

Cashless Payments for Public Transport: equity and exclusion issues

Sheida Abdoli¹, Matthew Burke², Abraham Leung³

^{1,2,3} Cities Research Institute and School of Engineering & Built Environment, Griffith University

Email for correspondence: Sheida.abdoli@griffithuni.edu.au

Abstract

Transit cards, debit and credit cards, and mobile wallets are replacing cash. Covid-19 accelerated this transition. However, some passengers do not have access to a bank account or credit card, and many do not own a smartphone or have internet access, potentially limiting their access. There have been few studies of the effects of cash removal and only limited attempts to understand key dimensions of the problem conceptually. This study aimed to: i) systematically review the literature on cashless fare implementation; ii) tabulate the key benefits and disbenefits of different fare payment types; iii) categorize and re-conceptualize the equity groups most vulnerable to exclusion due to cash removal; and, iv) understand the experiences of two early-adopter cities—London and Amsterdam. Most of the previous research has focused on the benefits, not disbenefits, of cashless fare payments. London and Amsterdam provide examples of benefits realization and measures to mitigate the effects of exclusion on key equity groups. Both cities gained significant benefits in the transition but mostly ignored exclusionary impacts. The paper develops a new conceptualization of "the excluded" to help operators understand those who may be impacted. This involves the *digitally-excluded* (those excluded due to lack of access to alternative digital payment methods) and the *self-excluded* (those who choose to exclude themselves, due to the mental and physical effort required to adopt alternative methods). Future research needs include the scale and costs of exclusion and the efficacy of particular mitigations to ease the transition for equity groups.

Keywords:

Cashless payments; equity; exclusion; fare policy; public transport

1. Introduction

In the mid-20th Century, public transport (PT) fare payment options were limited; some cash alternatives existed, with different payment options across operators and modes, but cash was generally dominant (Zamer, 2018). Even when alternative payment systems were used, such as metro tokens or magnetic swipe cards, cash was usually used at ticket machines to purchase them. Today, payment systems have advanced with most public transport operators in developed cities offering proprietary smart cards as a contactless payment method (Buehler and Pucher, 2011). Additional options being introduced include debit and credit card payments and mobile wallet payments via smartphone apps, such that cash is in rapid decline (Fabris, 2019). The latter payment options are essential to the implementation of Mobility-as-a-Service (MaaS). Before Covid-19, the transition away from cash was well underway, with particular routes, then entire systems converted to near or full cash-free status. Many operators temporarily shift to cash-free operations in the pandemic with the potential for transmission via human touch on coins and notes. The temptation will be for many to remain cashless and for

those who have yet to make the transition to join them rapidly. The paper is structured differently from most systematic quantitative literature review (SQLR) papers, and two case studies (London, Amsterdam) are provided.

Before going any further, it is essential to first clarify the meaning of the terms "cash-free", "cashless", "contactless", "account-based", and "cloud-based", which are used to describe payment types and systems. "Cash-free" PT systems are those where any physical money (notes or coins) cannot be accepted as fare payment. Any payment method used to realize a cash-free transaction is called a "cashless" payment method (de Almeida et al., 2018). Cashless payment methods can be classified into two types: 1) payment methods that require physical contact, such as magnetic stripe fare cards; and, 2) "Contactless" payments, which do not require a physical connection between a point of sale (POS) terminal and a customer's card or device (i.e., pre-loaded RFID cards, smart debit/credit cards, or smartphone and wearable device (e.g. watch) payments) (Lacmanović et al., 2010). "Account-based" payment systems require a customer to set up an online account, whether that be tied to an individual card (i.e. a proprietary transit card) or a range of devices. "Cloud-based" payment systems, which make use of cloud computing to store a user's account, are almost always tied to a range of devices and allow more complex fare products to be introduced. Different countries have great diversity in their rates of payments by type, not only because of technological factors but also due to cultural and social habits (Rövekamp et al., 2017).

