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The Future of Fare Media in Automated Fare Collection Systems for Urban Mobility in the Latin America and Caribbean Region

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Transport Division

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THE FUTURE OF FARE MEDIA IN AUTOMATED FARE COLLECTION SYSTEMS

FOR URBAN MOBILITY IN THE LATIN AMERICA AND CARIBBEAN REGION

Julia Hollnagel
Alana Fook

IDB

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Executive Summary

Fare media is the most visible component in an automated fare collection (AFC) system and directly impacts the daily lives of passengers, operators and their employees, and the public entities responsible for the oversight of public transit. With the roll-out of AFC systems, options for fare media have evolved significantly over time, from cash to magnetic stripe cards to tokens, smartcards and mobile-enabled solutions. In cities in the Latin American and Caribbean (LAC) region, cash remains the dominant way of paying for transit and few comprehensive AFC systems have successfully been implemented and maintained.

This Technical Note aims to discuss the benefits and challenges of moving from cash-based payments to other fare media, particularly for urban transit systems in the LAC region. To accomplish this, the general benefits of implementing an AFC system that capitalizes on new fare media are reviewed, followed by a focused look at the challenges and opportunities specific to the LAC region, different types of fare media technology, and factors to consider when making the switch from cash to other fare media.

Amongst the region-specific challenges faced in eliminating cash from public transit are the high degree of informality in the transport sector, which makes the coordinated effort required to achieve interoperability a challenge, and relatively low levels of financial inclusion and digital literacy, which are a hurdle for widespread adoption. Furthermore, culture provides a challenge, on one hand for the users, being accustomed to cash and on the other hand, for operators who will need to restructure and implement technological changes. A cashless system would leave fewer loopholes and improve transparency, which might not be in the interest of involved parties currently taking advantage of such weaknesses.

Overall, we conclude that despite the challenges of switching from cash to other fare media as part of the introduction of an AFC system, there are several key benefits, including the ability to integrate fares, have interoperability built in from the beginning, and use proprietary, anonymized customer data to optimize planning, operations, and to introduce more targeted incentive programs. Furthermore, automating fare collection allows the transport sector to capitalize on growing mobile phone penetration levels and contribute to improved operational efficiency and customer experience.

Based on the recognition of benefits from eliminating cash, a variety of available and future fare media is explored, each of them with a different set of technical advantages and flaws but with one common strength, all being superior to cash in terms of overall performance and potential positive ripple effects. Technologies new to the public transit sector in the LAC region, such as biometrics, could be applied in pilot projects, learning from ongoing implementation in other regions, especially in Asia, or in from another sectors' experience.

The key decision to be made is to update from cash to a new fare media, making sure to consider and address the challenges and designing a system, ensuring it maximizes the potential benefits. The final choice of a fare media, however, depends on the local context and culture as it requires operational and behavioral adjustments from all stakeholders involved in public transport.

1. Introduction

In Latin America and the Caribbean, more trips are completed using public transportation than private automobiles – 120.5 million trips versus 93.2 million trips, daily – and the majority trips on public transportation are made using conventional buses (CAF, 2016).

Fare media – the point of interaction between the transport service provider and the customer – is an integral part of a fare collection and plays an essential role in the overall service experience, particularly at the crucial moment of payment for the transport service. In the context of AFC, fare media is the most visible technological component and interacts with the remaining components. The choice of fare media also impacts operations and performance of the transport service provider, creating or limiting possibilities for fare and transit integration, the collection and use data on consumer habits, and development of additional services.

Figure 1: Typical Components of an AFC System

Source: Adopted from Crotte & Arvizu, 2018.

As of 2013, in nine capital cities or metropolitan regions with four million inhabitants or more, AFC systems are available in all ten and seven count with fare integration between bus and rail-based transit services. Looking at cities with less than four million inhabitants (average population of 1.7 million), only four cities employed an AFC system and only one city had fare integrated fares. The fare media in all cities with AFC is a contactless smartcard (UITP, 2013). The table below summarizes the situation in the Latin America and Caribbean (LAC) region and describes the progress has been made with regards to the use of electronic fare media and integration.

Table 1: Automated Fare Collection and Fare Integration in LAC

	Country	City	2013		2019	
			AFC System	Transit Integration	AFC System	Transit Integration
Cities with four million inhabitants or more	Mexico	Mexico City	Yes	Metro & BRT	Tarjeta Distrito Federal (TDF)	Metro (195 stations), Metrobús, Tren Ligero
	Brazil	São Paulo	Yes	Municipal Bus, Metro & Trains	Bilhete Único[1]	Municipal Bus, Metro & Metropolitan Trains
	Brazil	São Paulo Metropolitan Region	Yes	Metropolitan Bus, Metro & Trains	In addition to the Bilhete Único, the Cartão BOM[2]	Municipal Bus, Metro & Metropolitan Trains
	Brazil	Rio de Janeiro	Yes	Buses (municipal & metropolitan), Metro, Train and Boats	Rio Card mais[3]	Bus, Train, BRT, VLT, Subway and Boats
	Argentina	Buenos Aires	Yes	Bus, Metro & Train	SUBE (Sistema Único de Boleto Electrónic, or the Unified Electronic Ticket System)	Used in 33 cities with populations over 100,000 and accepted on Metro, Bus and Train[4]
	Peru	Lima	Yes	BRT only (structural & feeder)	Lima Pass[5]	Municipal and Metropolitan Bus, Metro
	Colombia	Bogota	Yes[6]	BRT only (structural & feeder)	TuLlave Card[7]	TransMilenio System and the zoning services of the SITP (urban, complementary, special).
	Chile	Santiago	Yes	Metro & Buses	Tarjeta bip	Bus and Metro[8]
	Guatemala	Guatemala	Yes	BRT & Buses	Yes	Bus only[9]
Cities with less than four million inhabitants (average 1.7 million)	Costa Rica	San Jose	No	N/A	Pilot Project	Bus
	Haiti	Port au prince	No	N/A	No	N/A
	Ecuador	Quito	Yes	BRT & Feeder Lines	Yes	BRT & feeder lines
	Ecuador	Guayaquil	Yes	BRT & Feeder Lines	Yes	BRT & buses
	El Salvador	San Salvador	No	N/A	Yes	BRT & some feeder lines
	Panama	Panama	Yes	BRT only	Yes	BRT only
	Bolivia	Santa Cruz de la Sierra	No	N/A	No	N/A
	Honduras	Tegucigalpa	No	N/A	No	N/A
	Uruguay	Montevideo	Yes	Urban bus service only	Yes	Urban bus service and public bicycle, metropolitan area buses planned to be integrated from end of 2019
	Guyana	Georgetown	No	N/A	No	N/A
	Jamaica	Kingston	No	N/A	Yes	Bus only
	Nicaragua	Managua	No	N/A	No[10]	N/A
	Paraguay	Asuncion	No	N/A	Pilot	Target: interoperability across all companies countrywide by 2020

1. There are specific cards for certain passenger types, certain services or valid at certain times of use, such the Bilhete Único Escolar for students, the Bilhete Único Especial for elderly or disabled, the employer-paid Transport Voucher, E-Fácil card for parking, the Cartão Fidelidade for rail transportation only, but which is valid in Sao Paulo and metropolitan area, and the Bilhete Lazer (BLA), a leisure ticket which is valud from 6pm until close of operations on Sundays. http://www.metro.sp.gov.br/en/your-trip/tickets-cards/index.aspx.
2. The Cartão BOM also has several categories for various passenger types, including seniors, students, the disabled, business passengers and the elderly, who travel for free (CTMP, 2019).
3. https://www.riocardmais.com.br/praticidade/.
4. The SUBE card is also accepted for tolls, parking and other micropayments (MIFARE, 2018).
5. The Lima Pass is Interoperable and interchangeable with the Metropolitan Card, and both can be used for buses and trains, inside Lima and in the wider Metropolitan areas. Students (including university) are entitled to half price fares, while the disabled (as evidenced by a CONADIS card), the police and firefighters ride free with proper ID (PROTRANSPORTE, 2019).
6. As of 2015, Bogota had an advanced fare collection system based on contactless smart cards, using prepaid cards and off-board fare collection, but involved several different cards and several different issuers; Tarjeta Capital/Capital Card and Tarjeta Propia/Own Card (TransMilenio system), Tarjetas Cliente Frecuente/Frequent Customer Card (rechargeable stored value smart card) and Tarjetas Monedero/Wallet Card (loaded with a value that is used to pay the fare) provided by Angelcom for TransMilenio system Phases I and II, and Tarjeta TuLlave/Key Card (issued by Recaudo Bogota for us on TransMilenio Phase III and on the SITP buses) (Global Mass Transit, 2015).
7. The TuLlave card, which must be purchased and recharged prior to entry or boarding, replaced the Angelcom cards and were accepted on Phase 1 and II starting in September 2015 (TransMilenio, 2019).
8. There are three types of bip card – bip portador (unregistered and can be used by anyone in physical possession of the card, therefore the balance is unprotected in the case of loss or theft), bip personalizada (registered, customized card), bip bancaria (offered by State Bank, with debit card functionality) – which are accepted on buses and Metro and so allows integrated fares (Directorio de Transporte Público (DTP), 2019).
9. The BRT System (Transmetro) stopped accepting the contactless card (SIGA) in 2015, there is an ongoing tender process for a automatic fare collection system (https://dev-test.elperiodico.com.gt/inversion/2018/12/20/licitan-nuevo-sistema-de-recaudo-electronico-para-el-transmetro/).
10. A smart card was in operation from 2013 until 2018 but has been discontinued since.

This situation leaves room for improvement, such as updating from cash-only fare collection and integration of modes into the fare collection system.

