distance-based fare structures shows that their equity impacts are highly context-dependent, shaped by urban form, income geography, and travel behaviour (Rubensson et al., 2020; Tiznado-Aitken et al., 2020; Zhao & Zhang, 2019). While distance-based fares often enhance vertical equity in car-oriented contexts (Brown, 2018; Cervero, 1981), flat fares can be more equitable where low-income riders commute from peripheral areas (Bandegani & Akbarzadeh, 2016; Nahmias-Biran et al., 2014). Research on the equity impacts of fare changes shows that higher fares reduce ridership, but their equity impacts vary across user groups and urban contexts (Chen & Zhou, 2022; Taylor et al., 2009; Wang et al., 2021). Fare increases can disproportionately affect low-income and transit-dependent riders, emphasising the importance of context-sensitive pricing and targeted mitigation measures (Ma et al., 2017; Nuworsoo et al., 2009). Research on differentiated fare policies shows that while targeted discounts can enhance equity and accessibility for low-income and vulnerable groups (Cadena et al., 2016; Myung-Jin et al., 2018; Wang et al., 2022), higher-income groups may receive a substantial share of the benefits when eligibility is based on social categories rather than diretctly tied to income (Arranz et al., 2022; Serebrisky et al., 2009). When creating equitable fare policies for low-income people, studies highlight the need for clearly defined income eligibility, tiered subsidies, and integrated support for first – and last-mile travel (Olvera et al., 2004; Perrotta, 2017; Reck & Axhausen, 2020). Fare capping has received limited attention and yet has the potential to significantly improve equity outcomes (Chalabianlou et al., 2015; Hightower

et al., 2022; Verbich & El-Geneidy, 2017). In contrast, while free fare public transport has gained considerable attention in the literature, its actual benefits may be quite limited (Hess, 2017; Kębłowski, 2020).

A research agenda based on the challenges described above would focus on insights into how to develop more equitable fares. This would include how best to identify low-income people, how to set fare policy for them, and how to ensure the fares can be implemented politically. Expanding the existing literature on multiple fare tiers for different income levels (Darling et al., 2021), addressing the first and last mile problem (Reck & Axhausen, 2020), and gaining political support for new forms of pricing (Butler & Sweet, 2020; Zolnik, 2007) would help clarify the most effective ways to increase transit accessibility for low income people. Additionally, future research on fare capping could look at methods for farebox neutral implementation and user experience with different nested capping systems. Finally, many of the articles cited in this literature review focus on individual cases. While a limited amount of fare equity research has explicitly addressed geographic differences (Bresson et al., 2003; Darling et al., 2021; Kębłowski, 2020; Rubensson et al., 2020), more research is needed comparing fare equity across different geographic and political contexts to determine which fare equity principles can be broadly generalised.

This literature review highlights the growing complexity and importance of equity considerations in transit fare policy. Over the past three decades, transit agencies have used technological developments to implement new payment forms and structures. Researchers have used data made available by GPS and smartcard systems to conduct analyses that integrate spatial, economic, and demographic factors in their evaluation of these fare structures. The findings consistently show that equity outcomes are deeply influenced by context and that policies directly benefiting low-income people offer the most promise for reducing transport disadvantage. Future research should prioritise comparing results across both different transit systems and different equity calculation methods. With broader issues of equity gaining increased attention over the past several decades, a deeper, more nuanced understanding of equity in fare policy remains necessary to ensure transportation systems can implement fares that meet their equity goals.

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ORCID

Matthew Bruno http://orcid.org/0000-0003-0383-1240
Niels van Oort http://orcid.org/0000-0002-4519-2013

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Appendix: Overview of literature