In some systems (e.g., Hong Kong and Singapore), cash payments are accepted only if they are tendered as exact fare into a farebox. In many zonal fare systems, paper tickets are still the preferred proof-of-purchase and buses often accept cash for fare on-board. Maintaining cash payment capability comes at a considerable cost to operators and PT agencies. For instance, in 2010, when cash payments were still relatively high in Sydney, the estimated cost savings of removing on-board cash payments for a bus with average demand and length of the Sydney route were calculated. Under different scenarios, the cost savings for a bus with a high average demand of 4 passengers / bus-km and a high-frequency 10min headway were (Tirachini, 2011):

- Fuel cost savings of between AUD\$2.35 and \$3.38 per hour;
- Labour cost savings of between AUD\$23.23 and \$33.43 per hour; and,
- Environmental cost savings of between AUD\$1.14 and \$1.53 per hour.

The operational benefits of entirely cashless payments on buses in Sydney have been explored in only a small number of research efforts. For example, Tirachini (2013a) used manual count observations of riders on buses in and around the Sydney CBD and in Blacktown in suburban Western Sydney to determine the effect of cash payments vis-à-vis cashless payments on dwell time and running times of services. In Blacktown, an additional 5.66 seconds, on average, was needed for passengers who paid the exact fare in cash; 12.73 seconds was required for passengers who required change. On a route in and near the CBD, these delays were 9.02 seconds for exact fare passengers, 16.23 seconds for those requiring change, and only 4.61 seconds for a user of a magnetic stripe payment that still needed contact (Tirachini, 2013a).

In other words, a cash-paying customer on the CBD route took at least twice as long to process if they had the exact fare and almost four times as long to process if they required change. This was in comparison to a clumsy magnetic stripe payment system. Using regression modelling, Tirachini showed just how detrimental cash payments could be, based on demand and payment type. Across a range of demand scenarios, for the Sydney CBD, he estimated a dwell time increase of at least two and up to six times greater than the base case if passengers all used cash. (Tirachini, 2013a).

In this paper, the theoretical framing is first provided. The methods are outlined briefly, followed by a summary of the findings of the review. More attention is then given to the

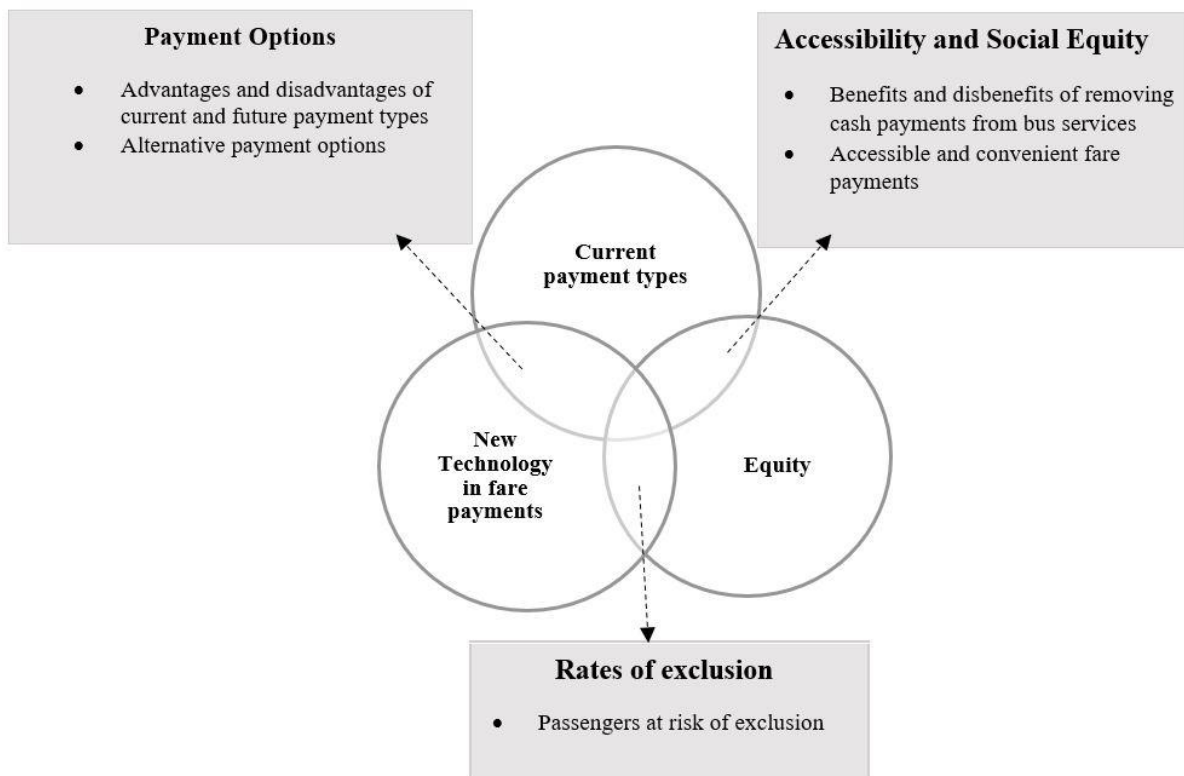
experiences of London and Amsterdam, to highlight what these cases tell us, the issues of implementation in the real-world, and what was omitted in the reporting of outcomes. A lengthy discussion then outlines what we know has happened during the pandemic, what remains the issues of concern, how we might better conceptualize them, and what future research is needed in this sub-field.