While future cost savings are often the main motivating factor driving a move to a new fare collection system (Perlmutter, 2015), there are a variety of other advantages of non-cash fare media. Such positive aspects can include shorter dwell times for buses, the ability to provide integrated fares and demand subsidies and, including passengers with special needs by giving them opportunities to move more independently.

For those cities with AFC systems in place, emerging technologies offer the potential to improve their systems, while those cities where fare collection is still cash-based can leapfrog beyond early technologies, such as magnetic stripe cards, and take advantage of the new developments in fare media products.

Despite the global nature of technological developments, it is essential to carefully consider the local context and all involved stakeholders. Within the Latin American and Caribbean region, and within each country that comprises it, there is a rich tapestry of socio-economic contexts that have influenced the levels of affinity to use cash, and the awareness of and sensitivity to privacy issues when digitalizing services.

This publication will introduce some emerging fare media technologies and explore how they compare to cash-based fare collection systems, identify and discuss the opportunities and challenges associated with implementing them in the Latin American and Caribbean context, and finally, distil the key factors to be considered when selecting fare media.

2. Automated Fare Collection Practices

The earliest iterations of AFC systems involved tokens or paper tickets issued by staff or dispensed at a self-service vending machine, which could be paid for using cash or, more recently, debit and credit cards. From the perspective of the rider, tokens and paper tickets were not dissimilar to cash. The ticket or token still needed to be presented at the time of entry or boarding, and, if lost or stolen, the value could not be recovered. Conversely, for the operator, the sale of a ticket or token took place at a single location – a sales window or vending machine – rather than at the point of entering the station or boarding the bus, which likely improved operational efficiency and schedule adherence.

Payment technology is steadily advancing and like most industries, transit agencies and operators will need to keep pace with and capitalize on these developments to minimize their potentially disruptive impact and keep or grow their customer share. Furthermore, advancements in payment technology provide additional flexibility for fare structures, create an image of high-quality service and added value for customers and make use of the potential to collect and analyze data from new payment technologies to improve the quality and efficiency of operations. The following practices in AFC are common among systems, which are either currently undergoing upgrading, such as New York or have been upgraded (for example Chicago and London) and provide the basis for the implementation of further advancement of fare media and ticketing technologies.

a. Account-based ticketing

According to the Secure Technology Alliance, account-based ticketing refers to "transit fare collection system architecture that uses the back-office system to apply relevant business rules, determine the fare, and settle the transaction." Put more simply, customer information is maintained in an account, stored on servers or the cloud, while the travel card is only used for identification purposes.

When compared to card-centric solutions, account-based ticketing provides a number of advantages for both transport service providers and customers. Firstly, account-based ticketing is compatible with a variety of fare media – QR codes, or other vendor registered cards – as tokens and customers can top up their account or buy period passes without going to a ticket machine or kiosk. Furthermore, it allows for a more flexible fare structure, since the back-office system calculates the fare and updates the customer's account with the relevant balance after the trip is completed, and the direct provision of subsidized tariffs.

Account-based ticketing systems represent a shift from a hardware-based fare collection to software-based fare collection, where hardware is an enabler rather than a requirement for the system to operate. This reduces the limitations of services being offered and opens the possibility to integrate into a larger mobility system. However, it is important to note that as the system oper-

ates online, stable, reliable internet connectivity is required, which could increase the operation cost. This does not mean that the card readers need to be connected continuously to operate, but at least require a connection at regular intervals in order to perform essential functions, such validating payments and identifying blacklisted accounts with insufficient balance or expired travel passes.

b. Open- and closed-loop systems

Open-loop systems facilitate acceptance of payment methods with a broad range of other uses. The standard used in open-loop systems was collectively defined by Europay, Mastercard and Visa, which is why it is also called EMV payments. Increasingly, mobile phone-enabled payments, such as Apple Pay, and pre-paid debit cards, are being integrated into open loop fare. For example, the future update of New York's payment system will replace the current magnetic stripe card with a white label EMV card.

On the contrary, in a closed-loop system, the card or mobile/digital wallet is merchant-specific and can only be used for purchases from the issuing merchant. Further, funds need to be pre-loaded to the account, whether by cash at a designated location or through connection with a bank account. Amongst the closed-loop cards are Calypso, MiFare, FeliCa and Cipurse, all of which are microcontroller smartcards under the ISO 14443a standard, which defines proximity cards for identification and their communication protocol.

There are also hybrid systems, using both open and closed-loop in a parallel manner. Transport for London (TfL) has implemented contactless ticketing, allowing the use of EMV cards on their buses in 2012 and metro and rail services in 2014 in parallel with their smartcard (Oyster Card).

3. A new way to pay: The (business) case for rethinking fare collection

Traditionally, user fares represent the main source of operating income for transport service providers. Collecting and processing those payments comes at a significant cost for the operators, ranging between 5 and 15% of annual revenue (Pelletier et al., 2011). To maximize operational efficiency and improve the customer experience, while allowing operators to harness tremendous value from data on customer behavior, many transport operators are re-thinking fare collection. This chapter will identify and assess the merits of automating fare collection. The challenges and hurdles to overcome when moving from a cash-based fare collection system to an AFC will be discussed in the next chapter (IV. Replacing cash in transit in the LAC region: Challenges and opportunities of new fare media).

A. Efficiencies in operations

Research on the impact of automating fare collection suggests that the gains in operational efficiency compared to cash can be substantial. For example, if each passenger is using a smart card instead of cash saves just two seconds, this can add up to a reduction in dwell time of 56 hours per day, per 100,000 passengers (Shockley, Salinas & Taylor, 2015). Taking it a step further– requiring that fares be validated before boarding – can enable even more time savings over and above those of contactless cards (Tirachini, 2013). The combined effect of these seemingly insignificant time savings is shorter headways, higher average operation speeds and shorter travel times, solely by automating fare collection. In addition to the improved service experience for passengers, this translates into cost savings for operators; ticket validation can be done by a smaller number of inspectors, equipped with handheld devices using near field communication (NFC) technology to verify the phone or card used to purchase the fare, either onboard or at station exits, and, if connected to the agency database, identify repeat fare evaders or apply relevant discounts. Similarly, especially for high volume stations, higher transaction speeds mean a smaller number of ticket gates can adequately serve the same number of passengers, reducing both up-front investment costs and operation and maintenance costs, while allowing operators to pursue additional streams of income by renting out space to kiosks or commercial vendors.

These positive impacts on operational efficiencies and their requisite impacts on financial performance are often among the key factors motivating the decision to automate a cash-based fare collection system or update an older system, such as magnetic stripe cards. In a study by Perlmutter (2015), five out of six transit agencies cited operational cost savings among the rationales behind the update of their payment system and all cited improved customer experience as a benefit of the new system.

Despite having higher capital cost at the point of implementation, that cost can be offset by lower life-cycle cost in operation when transitioning from both, cash-based and older systems, such as magnetic stripe cards. Singapore and Hong Kong reported a decline in operating cost of fare collection after implementing a smart card system due to elimination of personnel intense processes of handling cash, longer durability of the cards compared to magnetic stripe cards, and lower maintenance cost of equipment (Perlmutter, 2015). The annual operation cost of fare collection dropped by 6% in the case of Singapore and by about 50% in the case of Hong Kong (Perrota, 2014). US transit agencies report similar findings with the total cost of processing cash being between two and six times higher than the cost of electronic ticketing (Quiriba, 2006).

b. Availability of data for improved service quality and credit access

Automating fare collection – particularly with account-based systems – allows operators to collect a vast amount of very valuable data on ridership. The ability to not only track ridership volumes, but to disaggregate the data by route, station, month of the year, day of the week, and time of day allows operators to detect and understand overall trends and optimize operations. Compared to a traditional Origin-Destination survey, where respondents answer questions about their trips over the most recent week, which are expensive and time-consuming to conduct, real trip data is very likely more detailed, more accurate, and provides more options for its analysis and interpretation (Bagchi & White, 2005).

Moreover, transit agencies can benefit from having proprietary data for better planning and adjustments in their plans. For account-based systems, aggregated data on user patterns can help operators and policymakers drive rider behavior through targeted incentives, such as adjusted fare policies or specialized marketing campaigns (Chan et al., 2018). Furthermore, the availability of transparent and traceable operational data, such as the proof of ridership numbers and transactions made can improve the operator's access to finance either from commercial banks or the stock and/or bond markets. This is an important benefit for operators, as lack of access to credit due to informal business practices can greatly limit their ability to invest in and grow their operations.

Both operators and transit agencies can benefit from ownership over accurate and up-to-date data collected in a standardized way, and save valuable resources otherwise spent on costly data acquisition from third-party providers or the contracting of data collection.

c. The emergence of Mobility as a Service (MaaS)

Today's commuters certainly have more options at their disposal; driving a private car, taking public transit (bus, train, tram), using a private and shared ride-hailing service, or micro-mobility services (like bicycles and scooters), just to name a few. As the mobility options proliferate, so have the methods available to identify, book and pay for them. Even as automated fare collection has become more common, electronic fare media continues to be more widely accepted and apps enable the trip booking or ticket purchase process, most platforms focus on a single transport mode, or even just a single service provider.