Fare equity calculation methods

First Author	Year	Title Start	Method	Data	Study Area
Chen, H.	2022	The Impact of Rail Transit on Accessibility …	Accessibility calculation	Census data	Guangzhou, China
Conway, M.W.	2019	Getting Charlie off the MTA …	Accessibility calculation	Network and fare data	Boston, USA
Da Silva, D.	2022	Living on a fare …	Accessibility calculation	GTFS data	US Urban Areas
Dixit, M.	2021	Examining circuity of urban transit …	Equity evaluation	Smartcard and census data	Amsterdam, The Netherlands
El-Geneidy, A.	2016	The cost of equity …	Accessibility calculation	Census, fare and GTFS data	Montreal, Canada
Herszenhut, D.	2022	The impact of transit monetary …	Accessibility calculation	Census, Open Street Map, and GTFS data	Rio de Janerio, Brazil
Huang, D.	2021	An Optimal Transit Fare …	Fare optimisation	Transit network data	None
Li, W.	2023	Collective and individual spatial equity …	Accessibility calculation	Road network and fare data	Kunming City, China
Liu, D.	2020	Measuring spatial mismatch …	Accessibility calculation	Census data, transit fares, Google Maps	Chicago, USA
Liu, D.	2020	Measuring Job Accessibility …	Accessibility calculation	Census data, transit fares, Google Maps	Chicago, USA
Varghese, V.	2023	Environmental sustainability or equity …	Equity evaluation	Stated preference survey	Dhaka, Bangladesh
Xiao, L.	2021	Paying for Travel Distance and Time Saving …	Transit fare and benefit mismatch index	Census, network, fare data	Hong Kong
Yu, L	2023	How subway network affects transit accessibility …	Accessibility calculation	Network maps, census data, travel diaries, housing prices	Xi'an, China
Zhang, D.	2023	Understanding mobility inequality …	Equity evaluation	Stated preference survey, econometric modelling	Beijing, China

Flat vs distance based fares

First Author	Year	Title Start	Method	Data	Study Area
Bandegani, M.	2016	Evaluation of Horizontal Equity …	Fare elasticity and probability distribution	Field survey	Isfahan, Iran
Brown, A.	2018	How flat and variable fares affect transit equity …	Equity analysis	Travel diaries	Los Angeles, California
Farber, S.	2014	Assessing social equity in distance based transit fares …	A spatial model of trip starts and distance travelled	Household Travel Surveys	Salt Lake City, Utah
Fiedeń, Ł.	2023	The importance of ticket price …	Survey analysis	Survey data	Rural Poland
Hensher, D.	2011	What Does It Cost to Travel in Sydney? …	Spatial analysis	Household Travel Surveys	Sydney, Australia
Kholodov, Y.	2021	Public transport fare elasticities …	Elasticity analysis	Smartcard data	Stockholm, Sweden
Li, T.	2015	Differentiating metropolitan transport disadvantage …	Spatial analysis	Journey to work, fare and vehicle registration data	Brisbane, Australia

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First Author	Year	Title Start	Method	Data	Study Area
Nahmias-Biran, B.	2014	Equity Aspects in Transportation Projects …	Descriptive statistics	Fare-box revenue data and an on-board survey	Haifa, Israel
Rubensson, I.	2020	Is flat fare fair? …	Statistical analysis	Census and transport forecast data	Stockholm, Sweden
Tiznado-Aitken, I.	2020	Who gains in a distance-based public transport fare scheme? …	Accessibilty analysis	Smartcard data	Santiago, Chile
Zhao, P.	2019	The effects of metro fare increase …	Cost burden distribution calculation	Survey data	Beijing, China

Equity impacts of fare changes

First Author	Year	Title Start	Method	Data	Study Area
Chen, R.	2022	Fare adjustment's impacts …	Travel pattern change analysis	Smarcard data	Wuhan, China
Kębłowski, W.	2019	Towards an urban political geography of transport …	Urban political geography analysis	Employment, transit, and fare data	Kelowna, BC, Canada
Kębłowski, W.	2020	Why (not) abolish fares? …	Multiple case study method	On-board survey data	Alameda and Contra Costa County, California
Ma, Z.	2017	Modeling the Impact of Transit Fare Change …	Multinomial logit mode choice model	National Transit Database and US Census	265 US urban areas
Nuworsoo, C.	2009	Analyzing equity impacts …	Elasticity calculations	Smarcard data	Southeast Queensland, Australia
Taylor, B.D.	2009	Nature and/or nurture? …	Two-stage simultaneous equation regression models	National Transit Database and US Census	265 US urban areas
Wang, S.	2021	Equity of public transport costs …	Fare equity evaluation	Smarcard data	Southeast Queensland, Australia