The review aimed to: i) undertake an (SQLR) on this topic to better understand the sets of studies undertaken on cashless fare payment; ii) to tabulate the key benefits and disbenefits of different fare types; iii) to identify, categorize and re-conceptualize the equity groups most vulnerable to exclusion due to cash removal; and, iv) to understand the experiences of early-adopter cities. Four research questions underpinned the QSLR component:

- Why should we move towards fully cashless payments?
- What are the trade-offs between the advantages and disadvantages of a cashless system in PT?
- What are the impacts of removing cash payments from PT? and,
- Who would be excluded by removing cash payments?

The review explored 20 years of publications (2000 to 2020) from Science Direct, Scopus, Web of Science, and TRID listed publications by conducting this research based on the conceptual framework shown in Figure 1. The conceptual framework identifies the discipline areas relevant to the study and their intersection, with a focus on payment options, accessibility and equity, and rates of exclusion.

Figure 1: Theoretical Framework



2. Methodology

The Systematic Quantitative Literature Review (SQLR) approach promoted by Pickering and Byrne (2014) was used, which adopts the PRISMA technique . By adopting this approach, the

advantages, disadvantages, and limitations of previous studies can be identified. The selected databases were interrogated by searching within the title, abstract, and keywords, the combination of keyword ((Public transport* OR transit) AND (cashless OR contactless OR no cash OR cash-free) AND (equity ticketing OR equity OR equity payment)) AND (fare policy)) was searched. A first set of scholarly and industry literature was then obtained from each database, with the results shown in Table 1.

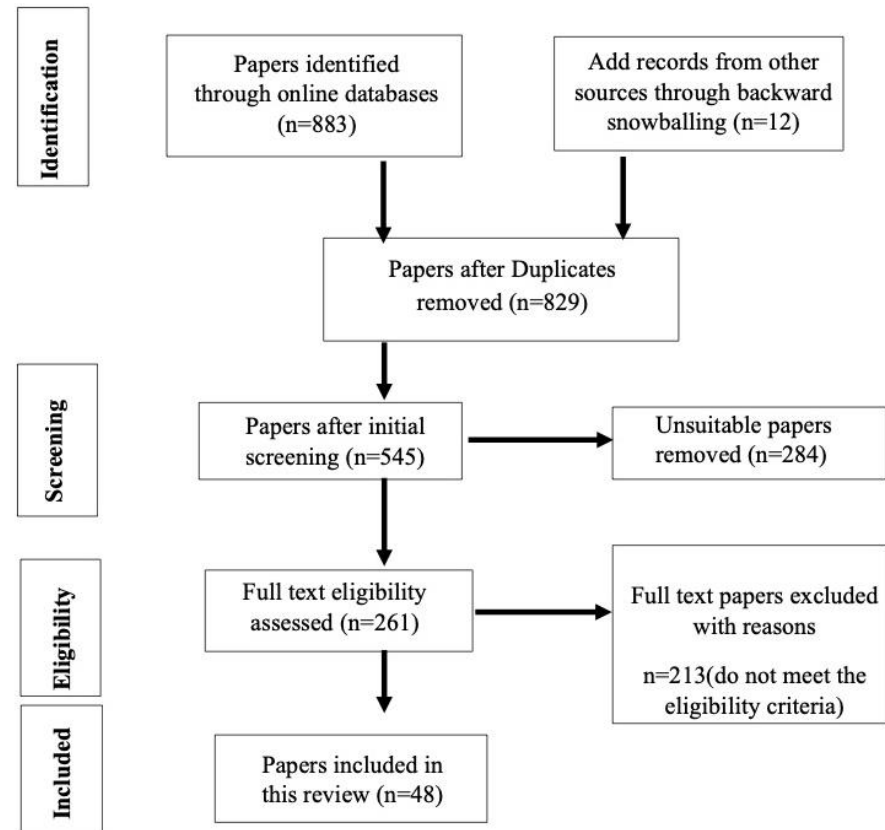
Table 1: The number of papers obtained by each database