A 2018 study by the Finnish Transport Agency (FTA) identified multi-phase planning – due to the fragmented nature of information about schedules and fares, lack of connectivity with other modes and the lack of fare integration – as one of the biggest impediments to using public transportation, especially in an unfamiliar city. Mobility As A Service, more commonly known as MaaS – arguably one of the most innovative trends in the transport sector today – attempts to address this challenge by allowing the user to plan and purchase trips, combining options offered by a suite of Transportation Service Providers (TSP) to meet their needs. To date, there is no universal definition of MaaS, but for this publication, it refers to a platform integrating the route planning and payment functions for all modes and mobility services available to a customer. MaaS and the inherent focus on the commuters' mobility needs in a mode- and service-agnostic way is poised to change the face of urban mobility. This does include public transit, as well as ride-hailing services, shared bicycles, scooters, cars and parking amongst others. The current developments of startups in the area are

aiming to create mobile applications for using those services through one single app. So instead of using a different app for each service provider, which can be over thirty in the case of Madrid in 2019, they are integrated into a single platform. Furthermore, the British startup CityMapper has launched a prepaid card service in London, offering several plans on a subscription basis including the use of Transport for London (TfL), shared bicycles, and their own ride-sharing service (Dillet, 2019). Being ready for this development and aware of the implications is a necessity for transit operators and authorities, on one hand to offer more convenience to their customers and on the other hand to remain in control of planning processes.

Whether implemented using an app or card, is under the leadership of the public sector or the private sector, MaaS providers must be able to produce tickets for their customers, which requires a common standard for creating, reading and updating tickets. Box 1 illustrates the application of MaaS in Helsinki, Finland.

d. Emerging options for fare policies and incentives

Fare collection technology and fare policies should go hand in hand. New fare collection technologies enable the implementation of new fare policies, which were previously not technically possible or very challenging to implement. TfL, for example, offers daily and weekly fare-capping, which limits the total paid for all journeys in a single day or week, depending on the time of day (peak or off-peak) and the type of transport used (bus, Tube, tram, DLR, London Overgroud, TfL Rail and National Rail journeys in London) (World Bank, 2016). Fare-capping is available for pay as you go customers but only works if the customer taps in and out using the same contactless card, Oyster card or smartphone, otherwise, the customer pays the maximum fare. This fare policy allows TfL to benefit from journey data, even for one-off journeys by tourists and infrequent riders.

Box 1: Mobility on a Whim – The application of MaaS in Helsinki, Finland

WHIM – arguably the first attempt to offer planning and payment for several modes and service providers in a single application – is designed to compete, not with other transportation service aggregators, but with car ownership. WHIM users can select from a suite of membership options, ranging from WHIM TO GO, a pay as you go option where the primary benefit is the ability to book, pay and execute in a single platform, to WHIM unlimited, with a monthly subscription fee of €499, but includes unlimited public transportation, car rental use, as well taxi rides and city bikes for within certain distance and time restrictions.

Tier:	WHIM TO GO	WHIM URBAN	WHIM UNLIMITED
Subscription fee:	0€	€49 per month (€99 for extended Helsinki region)	€499 per month
Includes:	• No monthly fee • Pay as you go • Public transport tickets, taxi rides and rental cars can be all bought from Whim App	• Unlimited number of public transport tickets • All taxi trips within 5 km radius for max € 10 • Fixed € 49 daily rental car fee • Unlimited city bike trips up to 30 min. at a time	• Unlimited number of public transport tickets • Unlimited number of taxi trips within 5 km radius • Unlimited rental car use • Free to use city bikes for 30 min. at a time

The creation of loyalty programs, which are already widely used in retail, service and e-commerce, is yet another option enabled by account-based ticketing and electronic fare media. Similar to frequent-flyer programs, customers could collect points and either use them to purchase rides or convert them into e-money, which might be accepted at a business in and around transit stations. These and other incentive programs can be customized and targeted to accomplish a variety of objectives, such as increasing ridership or incentivizing off-peak use. A survey by TfL, designed to assess customers' response to messages and campaigns to increase the use of contactless bank cards (EMV) for pay as you go journeys, as well as weekly passes, found that financial incentives or rewards (e.g. vouchers, free travel on birthday) were the most attractive motivators to the switch from the Oyster card to using their contactless bank card or payment app (TfL, 2015).

On the other hand, a too complex fare system can make integration a challenge. When updating their fare collection platform, The Metropolitan Transit Commission (MTC) in the San Francisco Bay Area (US) received only one bid as many companies opted not to bid due to the region's complex fare policy, which integrates 27 transit agencies and 35,000 fare rules (Fleisher, 2018). Fare categories and discounts that are standardized across all transit agencies, such as implementing a "one-more-ride" policy or the use of fare-capping instead of fare passes, are some of the examples of policies that can maximize the incentive benefits while minimizing the complexity of implementation.

e. Including passengers requiring special attention

In countries of the LAC region, around 66 million people are restricted in their mobility due to some kind of disability, with low-income population and older adults showing the highest rate of disabilities. Furthermore, the global trend of an ageing population is also affecting LAC countries' population composition, with a rising share of the group of people above 60 years of age (Granada et al., 2018).

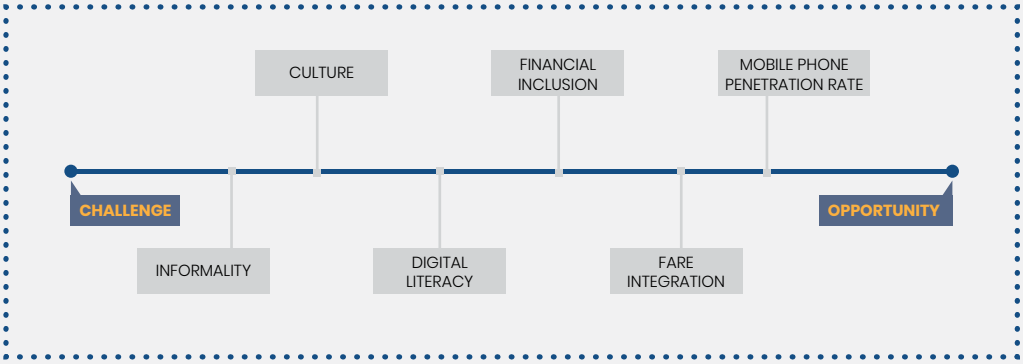
Technology has the potential to facilitate greater inclusion of and access to services by the vulnerable population, such as the elderly and people with disabilities, and thereby afford them increased levels of independence in their daily lives. A study by Olivares Medina et al. (in press) found that for people with disabilities in three major cities of the LAC region (Bogota and Medellin in Colombia; Santiago de Chile) on-board validation and cash payments create difficulties, stress and the risk for injuries. However, they report having no major inconveniences paying and validating their trips offboard, using a smart card. The study also found that users ask for better information by visual and auditive aids to know their cards balance at the moment of charging and paying and the option to recharge their cards online. They would benefit tremendously from an integrated fare structure, reducing the number of interactions passenger needs for validating and paying for their trips, even when being forced to make transfers, making transit more accessible.

An example in which emerging technology is being used to facilitate better access to trips and trip planning is Virgin Train's service to book assistance via smart speakers. Virgin Trains offers the service with Alexa-enabled devices – smart speakers capable of recognizing spoken commands – to facilitate the request for an assisted journey at the time of purchase (Virgin, 2019). Before the implementation, customers requiring assistance during their journeys were required to fill in an online form or make a call to a hotline after making a booking.

4. Replacing cash in transit in the LAC region: Challenges and opportunities of new fare media

Despite the potential advantages of automated fare collection systems, in the LAC region, there are some factors – socioeconomic, cultural, technological – which will have important implications for the infrastructure requirements and stakeholder coordination needed to implement a new system. Those factors directly impact the potential for success and, therefore, need to be carefully considered when identifying the basic requirements to be met by an automated fare collection system. This chapter discusses the factors, and the ways in which they may make the introduction of new fare media in the LAC region uniquely challenging or how AFC could be the foundation for exceptional opportunities. This chapter is structured in a way moving from one end of the continuum, primarily restrictions, such as the sector's informality, towards the other end of the continuum, opportunities, such as the high level of mobile phone penetration amongst LAC countries.

Figure 2: Continuum of Challenges and Opportunities of cashless fare media in LAC



Source: Author's own representation.

a. High degree of informality

The ideal starting point for considering advanced fare collection technologies is a formalized transport sector, where TSPs already have sophisticated accounting and fleet management practices in place. Especially with more than one TSP involved, an overreaching agreement on the necessity and willingness to digitize fare collection is key. In the LAC region, where transportation services are, in large part, provided by small and medium-sized businesses or even individuals, many of whom operate in an unregulated and uncoordinated way, fares are collected mostly, if not exclusively, in cash. For example, a consumer survey found that in 2018, 78% of public transport users in

the LAC region pay most frequently with cash (AMI, 2018). Apart from the missed opportunity in terms of strategic planning to promote connectivity, the informality of the transit system and the associated dominance of cash as the primary payment method introduces some unique challenges that must be grappled with when evaluating approaches to fare collection.

Firstly, handling cash represents a security risk for TSPs and passengers alike, as vehicles may attract the attention of thieves and, in sub-franchised operated systems, whether publicly or privately owned, cash collection without accompanying accountability measures such as security cameras or passenger counting facilities, makes the system prone to pilferage by drivers. It also impacts the safety and pace of operations, as it either forces the driver to multitask, diverting his or her attention from driving and causing longer stops while passengers are boarding and paying, or requires either an additional person to collect fares and provide change. While these risks and costs are important, they can be insufficient justification for the size of investment required to implement an automated fare collection system. When coming from a cash-based collection system, implementing a new system can drive operating costs up rather than down, in the short term, eroding what is often the primary factor driving the adoption of electronic fare media. For example, the estimated cost for the rollout of a new system in New York Subway, updating it from the current magnetic card (Metro Card) to a system accepting contactless bank cards (OMNY) is US$539.5 million (Smartrail World, 2017), but this investment is expected to be offset by lower maintenance costs over time (ITDP, 2017).