Differentiated fares

First Author	Year	Title Start	Method	Data	Study Area
Arranz, J.M.	2022	Are public transport policies influencing … …	A discontinuity regression model	Household budget survey	Madrid, Spain
Butler, A.	2020	No free rides …	Statisitical analysis	Travel surveys	Toronto, Canada
Cadena, P.C.	2016	Social and distributional effects …	Multiple regression model	Travel surveys	Madrid, Spain
Guzman, L.A.	2018	Accessibility, affordability and equity …	Equity analysis of accessibility measures	Transit data	Bogotá, Columbia
Myung-Jin, J.	2018	The welfare effects of the free subway …	Discrete choice model	Smart card data and household travel surveys	Seoul, Korea
Serebriksy, T.	2009	Affordability and Subsidies …	Literature Review	Research papers	Global

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First Author	Year	Title Start	Method	Data	Study Area
Wang, Q.	2022	Optimization of Differentiated Fares …	Divide-and-conquer optimization algorithm	Fare and network data	Guangzhou, China
Zolnik, E.J.	2007	Cost Attribution in Unlimited Access Transit Programmes …	Case study approach	Interviews	Mansfield, CT, USA

Creating equitable fare policy for people with low income

First Author	Year	Title Start	Method	Data	Study Area
Cooke, S.	2022	Proximity is not access …	Qualitative analysis	Semi-structured interviews	Cape Town, South Africa; Lusaka, Zambia; Kigali, Rwanda
Darling, W.	2021	Comparison of reduced-fare programmes …	Multiple case study method	Public documents	Fifty largest U.S. transit agencies
Harmony, X.J.	2018	Fare Policy and Vertical Equity …	Univariate analysis	Community Transportation Association data	Eighty U.S. transit agencies
Loukaitou-Sideris, A.	2023	"It Is Our Problem!" …	Case studies	interviews	Ten U.S. transit agencies
Olvera, L.D.	2004	Daily Mobility and Inequality …	Equity analysis	Household travel surveys	Lyon France
Perrotta, A.F.	2017	Transit Fare Affordability …	Qualitative analysis	Interviews	New York, USA
Reck, D.J.	2020	Subsidised ridesourcing …	Empirical analysis	Value of travel time data and public rideshare data	Three U.S. counties

Fare capping

First Author	Year	Title Start	Method	Data	Study Area
Chalabianlou, R.	2015	A review and assessment of fare capping …	Evaluation framework	Transit system fare data	Austalia and New Zealand
Hightower, A.	2022	Current Practices and Potential Rider Benefits …	Multiple case study method	National Transit Database	101 U.S. transit providers
Verbich, D.	2016	Public transit fare structure and social vulnerability …	Statistical modeling	Smartcard data	Montreal, Canada

Free fare public transport

First Author	Year	Title Start	Method	Data	Study Area
Bull, O.	2020	The impact of fare-free public transport …	Radomized controlled trial	Trip diaries	Santiago, Chile
Cats, O.	2017	The prospects of fare-free public transport …	Modal split, equity, and accessiblity analysis	Travel habit surveys and interviews	Talinn, Estonia
Hess, D.B.	2017	Decrypting fare-free public transport …	Literature review	Evaluation reports	Talinn, Estonia

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First Author	Year	Title Start	Method	Data	Study Area
Kębłowski, W.	2020	Why (not) abolish fares? Exploring the global geography of fare-free public transport	Multiple case study method	Database searches and semi-structured interviews	Global
Kębłowski, W.	2019	Towards an urban political geography of transport: Unpacking the political and scalar dynamics of fare-free public transport in Tallinn, Estonia	Urban political geography analysis	Policy documents and reports	Talinn, Estonia
Štraub, D.	2020	The Effects of Fare-Free Public Transport: A Lesson from Frýdek-Místek (Czechia)	Survey response analysis	Surveys and interviews	Frýdek-Místek, Czech Republic
Tomeš, Z.	2022	Fare discounts and free fares …	Ridership and mode-share analysis	Eurostat data and company reports	Slovakia and the Czech Republic