Databases	Number of primary papers
Science Direct	55
Scopus	13
Web of Science	137
TRID	678

A snowballing technique was also used to help identify additional papers, particularly looking for scholarly papers related to industry reports or other 'grey' literature from the TRID database. This identified a further 12 papers. When duplicates were removed, 829 papers remained. In the initial screening, all papers were scanned by their titles, and those that were outside the field (284 papers) were removed. Abstracts were read in full and ineligible papers removed; 261 papers remained. The full text of the remaining papers was reviewed, and these 48 papers were eventually selected in the final sample. The full extraction process is shown in Figure 2. Two cities with documented experiences in going cash-free were investigated in greater depth. Contact was made via phone and email to the relevant transport agencies in London and Amsterdam to gain further insight. Once these relevant persons were identified, critical questions were asked about the main reasons to move away from cash to cashless payments, the implementation process, market segmentation of passengers that might be excluded, and the availability of further reporting on their experiences.

Figure 2: Review protocol (left) and papers obtained after the identification, screening and eligibility phases of the review, using the PRISMA technique (right)

Review step	Information collected
Title	Cashless payments in PT: A review
Research Questions	1. Why should we move towards fully cashless payments? 2. What are the trade-offs between the advantages and disadvantages of a cashless system in PT? 3. What are the impacts of removing cash payments from PT? 3. Who would be excluded by removing cash payments?
Search terms used in electronic databases	((Public transport* OR transit) AND (cashless OR contactless OR no cash OR cash-free) AND (equity ticketing OR equity OR equity payment)) AND (fare policy))
Electronic databases searched	Science Direct, Scopus, Web of Science, and TRID (Transport Research International Documentation)
Search strategy and initial selections	Title, Abstract, Keywords
Content assessment & Eligibility criteria	<p>Group one (The answers are all positive): Does the paper relate to the topic and research questions? Is it an original research paper?</p> <p>Group two (At least one of the answers are positive): Does the paper assess cash-free system, cashless payment, or smart ticketing? Does the paper assess factors including equity, fare policy, or new ticketing system? Does the study present a method for assessing cashless payment? Does the study present a method for identifying factors influencing cashless payment or smart ticketing in PT?</p>
Data collection process, cross-check and synthesis of results	<p>Primary data on the paper The paper title, Author, Journal, Year of publication, Type of work, Study location</p> <p>Methodological information Sampling methods, Model type, Analysis method</p> <p>Results classification of factors, the relative importance of each factor</p>



3. Results

The research results are summarised to report the findings of each research question, in sequence:

Why should we move towards fully cashless payments?