Secondly, and notwithstanding the security and safety risks of cash handling and the negative impact on operations operators might not be able to move ahead with new fare collection systems on their own. The disparate interests of several small operators, many of whom lack the resources and access to credit to make the necessary investments or the operational scale required to reach critical mass and recoup their investment within a reasonable payback period are one factor. Furthermore, they are unlikely to be sufficiently aligned to foster the type of coordination that will be required to move the market towards automated fare collection and electronic fare media.

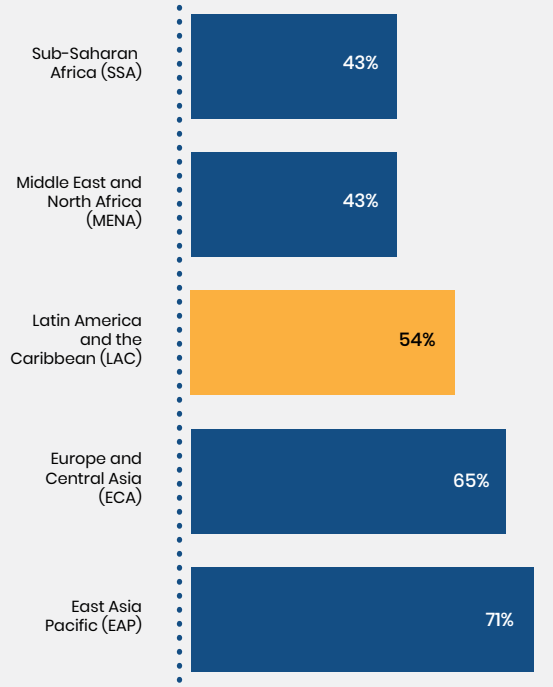
Moreover, the increased transparency associated with the implementation of such fare collection systems and media will facilitate enhanced income tax collection efforts transactions and might drive resistance from TSPs. Especially challenging are environments with many private transit operators, in which the public sector's role is limited to oversight without a proper regulatory framework and formalized systems for revenue tracking in place. Amongst the examples of well-meant attempts to improve the user's experience, security and improve tax collection by the introduction of electronic ticketing are Nairobi, Kenya (Masinde, 2016; Odero, 2016) and MPeso in Managua, Nicaragua. Both systems failed due to a combination of different reasons, including resistance from operators, the existence and high market penetration of mobile money applications, and high levels of price sensitivity among consumers.

On the other hand, while the all-cash starting point could introduce some challenges, the continuous tendency towards professionalization and formalization of LAC transit operators impose the need to rethink and evaluate fare collection systems. This presents the opportunity to apply local best practices, learn from other regions of the world where more advanced systems have been successfully implemented and leapfrog into the future, avoiding the phases of development and growing pains endured along the way when upgrading a system with outdated technology.

b. Inclusion of the un(der)banked population

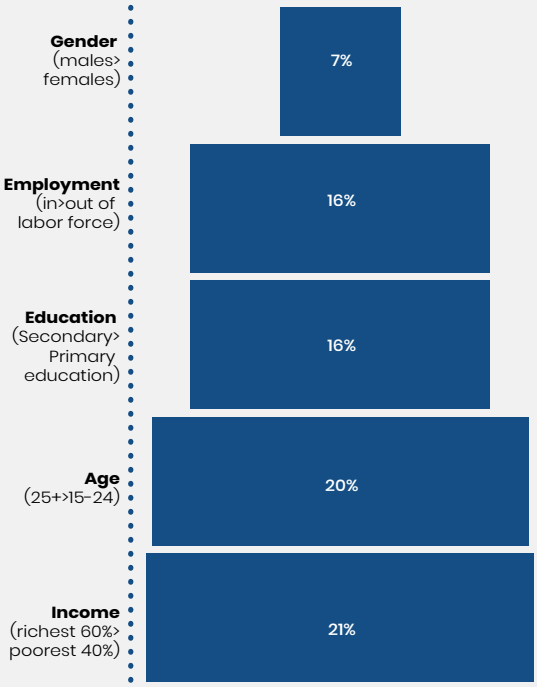
Strategies to automate fare collection and encourage adoption of digital fare media must engage all users of the transportation system, including the un(der)banked. When aiming to eliminate cash from public transport fare collection, low levels of financial inclusion among the ridership can be a significant hurdle to widespread adoption. According to the World Bank global financial inclusion database (Demirgüç-Kunt et al., 2018), only 54% of adults in LAC own a bank account. While this represents a significant improvement for the region – up from just 39% in 2011 – LAC is lagging behind other regions (see Figure 3), such as East Asia and

Figure 3: Account Ownership by Geographic Region (age 15 and older)



11. Demirgüç-Kunt, Asli, Leora Klapper, Dorothe Singer, Saniya Ansar, and Jake Hess. 2018. The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution. World Bank: Washington, DC.

Figure 4: What Affects Account Ownership in the LAC Region?[12]



12. Demirgüç-Kunt, Asli, Leora Klapper, Dorothe Singer, Saniya Ansar, and Jake Hess. 2018. The Global Findex Database 2017: Measuring Financial Inclusion and the Fintech Revolution. World Bank: Washington, DC.

Pacific (EAP) region, where 71% of adults own at least one account.

Several factors influence levels of financial inclusion, such as gender, education level, employment status, age, and income. Figure 4, which presents a financial inclusion gap analysis for the LAC region – the extent to which these factors drive the likelihood of owning an account – clearly illustrates that account ownership is higher among males, those with a job, with at least a secondary school education, who are over age 25, and are among the richest 60% of the population, with income being the most important predictor of account ownership.

Unsurprisingly, the majority of the unbanked in the LAC region say that the primary reason they do not own an account is that they do not have enough funds (58%) and that the costs associated with account ownership are too high (52%). Further, the unbanked cite lack of trust in financial institutions (29%), lack of necessary documentation required for account opening (25%), or the ability to access services through a family member's account (31%) among the reasons for not having their own accounts.

When income is small, irregular and/or received in cash, the purchase price of the fare media or the requirement to store value on the card can be a deterrent to adoption and usage. For public transport users from the low- and lowest-income groups, spending on transportation accounts for a larger share of income. For example, in Lima, the cost of public transportation accounts for 20% and 23% of their incomes, respectively (Scholl et al., 2016). And if there are significant time- or financial- costs associated with topping up fare media, people relying on cash income on a day to day basis may be more likely to choose single trip tickets instead of passes. Box 2, a case study on the approach taken by the Jamaica Urban Transit Corporation (JUTC) – the public bus company operating in the Kingston metropolitan area – to automate fare collection, illustrates the challenges of implementing AFC with low-income, and often unbanked, passengers in an uncoordinated transport market.

Box 2: Jamaica Urban Transit Corporation (JUTC) – The challenges of growing AFC adoption

The Smart Card – JUTC's first attempt at an automated fare collection system – was introduced in 2013, primarily in an effort to reduce theft. The establishment of discounted fares for students in a purely cash-based fare collection system created an opportunity for fraud; drivers issued a child's ticket, while collecting the full adult fare and keeping the 80% difference for themselves. Over time, based on ticket sales, the share of passengers benefitting from fare concessions increased from 30% to 55% of ridership – a trend that was unsupported by demographic shifts.

Despite continued efforts to improve adoption, including the 2014 decision to mandate usage of the re-branded Smarter Card for those accessing concession fares – seniors and children – only 30% of JUTC fares are paid for using the Smarter Cards, virtually all of which can be attributed to mandatory use by concession passengers.

So, why are full fare-paying passengers choosing not to use the Smarter Card to pay for their bus rides?

The challenge of increasing adoption of the JUTC Smarter Card is a complex, multi-faceted one. Both the transport system and the economy as a whole are characterized by a high level of informality; for most passengers, incomes are small, irregular and often delivered in cash due to low levels of financial inclusion, or informal sector employment. Transportation services are provided by a mix of regulated and unregulated providers, on highly a congested and evolving road network, in a largely uncoordinated fashion, with no fare integration and limited connectivity between transit operators. For passengers, navigating this system with limited information about routes, schedules and service options makes for often long, unpredictable and unpleasant journeys.

The JUTC Smarter Card lacks the flexibility and convenience of cash.

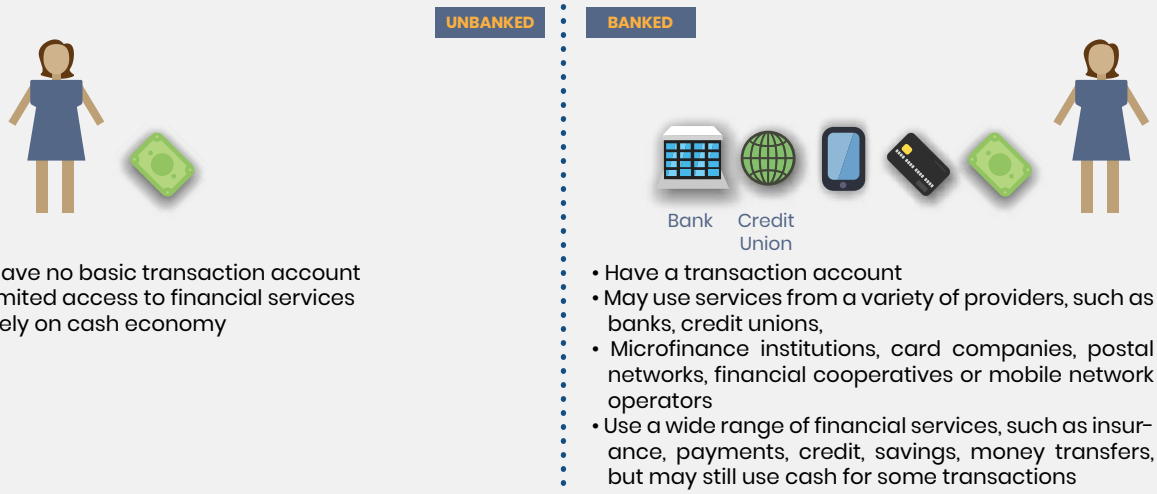
- The JUTC Smarter Card is not accepted by any other TSP, such as buses or taxis. This lack of interoperability, even within the transportation system, means that value stored on a JUTC Smarter card is inaccessible if plans change and the passenger needs to use a different mode of transportation. For low-income individuals for whom transportation likely represents a significant share of their income, the inability to access their funds essentially means eliminating the option to take another form of transportation in the event the bus is full or delayed.

- The JUTC Smarter Card can only be topped up using cash at selected merchant locations, such as the post office. For banked passengers who might have the financial means to keep money loaded on their Smarter Card, the lack of interconnectivity with the financial system and the need to go a physical location to load money on their card in advance acts as a disincentive to use the card.

By eliminating the need to carry cash to pay for bus fares, the JUTC Smarter Card has the potential to reduce security concerns for passengers, drivers and the company alike, but today, for both banked and unbanked passengers alike, cash remains a smarter choice than the Smarter Card.

As explained above, low levels of financial inclusion present a challenge for automating fare collection in the transport sector. At the same time, the broad reach, the ubiquity and the habitual nature of transit services, whether they be toll roads, metered parking or congestion charges for drivers, ride-hailing services, micro-mobility options like city bikes, or buses, make the transportation industry the ideal target for tacking financial inclusion. If payment services can successfully adapt to incorporate the un(der)banked.

Figure 5: Definition of Banked and Unbanked



Financial inclusion is a complex and multi-faceted issue; there exist many different shades of grey between the "banked" and "unbanked," as well as a wide array of definitions for these terms and the ones in between (see Figure 5). At the very least, the "unbanked" can be classified into two groups, based on the reason for not owning an account; firstly, those who are currently unbanked, by choice or because of lack of awareness, but are bankable, and secondly, those who are unbanked because they lack access to the banking system (un-bankable).

The following table (Table 2) proposes some important criteria for TSPs to consider when assessing options for new fare media in order to improve adoption among the different populations along the banked-unbanked continuum, as well as the potential role for biometrics.

Table 2: Financial Inclusion Considerations for New Fare Media

Financial Inclusion	Criteria	Potential Solutions	Potential Role for Biometrics
Banked	• Convenience	• Facilitate integration between fare media and existing bank accounts • Offer services such as auto top-up and online access to account • A service which works online and offline, capable of providing easy and real-time access to information on account balance and transactions	• Biometrics for payment – use body to pay • Ensure speed of transaction and display of fare/balance
Unbanked, but Bankable	• Consumer education • Easy setup • Adequate fee structure of services	• Partner with financial institutions to educate consumers about options • Explore ways to streamline account opening procedures by aligning requirements with Bank KYC requirements • Integrate bank card, ID and smartcard into one	• Partnership to integrate biometric verification for bank transactions, ID and transit into one enrollment step
Unbanked and Unbankable	• Access • Affordability • Interoperability with other transit services	• Provide sufficient, convenient, and reliable options to purchase and top-up fare media (if only electronic fare media is accepted), including for single trip tickets • Control adherence of vendors to avoid additional charges • Find other ways, such as tickets via text message or printed QR codes for single trips • Avoid adding a markup when topping up with cash to avoid penalizing the most vulnerable	• Enrol to biometric program and offer top-ups in cash at kiosks • Control eligibility for discount/subsidies by biometric ID

Inclusive solutions involving enough locations to top up fare media, which can be done at kiosks, local corner stores or fare vending machines, have been among the efforts to promote the use of travel cards. The use of fare vending machines, for example, which are often costly to operate and maintain, in addition to not being very user-friendly, should be reconsidered carefully. The Chicago transit authority implemented the following solutions: removing the barriers to using a card, by issuing a municipal ID card which can be used as a travel card for undocumented residents and placing fare vending machines, which accept cash in every station. Furthermore, users who register their travel card get its purchase price (US$5) refunded.

c. The role of culture and customer communication

Payments require a relationship of trust between the giving and receiving party. The points in this chapter are all having the common denominator that some of the underlying issues and potentials have a component of culture. May it be the affinity for cash, the local solutions for the formation of an informal transit system, the reservation about digital technologies due to mistrust or the lack of information, or the informal banking solutions in unbanked and underbanked surroundings. Culture is an important part, as it directly impacts the user's habits, perceptions and motivations. Implementing a new technology for fare collection can only be successful if it is accepted and used by its target group – this is why apart from all the hard, technological components and specifications, the "soft" part, namely communication, education and management of the change in habits required from the users is an essential challenge, but also creates an opportunity on a larger scale beyond public transit.

When considering implementing a new fare media and limiting the usage of the current media, which in the case of many LAC cities is cash, one needs to consider that this will directly impact every passenger's daily life and routine. Changes requiring some activity, may it be an enrollment or decision making

Box 3: SEPTA Key Card

In 2016, the Southeast Pennsylvania Transportation Authority (SEPTA) rolled out a smart card system. The program planned to sell the card and top-ups at 1500 businesses but by 2018 only 533 retailers were handling transactions. Moreover, customers complained that some retailers unlawfully charging a fee for top-ups, especially when paid for by cash (Laughlin, 2018).

Since 2018 the card can be used as a prepaid debit card, with the funds being loaded on the card via cash deposit or transfers via other accounts or third parties, is stored independently from the top-up for transit fares. As 42% of SEPTA's riders are earning under US$35.000 yearly (Laughlin, 2018a) his initiative seems to be targeting the 12% of the US' unbanked population of people with less than US$40.000 yearly income (Board of Governors of the Federal Reserve System, 2018).

The fee structure of the card is officially accessible online, on an external website under the card-holder agreement.

This additional functionality costs an initial fee of US$4.95 with the option to load funds either one time only, with no option to add additional funds to the card, or as a re-loadable version. In case of the reload option, the fees include amongst others US$1 for card to card or bank to card transfers, US$2 for reloading at a fare kiosk or at a SEPTA sales office, US$0.95 for a balance inquiry, withdrawal decline or balance inquiry decline at an ATM and US$1.95 for ATM withdrawal (Instant SEPTA Key Mastercard Cardholder Agreement, 2019). To put those fees in perspective, the basic trip fare of US$1 or US$2 for a token or US$1.25 for reduced fare trips on transit routes.

by users need to be carefully designed, tested and adjusted. Furthermore, a communication strategy and plan should target all users through the media they respond to the most, such as social media, but also local bulletins, neighbourhood groups could be targeted to raise awareness and build the users knowledge. As mentioned under "section c. Digital literacy among users and operators", especially people not familiar with mobile technologies, the use of bank and other cards, might need more than just theoretical information on the use of new fare media in their daily trips. The effect of increased knowledge and awareness could have a positive spillover effect on other areas of people's lives and their capabilities to adjust to technological advancements.

Together with the trust, there are other socially constructed constraints, such as the affinity for cash payments and reservations about data privacy issues. Those depend on the history and social norms of society and need to be considered when changing to a new fare media. For example, biometric verification might be met with especially high levels of resistance, due to their perceived invasion of personal privacy.

While technology can cause uncertainty and suspicion, there are also opportunities for technology to enhance security and thus contribute to building trust. Distributed Ledger Technologies (DLT), such as blockchain, known as the technological underpinning of Bitcoin and other cryptocurrencies, has the potential to improve transparency and traceability of money transfers while reducing the cost of compliance.

However, for tackling the challenge to familiarize customers with cashless payment methods, transport provides an excellent starting point on a national level. Especially in the LAC region, public transport riders are represented by low-income populations, relying on the service on a daily basis. Bringing public transit riders on-board of cashless payment methods could prepare them for further cashless transactions in the future.

d. Digital literacy among users and operators

Implementing a new payment system requires customers to change their behaviours – unlearn their current ones and learn new ways of executing daily tasks – and, thus, requires clear and frequent communication with customers prior to, during and after the transition. For example, although acceptance of contactless cards was introduced in the TfL system in 2012, the problem of card-clash remains a challenge in 2019, nearly seven years later. Card-clash happens when a user has more than one contactless card in their wallet and taps in with the wallet instead of taking one card out, which results in processing delays when boarding the bus or accessing fare gates or charges to a different card, thereby causing a challenge for the fare-capping, which requires that all journeys are paid for using a single card or device. Continued consumer education is required to avoid card clash, even after several years of implementation, as seen in Image 1.

This is an area where the public transport sector can learn from the fintech sector, in which inclusive startups are aiming to provide technologically advanced, digital products aiming to reach under-

Image 1: Educating customers about card clash

Source: https://twitter.com/tfltravelalerts/status/1114817854635900928

served customers while at the same time becoming profitable. Stout and Parbhoo (2018) point out, that it is necessary to balance direct interaction with customers and digital solutions. The reasons why underserviced customers ask for direct interaction with staff of fintech products are the following:

- Low digital savviness: a lack of familiarity using the internet and mobile handsets.
- Limited product understanding: customers who have never taken a loan or opened a bank account will need some hands-on support.
- Lack of trust in financial service providers: Low-income and underserved customers tend to be more sceptical of the benefits of those providers.
- Limited brand awareness: Fintech start-ups lack the brand familiarity larger start-ups enjoy.
- Competitive Differentiation: Operating in a crowded market, non-digital interactions can help a business to stand out (adapted from Stout and Parbhoo, 2018).