In our sample, seven papers discussed the benefits and disbenefits of the "cashless society"; 12 papers explored the benefits and disbenefits of cashless fare policies on public transport in particular. Key authors suggest the advantages of cashless payments outweigh the disbenefits (Shen and Yazdanifard, 2015). Some of the main system benefits are the ease of new payment technologies, security and safety for drivers, reduced fraud from cash handling, and faster transaction times (Wulandari and Andilolo, 2017). Cashless payments help speed up boarding times (Blythe, 2004) with the flow on effects for passenger journey times and operator costs. By updating fare collection systems and reducing cash payments, bus passenger travel times can be decreased, by reducing time spent at stops (Tirachini, 2013b) encouraging mode shift and reducing private car use (Ellison et al., 2017). Other benefits include flexible fare management (e.g., integrated ticketing), fast validation times, faster overall journey times, and more convenience (Tirachini, 2013b). These factors improve service quality and contribute to consumers' intention to use cashless fare systems (Bartin et al., 2018).

Importantly, maintaining cash payment capability, when other payment types are also made available, comes at a considerable cost to operators and PT agencies. By removing cash from the system, bus drivers are less likely to be robbed of cash, and also less time is needed by operators to count and manage their cash tills prior to and after each run (John et al., 2006). A further disadvantage of a cash system is that agencies cannot gain the same data insights on travel patterns from cash payments (Evans et al., 2015) which is useful in PT planning and programming (Arnone et al., 2016). The continuously flowing data on passenger behaviour can enhance transit authorities' strategic, tactical, and operational performance (Pelletier et al., 2011).

The main disbenefit of removing on-board cash payment is that it may discriminate against groups of passengers who may not have smartphones, data, credit cards or other means to provide payment and who may be excluded from public transport services (Golub et al., 2019). Consumers' adaptation to smart ticketing systems matter, and an individual's innovativeness positively affect their adoption of cashless payments (Cheng and Huang, 2013). The main concerns are about the exclusion of equity groups such as seniors, low-income groups, recent immigrants, and others who may not have bank accounts, debit or credit cards, or are digitally illiterate (Golub et al., 2019).

What are the trade-offs between the advantages and disadvantages of a cashless system in PT?

The benefits obtained and the likely rates of exclusion differ with each payment technology potentially adopted. Table 2 summarises the different payment types and their key benefits and disbenefits as identified in this literature.

Table 2: Summary of payment types, benefits and disbenefits

Payment type	Key Benefits	Key Disbenefits
Cash	<ul style="list-style-type: none"> • Ubiquity of cash • Convenience and ease of use • Privacy • Services the "unbanked" 	<ul style="list-style-type: none"> • Delay to services from on-board payments for ticket purchasing (not an issue for "exact fare only" systems, e.g. Singapore and Hong Kong) • Costs managing cash • Hygiene • Security risks of theft or robbery
All alternatives to cash, such as paper tickets, magnetic strip and including all the contactless options below	<ul style="list-style-type: none"> • Ease-of-use for most customers • Increased security; bus driver safety • Increased speed of payment; easier integration of payments • Better operating speeds/costs for operators • Hygiene 	<ul style="list-style-type: none"> • Welfare and equity impact on people who are excluded • Potential for technology to fail/become obsolete • Some customers need cash to budget well • Potential vulnerabilities in card payment technologies; fraud
Proprietary / closed-loop contactless systems (i.e., Octopus (Hong Kong), Oyster (London), Suica (Tokyo), Opal (Sydney) cards, etc.)	<ul style="list-style-type: none"> • Ease of use for most customers, after initial set-up time/costs • Low processing costs for agencies • Regulators can maintain significant control and transparency due to monopoly • Specific travel data to enable planning 	<ul style="list-style-type: none"> • Lack of scale; requires payment literacy training, marketing, branding • Requires extensive network of retailers; difficulties providing customer service • Significant set-up costs for users • Customers living in suburbs without go card top-up capacity • Requires tourists and visitors to purchase a new card in each city • Many risks are held by the proprietor • Lack of immediate visibility of account credit
Debit/Credit cards (NFC contactless)	<ul style="list-style-type: none"> • The high adoption rate in Western countries • Allows high volumes of transactions • Uses trusted providers and common financial standards • Many risks and operations are shifted to card suppliers and cardholders 	<ul style="list-style-type: none"> • Equity issues for the "unbanked" • Financial institution processing fees • Less control for regulators than proprietary systems • Potential vulnerabilities in card payment technologies; fraud • Lack of immediate visibility of account credit • Many risks and operations are shifted to card suppliers and cardholders
Mobile payment apps / Mobile wallets	<ul style="list-style-type: none"> • The growing adoption rate of NFC systems in Western societies and QR code scan-based systems in China • Particularly good for tourists • Many risks are shifted to app providers 	<ul style="list-style-type: none"> • Requires a smartphone or device that is powered up • When a customer inevitably must update their account or turn on payment functions on their smartphone, they will require: i) Wi-Fi or mobile signal, and ii) smartphone data credit • Some protocols still requires bank account or debit/credit cards. Equity issues for the "unbanked" • App provider / financial institution processing fees (e.g. Apple Pay, Google Pay, WePay, etc) • Less control for operators than proprietary systems. • Potential vulnerabilities in app security; fraud