Thinking of the elimination of cash payments for public transport, as an implementation of new, digital payment methods via mobile payments, or even biometrics, and increasing the complexity of fare structures and mobility products (in the most advanced case- moving to the offer of a MaaS, there are several similarities to be found among fintech products and the introduction of new fare media. That creates a need for a direct client to customer interaction, the implementation of a new fare media needs to be accompanied by an education and service strategy and plan, to ensure success.

This strategy needs to include not only customers but also other stakeholders facing new roles and tasks, such as system operators, bus drivers and fare vendors. This can prove a further challenge, as the management of technically complex systems requires solid understanding of the technology behind. Moving from a cash-only system to a more advanced ticketing system requires IT skills for the implementation, operation and maintenance. This is not a common profile amongst human resources in transit-related businesses and authorities in the LAC region, so building and maintaining the necessary human resource and organizational structure can be another challenge.

e. Playing catch-up: Interoperability and Fare Integration

Studies show that users are sensitive not only to the pricing of transport services but also to the frequency with which they are asked for payment, so requiring a customer to pay each time he/she transfers reduces the convenience and increases the perceived cost (Fang & Zimmermann, 2015). When the only accepted payment method is on-board cash payments for each operator, without any fare integration, the customer is forced to pay the full fare for each leg of the trip causing a real, not just perceived, increase in the total cost for the journey. Updating the payment system could be a catalyst for the implementation of an integrated fare structure across various operators prior to, or hand in hand with, an upgrade of fare collection media. This benefits the customers, as well as operators, who can coordinate resources and take advantage of potential savings and an increase of buying power from a shared system compared to taking this step alone (Amin, 2014).

While the starting point for the fare collection system in the LAC region – a fairly informal, uncoordinated, cash-based system – has its challenges, it also represents a tremendous opportunity. Apart from the physical integration of transport services, such as locating a bus stop, taxi stand or city bicycle rack at or near to a train station, fare integration could go a long way to facilitate inter-modal connectivity by offering a combined fare, rather than paying the full fare each time. When accepted by various TSPs across several transit modes, an automated fare collection system that uses electronic media, facilitates fare integration and interoperability, making for a more convenient transit experience and could even increase ridership. Fare integration allows electronic integration between different service providers and allows passengers to make transfers using the same ticket (for example, from one bus/train to another within the same system, or between the bus and train system), usually within a limited period of time or a limited number of times, without paying for the transfer or paying a reduced fare for a lower total trip cost than if completed with cash. Interoperability of fare collec-

tion between operators promotes multimodality and improves the transfer experience between different operators and modes, which not only improves the service experience for the commuter but could also enhance revenues through an increase in linked trips.

The challenge of interoperability cannot be solved by the single intervention of updating the fare media to a cashless media alone. The process to update fare media is just the tip of the iceberg of a complex AFC system. However, due to its visibility, compared to the other components of an AFC system, it can serve as an initial point to enter discussions and staring the process to plan and implement. Rodriguez Porcel and Gordillo (2018) have analyzed case studies of three cities in the LAC region (Mexico City, Buenos Aires and Sao Paulo) and present the relevant institutional, commercial and technical aspects for an interoperable AFC system. According to the analysis interoperability in those cities all of them have a well-defined distribution of responsibilities for tasks such as sales, validation, security and compensation in the system, the institutional architecture, however, varies between the three cities. For the commercial aspect, the scheme for accounts also varies- for the collected fares are either centralized accounts with a share being calculated for each actor, or decentralized for each subsystem, with transfers between each account. For the technical aspect, Mexico City uses Calypso smartcards, the other two cities uses MIFARE Plus. This shows, that there is no one standard model to reach an interoperable AFC system, but the required conditions for an institutional system, the commercial and technical aspects need to be fulfilled and well defined in planning, implementation and operation. In the future, this can enable the readiness to offer MaaS solutions mentioned in Chapter 2. MaaS is a built on the foundation of an efficient, accessible and interconnected public transport system, but fare integration and interoperability – virtually impossible without automated fare collection systems – are necessary ingredients for it to take hold in the LAC region. Box 3 explains the benefits and challenges of one of the SUBE smartcard in one of the most advanced fare collection system of the LAC region.

f. Growing mobile phone penetration levels

Despite the affinity for cash payments for transit service, the LAC region is well connected online and counts with an above-average adoption rate of fintech services. The number of access to mobile phones has increased from 10% in 2007 to over 70% in 2017 (D'Almeida & Margot, 2018) and the average number of mobile phone subscriptions per 100 inhabitants is higher than the OECD average (116% in the LAC region vs. 106% OECD average (OECD/BID, 2016). According numbers of the 2018 (GSMA) report on the mobile economy in LAC, of the total number of mobile phone subscriptions in the LAC region, in 2017, 62% are using smartphones and in 2018, 82% of the population is covered by a 4G network. However, as of 2018 only 38% of the connections are using a 4G network, which is expected to expand to 64% until 2025. Despite growing numbers of a better network and users, there will still be around 240 million people in the LAC region suffering from digital exclusion, which is why the entrance barrier to those services needs to be tackled by joint efforts of the private and public sector.

However, in some of the region's nation, the population being active online is on an internationally comparable level and the adoption of mobile financial technology services are more popular than in other, industrialized nations. In a survey of the online active population of 20 countries worldwide (EY, 2017), that included two Latin American countries, Brazilians came in fourth place (40%) and Mexicans in seventh place (36%). Both are above the world wide average adoption rate (33%) of FinTech services and ahead of countries such as Japan (14%), Canada (18%) and the US (33%). However, when looking at the services available in Latin America, the options to pay for public transport by mobile payment are the most limited among all mobile payment services offered: Only 6% of mobile payment service providers offer customers the possibility to pay for public transport (CEMLA, 2017).

According to EY (2017), 64% of FinTech users prefer the use of digital channels for transactions in their daily lives, compared with 38% of non-users. The reason most often cited among non-users of fintech products is their lack of awareness of the existence of the service. Given the high prevalence of cash payments for public transport, this is an area with enormous new possibilities, especially with the incorporation of FinTech services and the increasing introduction and use of biometrics in smartphone

Box 4: SUBE (Sistema Único de Billete Electrónico) – Smartcard in Buenos Aires

The SUBE card was launched in 2009 and as of 2019, it can be used for public transport in Buenos Aires, all other major cities across Argentina and for paying for toll on toll roads. As of February 2019, there are 13 million active cards in circulation. The card can be used on seven train lines, six metro lines and 383 colectivos (minibus) routes in the metropolitan area of Buenos Aires, which covers a radius of 80 km from the city's central districts, the Ciudad Autónoma de Buenos Aires (CABA). It can be topped up at one of 24,000 recharge locations, and the responsibilities differ amongst the transit services: Metro and rail systems can perform sales, recharge and validation, the BRT bus network can recharge and validated, while minibuses can only validate payments (Rodriguez Porcel & Gordillo, 2018). In 2018, there were an annual 5,000 million transactions, of which 3,889 million were made in colectivo (minibus) services, 727 million in trains, and 340 million in the Subte (metro). On a daily basis, an average of 15 million trips paid for by Sube are processed (SUBE, 2019). The card also allows for demand subsidy and among the beneficiaries are students and people eligible for a special social discount.

However, the processing and use of the data generates comes along with some technical challenges, such as the challenge to generate new indicators, make use of unstructured data from sensors, social networks and images. The amount of data generates also requires solid IT infrastructure on the hardware side and transaction speed, as the monthly amount of data from economic transactions sums up to 90 gigabytes (SUBE, 2019).

In a study of mobility and accessibility of inhabitants in informal settlements of Costa Esperanza, Costa del Lago and 8 de Mayo in Buenos Aires by Scholl et al. (in press), findings show some challenges related to the use of the Sube card. They report that the places to recharge the card inside their neighborhood frequently are out of service, due reasons such as system issues or the lack of electricity. This causes the inconvenience of having to reach another charging point. The inhabitants also report of having to pay an additional fee for the service of charging their cards, which can reach up to five Argentinian Pesos. As people's income fluctuate, they recharge their cards on average 1.58 times per week with small amount between 30 and 50 Argentinian Peso. Because of this pattern, the cost per trip is resulting more expensive than the official fare.

usage. New fare collection systems can support fair and integrated fare structures, including for new mobility options, such as shared vehicles. They could also potentially act as a catalyzer to raise the awareness of FinTech services and include people who are currently not able to access banking services and rely on cash for receiving and making payments. Especially emerging economies could benefit from the unmet demand in the growing middle-class market for FinTech services and implement newer systems without having to deal with legacy systems. This leaves policymakers with the challenge to both encourage and regulate the FinTech market.

Despite not being in the LAC region it is worth mentioning the advancements in China, which has seen a rapid increase in banked population and the use of digital payments. In China, financial inclusion has been a policy priority since 2015, when private banks were encouraged to serve Small and Medium Enterprises (SMEs) and private clients in rural areas which has resulted in improved levels of financial inclusion. In 2017, approximately 80% of persons aged 15 and over had an account and 68% of the population have used digital payments, with a slightly lower rate of 64% in rural areas (Roest, 2018). However, the population's trust in private banks remains low and people are uncomfortable linking their payments directly to their bank accounts. Due to the availability of affordable, locally produced smartphones (often for less than US$ 100), digital inclusion is high – over 55% of the total population owns a smartphone

(Newzoo, 2018) – and QR codes are commonly used in payments and e-commerce. As a result, online and/or mobile wallets offered by third-party providers, such as Alipay (provided by Alibaba) and WePay (provided by Wechat), are widely considered to be more trusted than private banks. China's regulatory and political climate is unique, and the results achieved there may not be easily replicated in a different environment.