Key Sources: (Fabris, 2019, de Almeida et al., 2018, Lacmanović et al., 2010, Zalar et al., 2018, Zamer, 2018)

Interestingly, the vast majority of the literature on cashless fare policies and related issues highlights the benefits but fails to discuss the disbenefits of going cashless. Comparatively, few efforts have gone into understanding the trade-offs between a cashless system's advantages and disadvantages. Only one study has been conducted using a social cost-benefit analysis of cashless systems. This suggested that in Trondheim, Norway, a cashless smart card ticketing system was, in sum, advantageous from a socio-economic point of view (Welde, 2012).

What are the impacts of removing cash payments from PT?

Other than the issues on operations discussed above, going cashless has impacts on the disadvantaged and can alter societal attitudes. Seven papers in our sample explored attitudes towards removing cash payments. A key problem for societies that give up cash is the impact on those outside the banking system and without access to alternative means of payment (de Almeida et al., 2018). Any transition towards a cashless society requires consideration of many factors, including a need to focus on low-value products and payments and their merchants, the domestic market size, payment interfaces, the role of mass transit cards, and strategic government intervention (Dennis, 2018). A few key studies considered the attitudes of different groups of passengers towards removing cash payments from PT systems. In London and Chicago, passengers who have credit or debit cards prefer using contactless bank cards in transit systems (Brakewood and Kocur, 2011). From some of the passengers' and the service providers' perspectives, an integrated smart card facilitates more convenient access to services and travel options (Evans et al., 2015). However, surveys suggested that eliminating cash payments on London buses may alter money's social function and create new forms of work for drivers and passengers (Pritchard et al., 2015).

Two key jurisdictions have transitioned to cashless fare policies and have had evaluations of the experience undertaken. It is worth exploring these experiences in more depth.

London

Transport for London (TfL) went cash-free on their buses in 2014 (TfL, 2014). The reasons for removing cash payments from the system were quicker journeys and shorter queues, and already low cash use in London at only around 1% of all journeys at the time. Prior to implementation, TfL undertook research to understand the concerns of passengers and to mitigate concerns. They received over 37,000 responses to their survey. The results were reported in a consultation report that showed 68% of TfL's respondents disagreed with the proposal (TfL, 2014). The respondents' concerns included those from the elderly, disabled, and young people who may have forgotten their Oyster card, or only had cash on them, especially at night or in unfamiliar places, and other passengers not able to help to pay for the fare by offering cash. Despite this, the consultants concluded that the cash-free bus proposal should move forward. Recommendations were made to provide more places to top up (including at bus stops), offering fare vending machines at bus stops, removing/reducing the deposit for Oyster cards, and providing free travel at the driver's discretion (TfL, 2014).

The most important issue was not leaving vulnerable people stranded (TfL, 2014). TfL consultants noted how they would mitigate the issues, such as engaging with organizations representing vulnerable individuals, setting clear rules and procedures for drivers to permit passengers to travel without a valid card or ticket, working with organizations representing vulnerable individuals to refine and develop rules and procedures further, and running workshops to ensure that staff and user issues were fully considered and worked through. TfL's report also acknowledged the concerns about the availability of options to reload Oyster cards at night and outside London and suggestions to put fare vending machines near bus stops and outside rail stations (TfL, 2014). The consultants expressed that costly machines would not be

cost-efficient, considering the number of users. However, they also noted that retail locations were under "constant review", and a limited number of additional retailers may be added to the network, particularly in areas where cash use is higher than the network average. It appears only a limited number of Oyster Ticket Stops were added to the rollout, which does not address fully the night-time issue (TfL, 2014). This highlights the importance of keeping constant tabs on the effectiveness of the POS network in serving vulnerable riders. Post-implementation, there appears to have been no analysis of rates of exclusion or their effects.