Related to the issue of mobility and mobile applications it should be mentioned that transport network companies (TNC) such as Cabify and Grab are moving forward with projects to provide financial services. Both are TNC's operating in different geographic regions. Grab is a Singaporean company with operations in eight South-East Asian countries, including Indonesia, Thailand and Vietnam. Cabify is a Spanish company, operating in 12 countries, of which ten are in the LAC region. Cabify's new project called Lana plans to "create an alternative banking platform optimized for gig workers that empowers to get paid more quickly, reliably, and with the security for saving and making payment" and build a product with the potential to grow into a company that changes the lives of millions of people who currently don't have access to electronic banking (Lana, 2019)." It is currently working on pilot versions in Chile and Mexico, offering a digital wallet to their drivers, to pay basic bills and giving access to some other financial services. For this service Cabify is leveraging the information collected over their years operating on the financial habits and situation of their drivers (LABS, 2019).

Grab Financial which is a unit of the ride-hailing service Grab, is rolling out financial services in Southeast Asia, including an online checkout system, and a post-payment credit option which allows customers to pay the total of their spending on the company's services at the end of each month (Choudhury, 2019). Rather than being a limitation, the development of those companies to move beyond the pure provision of transport and transport-related services (food delivery, etc.) could be a chance for partnerships. Depending on the financial regulations, public transport operators could integrate financial services when updating the fare collection system and moving towards a MaaS platform. However, this is still in the beginning and existing users of those TNCs might not be the under and unbanked target population, but those companies could act more agile, flexible and open to new business solutions and lower the entrance barrier for financial services, compared to established commercial banks.

5. Technologies and changemakers

The previous chapters discussed the circumstances, challenges and opportunities for the introduction of new fare media. The following pages will introduce current options for smart card systems, optical encoding and mobile payments and future technologies, focusing on biometrics. Older technologies, such as magnetic stripe cards will not be introduced, as they have been or are currently phased out in favour of newer systems.

a. Mobile-Enabled Payments

There are several ways to process payments using mobile phones, which are relevant for transit. They range from optical encoding, which uses printed or displayed codes which are scanned by another phone's camera to NFC, Bluetooth and mobile wallets.

i. Optical Encoding

QR Codes are similar to a simple, old technology, which is called Aztec. Atztec is an optical code looking similar to QR code from the perspective of the end-user, but easier to decode. Especially as those codes need to be able to be read under difficult lighting situations, vibrations and dirty phone screens easy decoding can be an advantage.

QR Codes widely used in China, some differences between QR and contactless payment by cards.

In the case of China, QR codes are also used for payment of public services, such as hospitals and at markets in rural areas. QR codes can be printed with any printer and read by any smartphone with a camera. Due to security reason, the daily amount to be spent is capped at a ceiling of US$ 90. Customers are familiar with those service providers and trusting them. A further reason, why mobile

Table 3: QR Codes vs contactless cards

Modality	Function	Cost	Reaction Time	Security	Environment
QR Code	Read Only	Low	Slower	Low	All online on the consumer side
Contactless Payment	Read & Write	High	Fast	High	Functions in an offline environment

payments are widely accepted among the population is that amongst all internet users in China, 98% of its users are mobile internet users in 2018. Back in 2008 less than half of the total internet users were accessing the internet on mobile devices.

ii. Mobile Wallets

Apple Pay, Android Pay and Samsung Pay are mobile wallet services, which use a combination of software and hardware aiming to replace the use of conventional debit or credit cards. The user needs to load or input the information of their debit or credit card to their device. The phone can then be used for making payments and payments are then processed between the user, card issuer and merchant. The payments have in common that they are initiated by placing the devices close to an NFC enabled terminal (Enisa, 2016).

iii. Bluetooth In and Out

By using smartphones and gates equipped with Bluetooth, the gates could validate and open automatically. This would require a passenger to have a smartphone, an app, have Bluetooth turned on, and enough battery on their phones. Hence the technology requires the user to invest their time to enroll and leaves them. Hence the technology requires the user to invest their time to enroll and leaves them dependent on their phone's battery life.

b. NFC technology

"NFC (Near Field Communication) is a technology enabling contactless data exchange between two NFC devices over a distance of two to ten cm. In simplicity, it can be described as a technology that combines Smart Card (RFID) and mobile phone (Olivková, 2017)." NFC is partly based on and compatible with cards of the standard ISO IEC 14443 A (a microcontroller smart card standard under which the Mifare, Calypso, FeliCa and Cipurse fall). Several cities, including Tokyo, are using this technology which allows users can tap-in and out with their mobile phones. It is also used for SMS (Short Message Service) ticketing in other cities, such as Vienna. However, there are security concerns that systems can be possible targets to a range of attacks against users, their mobile devices, the payment applications on their phones, payment service providers or the point of sales. Incidents can include the upload of malware to the user's phone or the point of sale terminals, data connectivity compromise or creating a denial-of-service scenario by which the service gets interrupted (Enisa, 2016). This creates risks and an environment which is hard to control for operators, in relation to negative impacts on the customer's trust.

iv. Other NFC-based fare media options

Apart from smart cards, NFC technology can be integrated into other forms, such as wearable products like rings, wristband, key fobs and watches. Further options are token, which are used for single trips, using the contactless functionality when entering a station and returning the token at the gate when exiting the station. This token system limits the functionality to routes or services with a simple fare structure or would work well at services with limited stops (e.g. for airport lines connecting the airport and a city centre).

v. Contactless Bank Cards: EMV bank cards and white label cards

EMV can be used in cards, as well as phones and other devices. It is a contactless technology and the information is stored and protected in an embedded microchip. As mentioned before, this technology is part of open-loop systems, in which the fare media can be used for other purposes as well. The technology behind the EMV cards is based on the same (ISO 14443 A) standard applied for closed-loop smartcards and the EMV technical standards. One of the cities using this technology is London, which accepts apple Pay, contactless bank cards and their own, closed-loop smartcard (Oyster). The acceptance of bank cards with EMV technology brings a certain risk to the operator: the value is not stored on the card, but on the account, which is not accessed at the moment of the rider touching-in at a turnstile. Because of this the system is not able to collect the fare from users in real-time and in the case of insufficient funds, this cannot be detected immediately. One way to work around this issue is regular updating of the user's data and the blacklisting (and de-blacklisting) of accounts without sufficient funds. Using this technology on board of buses requires them to be connected via a data network (4G or 5G) and update their data as

often as possible in order to prevent the abuse of this potential loophole. However, this does not require an internet connection at all times, a minimum of once an hour is deemed to be sufficient.

TfL reports a yearly increasing number of passengers using a contactless payment method since its introduction. The number of pay-as-you-go journeys on London Underground and the Dockland Light Railway in 2014/15 amounted to 31 million, followed by 147 million in 2015/16, 256 million in 2016/17 and 356 million in 2017/18 (TfL, 2019a).

The key distinction between purchasing a fixed price fare with a bank card when travelling (retail model) or using it for paying an unknown fare at the beginning of a trip (transit model). Another possibility is the use of a contactless card as identification for an account, which means instead of deducting the fare from the account associated with the card, the card itself is an identifier for an account registered with the transit operator.

c. Biometrics

Biometrics is the "science of counting and (body) measurement procedures involving living beings. In the context of identification systems, biometry is the general term for all procedures that identify people by comparing unmistakable and individual characteristics. In practice, these are fingerprinting and hand printing procedures, voice identification and, less commonly retina (or iris) identification (Finkenzeller, 2010)." Other biometric identification modes include lip recognition and palm or finger vein scanning. Biometric identification technology is existing for over a decade in for the use of specialized agencies, such as border control and police files. In recent years, the use of biometrics directly used by customers has increased through mobile phone, entrance gate and, in the financial sector. One of the major advantages of biometrics is its security over memorized passwords and other tokens, which can be lost, compromised by fraudsters and are vulnerable to attacks online (Lovisotto et al, 2017). This is why biometrics have been evolved from sectors and functions, with a need for high security, and accuracy for the authentication of transactions. Therefore, initially, transaction speed was not a key element as they served for controlling access to high-risk environments such as research laboratories handling hazardous substances for example. Lovisotto et al. (2017) conducted a study to understand the perception and attitudes of customers regarding the use of biometrics to authenticate payments. It included 449 participants who filled in a survey before and after trialling a mobile phone application which enables them to authenticate payments via face recognition or fingerprints. According to this study, 90% of bank account holders surveyed are willing to adopt biometrics to replace their passwords, 93% believe fingerprints are secure and 77% consider face recognition as secure. Similarly, a survey among US customers by Aite Group (2016) shows an extensive disposition among consumers to use biometrics for payment authentication. Among 2021 customers, depending on their age group between 25% and 35% accept or strongly like this approach, compared to 7% to 12% who do not like it. 5% to 10%, with the higher percentage being seniors answered to not really understand the approach of payment authentication using biometrics. With authentication via biometrics and the rapid rollout of those technologies in consumer goods, such as Apple's face ID, which was introduced in 2017 customers are steadily familiarized and aware of biometric authentication.

The processing time is also an important factor for performance measurement, but not as essential as in the use of biometrical authentication processes at ticket gates or a vehicle's entrance doors of public transportation providers where delays in processing could have serious knock-on effects for scheduling, customer experience, and operating costs.

To use biometric methods, the user will need to be enrolled and go through a process taking and registering the biometric information needed. Compared to mobile apps and cards, this is a crucial point, as this process can take significantly longer than purchasing a card from a vending machine or downloading and installing an app on the phone. Furthermore, those technologies are not universal solutions, as some part of the population might not be able to or also unwilling to sign up. This population segment may include kids, people with certain disabilities, tourists or visitors. Low levels of digital literacy and inclusion, coupled with privacy concerns, might be among the top challenges when considering biometrics as a means of verification when paying for transport.