Amsterdam

Amsterdam phased out cash between 2016 and 2018, starting with removing cash payments on night buses, then all bus services, ferry services, and finally all trams (GVB, 2017). There were two main reasons for removing cash payments from the system. Firstly, the municipal PT operator for Amsterdam *Gemeente VervoerBedrijf* (GVB) noted that cash payments on a vehicle caused delays at the stops. Therefore, they kept on-board payments but installed automated teller machines (ATM) as another option for electronic card payments in all buses and trams in phases. The second reason for removing cash from the bus was that there was a series of robberies. Therefore, GVB immediately cancelled the sale of day tickets on the bus services and developed a system where drivers could charge actual one-hour tickets on the bus when a transaction was finished. The customer could use this ticket to check-in and check-out, which means they could use the ticket to transfer to another bus, tram, or metro.

This change made life easier for people with credit and debit cards, but more difficult for people to pay cash. For example, research by GVB had shown that half of the passengers who buy a ticket on the bus or tram were tourists. Therefore, GVB put maximum effort into mitigating the impact of removing cash in PT on vulnerable groups. One way was to work closely with a group of citizens who represent all groups within society (the *Reizigers Advies Raad*). The focus was placed on the groups in Table 3.

Table 3: mitigating the impact of removing cash in PT on the vulnerable groups by GVB

Vulnerable Groups	Mitigations
Seniors	<ul style="list-style-type: none"> Senior citizens are generally already the owner of an OV chipcard (an electronic way of payment) because of the discount they receive from the state.
Tourists	<ul style="list-style-type: none"> Installation of machines in tourist hotspots GVB added credit cards to the system for visitors from abroad (Dutch people usually use debit cards) There has been a marketing campaign and service hosts at Schiphol Airport to inform tourists; GVB extended the number of resellers (e.g., tourist offices).
Low-income passengers	<ul style="list-style-type: none"> There have been several campaigns where people with a low income could receive an OV chipcard with a positive balance.
Children	<ul style="list-style-type: none"> There has been a particular campaign with gadgets for single travelling children (age <12) to inform their parents.
Those who do not have electronic cards or are not in bank account systems	<ul style="list-style-type: none"> There are still machines where customers can pay with cash at PT hubs; GVB updated all maps in the bus and tram stops and on the website to give clear information about where to find these; some ticket machines were placed in locations with more customer traffic.

In the first cashless weeks, the drivers and conductors could give away OV chip cards with a positive balance to those in need to help them with the transition. Multiple communication

campaigns used different channels to inform the customers about the change. Again, post-implementation, there was no study of exclusion due to these changes or their impacts.

Who would be excluded by removing cash payments?

A few key papers have sought to identify key population groups that are excluded by cashfree PT systems. Zhou et al. (2019) used smart card data in combination with traditional datasets such as census data to identify neighbourhoods and types of riders that probably experience social exclusion. Sion et al. (2016) developed a model to consider differential exclusionary impacts for different payment types, given that younger passengers are more likely to use smartphones while older are more likely to have credit/debit cards. Either way, going cashless can have exclusionary impacts on specific groups including those listed in Table 3, as well as recent immigrants (Coddington, 2019).

Deeper analysis of *why* individuals in these groups may be excluded reveals a different typology. Effectively two underlying groups can be identified: i) the **digitally-excluded** (passengers technologically excluded by the system due to lack of access to alternative digital payment methods); and, ii) the **self-excluded** (Passengers who choose to exclude themselves, due to the mental and physical effort required to adopt cashless alternatives and the many "functional" and "psychological" barriers they face).

4. Discussion

How do we make sense of how important exclusion might be compared to the benefits of cashless fares? One way is to consider theories of equity. Numerous conceptual and theoretical positions on the concept of equity are useful here, mostly drawn from the fields of political philosophy and economics. A few of the key positions drawn from these sources (Walzer, 1983, Rawls, 1971) are summarised as follows:

- Utilitarianism: people are motivated by self-interest; the morally right policy is the one that produces the most good, in terms of overall outcomes [most cost-benefit analyses implicitly take this position]. Here, the cost savings of going cashless should simply outweigh the disbenefits.
- Egalitarianism: people are equals in terms of their fundamental worth; they should get the same or be treated the same; people should have equality of opportunity; they might also deserve some equality in their living conditions. Here, all fare payers should be treated equally, and have equal opportunity to use public transport. Would there be many people excluded by cashless fares, this would be problematic under this theoretical position.
- Rawlsian: after John Rawls (1971); people are free and equal; society should be a fair system of cooperation; distribution should be on the basis of equality-based reciprocity; all social goods should be distributed equally; a fair distribution should be to the greatest benefit of the least-advantaged members of society ("least-advantaged do best"). Here, the focus would be more on the socially disadvantaged member groups who would be most affected by going cashless.
- Walzerian: after Michael Waltzer (1983); goods have social meanings to different groups in society; social meaning should determine fair distribution; goods like PT have a social meaning and should be taken out of the sphere of free-market exchange, deserving their own autonomous 'distributive sphere'; inequality in spheres like health, education, and transport may exist, but should help limit the dominance of power and money. Here, the social

meaning of public transport, more so than its pure utilitarian economic value, should be considered in fare policy decisions.

These theories all provide a slightly different perspective on how goods and services, like PT, should be distributed. As there is a tension between moving to fully cash-free and the justice outcomes that this will produce, one must recognize the equity outcomes. London and Amsterdam, like most cities, felt the cost savings and other benefits greatly outweighed the disadvantages, for the system overall. However, from an egalitarian perspective, one might wish to retain cash payments until wider adoption of alternative payments has occurred rather than a rapid forced change in technology. PT agencies would deliberately lag rather than lead society's transition toward a cashless society. Under a Rawlsian perspective, social exclusion must focus on accessibility for all passengers. To this aim, policy evaluation should prioritize disadvantaged groups, respect individuals' rights, and reduce inequalities of opportunities to mitigate transport externalities (Pereira et al., 2017). In this perspective, identifying the impacts of cashless fare policies on the least-advantaged would be more pressing. This may include recent immigrants or seniors, and could be spatially concentrated. Mitigations that would focus on these particular groups may be sufficient to achieve a good Rawlsian outcome. Effective mitigations such as ticket machines in particular neighbourhoods, or, initial training and coaching in use of the new technology in disadvantaged groups are not expensive. It is hard to suggest moving to full cashless payments until effective mitigations against social exclusion can be implemented and impacts on least-advantaged groups are more fully identified and counter-weighted. A rapid forced adoption approach to introduce cashless fares would likely produce significant exclusion with high social welfare costs.

Trials can be considered before going completely cashless. These could include service type trials (i.e. particular representative types of bus services in a city); and/or sub-regional trials (across all services in a small part of a city). Such trials should be analyzed carefully to determine both benefits and exclusionary impacts. These analyses can evaluate the benefits of cashless payments and locations with very high rates of cash payments and the rates of exclusion across the network. The social welfare impacts of that exclusion; and mitigations to reduce those impacts can be determined. A large focus should also be placed on mitigations, including:

- Ticket machines or vendors that accept cash and are accessible, especially in key locations
- Compensatory fare products for the least advantaged
- Training and education to improve payment system literacy
- Short-term use of options such as on-board cash boxes on tourism routes
- Changes to policy (e.g., removing/reducing high-value smart card deposits or minimum balances)

A major study of the rates of exclusion caused by cashless fare payments and their effects appears the most pressing need in this field. Until such a study is completed, the jury will still be out on how advantageous cashless fare policies really are. Ideally, such a study would be longitudinal, looking at both short-term exclusion, impacts and efficacy of mitigations, as well as long-term impacts well after the transition to cashless fares has occurred. This study could also investigate exclusion in systems where MaaS has been introduced.

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