In cases where levels of digital literacy and inclusion are low, such as among non-smart phone users, it might be necessary to demonstrate the safety, efficiency and accuracy of biometric technologies to incentivize adoption. For example, the Government of Zambia, in partnership with two payment firms – Ingenico Group and Paycode – used a biometric validation by fingerprints during the registration for a digital wallet for the distribution of subsidies to rural farmers. Within three months 91% of eligible farmers have purchased material with the new solution (Planet Biometrics, 2018).

vi. Face Recognition

Face recognition is a growing market, with a study in June 2016 estimated that by 2022, the global facial recognition market would generate US$ 9.6 billion of revenue, supported by a compound annual growth rate (CAGR) of 21.3% over the period 2016-2022 (Allied Market Research, 2016).

The main markets can be grouped into three categories: security and law enforcement, health, and marketing and retail.

In the past, the technology required to use fingerprints and facial recognition for identity verification was expensive and, as a result, not as commonly used as it is today. The integration of these technologies into everyday routines, such as unlocking a smartphone or laptop, gaining access to an office building or doing an online funds transfer, creates familiarity and greater willingness to link personal identities to fingerprints or facial features. Although the underlying technology used for facial recognition in smartphones is different from the ones used at security gates or surveillance cameras, the similarity of the end-user experience means that the ubiquity of these technologies in other sectors has a positive spin-off effect of higher levels of trust in biometric-based security. The growing penetration rate of smartphones in the LAC region – 62% of the total connections in 2017 and a forecast of 78% by 2025 (GSMA, 2018)– certainly suggests that users might already be familiar with this type of security feature.

China is a pioneer in deploying face recognition technology, which has its roots in surveillance of public spaces, and the technology has become part of a citizen's daily life. Due to the absence of strict privacy protection laws and anchored using Artificial Intelligence (AI) in state surveillance, China is leading the market of face recognition start-up companies. In over 300 locations of the fast-food chain Kentucky Fried Chicken (KFC), customers can make payments via the "Smile-to-Pay" facial recognition payment system developed by Yum China (Mayhew, 2019). In other countries, face recognition and the matching of a person's photo with a database of images via AI is seen as controversial. The European Union (EU) has published a guideline on ethical and trustworthy AI, which shows the importance of this topic on a global scale. However, apart from China, private companies in other countries, such as NEC Corporation, Gemalto, Axon, Cognitec Systems and Amazon are also developing and selling facial recognition software. Despite the concerns of privacy, profiling and monitoring of citizens, the technology is used or trialed commercially for payment processing, marketing purposes (for example identifying the age, gender and ethnicity of someone in front of a video billboard to deliver targeted advertising) and easing up processes and security concerns of consumer and provider interaction.

The UK start-up Facewatch, which uses an algorithm to match faces recognized by surveillance cameras with a watchlist to which clients can add their own images of people they would like to add. It is being used in Brazilian commercial centres and UK supermarket chains. The company plans to charge 2000 GBP for a three-year license per camera (Murgia, 2019).

Another example is the implementation of face recognition replacing the use of a personal security number at ATM's for customers of the Spanish CaixaBank. Customers will first need to have a photo taken and register at a branch to enrol in this service. The bank started with 20 ATM's in Barcelona and eventually plans to implement this technology across their 9,400 ATMs (Mount, 2019).

In 2018 the US Homeland Security Science and Technology Directorate conducted a Biometric Technology Rally, benchmarking 12 available face- and iris-recognition software against each other. The volunteers consisted of different races, age groups and had several images uploaded to be matched against. Another challenge was that 20% of the volunteer's images were not uploaded to the system needed to recognize this fact as well. The volunteers did not receive any

instructions and the system should be self-explanatory and easy to use. The goals were for the users to spend less than five seconds for a transaction and a matching accuracy larger than 95% after five seconds and 99% after 20 seconds. Only one system met the goal for efficiency with a reaction time of 4.7 seconds, a user satisfaction of 96.7% over 95% accuracy within five seconds but did not meet the 99% accuracy within 20 seconds (MdTF, 2018). Those results show, that few of the system providers can meet the necessary standards for reliable and smooth face recognition procedures, even in controlled settings. However, as initially mentioned the market for face recognition is growing and with the demand, the technological solutions will improve.

There have also been trials of face recognition systems in relation to transport, mostly for security checks, but also for ticketing. As mentioned before, the leader for the technology appears to be China. Shenzen Metro is piloting a system in partnership with Huawei, connected via a 5G network, in which people scan their faces on screens installed on entrance gates. The accounts of the registered users are linked to their faces to process the payment (Mayhew, 2019).

Another example is a trial by the company Cubic, which has been working on gate operating with face recognition of passengers previously enrolled via a 3D head scan. Between 65 and 75 users would be able to walk through the gates per minute and will receive feedback on the success of their payment by visual information at the gate and on their mobile phones (Spears, 2017; Blunden, 2018).

Mandates, such as the EU's second payment service directive, can spur the further development and improvement of biometric authentication technologies. The directive requires two-factor authentication for electronic payments, of which one can be facial or fingerprint recognition (ECB, 2018).

vii. Palm Vein Scanning

Palm Vein Scanning is another biometric security technology that uses a person's individual pattern of veins underneath the skin of the palm to identify them. Similar to a fingerprint, palm vein patterns are unique and do not change significantly after reaching the age of about ten years (Vein recognition in Europe, 2004). Because of these characteristics, palm vein recognition is being applied for access control in highly sensitive environments, such as laboratories dealing with biohazard material.

Unlike fingerprint readers, palm vein scanners do not require direct physical contact and, therefore, are less prone to verification issues related to dirty sensors or the use of hand lotions. Furthermore, being a contactless technology has the added benefit of being more hygienic, which could improve user acceptance, especially during times of the outbreak of certain diseases, such as influenza. As a person's palm vein pattern cannot easily be altered or obscured, this technology has some advantages over fingerprint and face recognition, which require certain lighting conditions and can be spoofed (Michael, Connie & Teoh, 2011).

Compared to fingerprint and face recognition, the reaction time of currently available technology is faster. Fujitsu (2019) reports on their product information page a false acceptance rate of under 0.00001% and a false rejection rate of 0.01%. The enrollment process of two images and one verification takes around 10 seconds, verification processing time 0.8 seconds and identification processing time one to two seconds.

Furthermore, it is already used, for example for reducing errors in patient identification upon check-in at a health care provider running 39 hospitals and 900 care sites in North Carolina, US. Over 96% of patients participate in the program and the error of duplicate health records decreased to 0.1% (Hayes, 2017). In relation to public transport operations, Beijing Metro has reported starting using palm scanning and Shanghai Metro is already using this technology in their system (Jourdan, 2018).

Apart from the technical advantages over fingerprint sensors and face recognition, this technology could respond well for privacy concerns. Photographs and fingerprints are typically used for official IDs and identification in criminal records. Moreover, face recognition can be used in surveillance cameras, identifying a person's location and actions without being noticed. Given the fact, that palm vein scanning is an active process, in which the user agrees to be recognized by placing the hand in front of the sensor and has no association with the issues, it could be more acceptable by people who are feeling sensitive for the invasion of their privacy.

VI. Considerations when deciding on a new fare media

The previous chapter introduced a variety of potential fare media types, some of which are already being used on a large scare, while others are still under development and are not sufficiently mature for easy deployment. This section will identify and explore the key factors to be considered before deciding on a new fare media.[13]

Transaction time

Transaction time is one of the most important factors influencing the choice of fare media since it is critical to ensuring smooth movement within stations, especially during peak hours and at key intersections. There are no official industry standards regarding reaction time and varying opinions and non-official industry standards. These vary between a maximum of 300 milliseconds (Smart Card Alliance, 2006) and 600 milliseconds reaction time. Fast reaction time may be more crucial for high-volume, gated stations, whereas stations with low ridership or longer wait times between services could be adequately served with slower systems without significantly affecting the operational efficiency.

Integration with other services

As described in the introduction, in an open-loop system fare media can be used for payments of other services and commerce, apart from transportation, serve as official ID or other purposes.

Setup: Only digital fare media or mixed system

This decision impacts the potential to speed up operations and the ways of enforcing fare payment among users. This could potentially impact the rate of fare evasion and the cost associated with enforcement and control practices. Digital-only means that cash transactions are eliminated in the transit system, users pay with cards, phones or QR codes, etc. However, cash can be used for topping up the fare media used. In a mixed system both, cash payments and payments by electronic fare media are possible. Mixed systems – where both cash and electronic payments are accepted – ensure that un(der)banked or those with small, irregular, or cash-based income streams are still able to access public transportation conveniently, which often determines access to economic opportunities and other critical services, such as healthcare and education. This duality, on the other hand, complicates enforcement and may limit the operations efficiency and data collection benefits accruing to a fully digitized fare media system.

13. The information gathered for this section comes partly from conversations with specialists in the field, panels on the topic and the following publication: Olivková, 2017

Usability and comfort - Feedback to the user

When paying for transit the user would like to know if the payment was successful, the fare he/she was charged for the trip and the balance remaining on the ticket (which in the case of an account-based system is stored in the user's account). Furthermore, the user should have a positive experience of when paying without hurdles and lengthy processes. If for example, the application of one of the methods using biometric features requires the user to conduct other steps to verify their payment, they are unlikely to adopt it. Especially if a more convenient solution is readily available (e.g. tapping a bank card to a reader).

Cost of fare media

Amongst all options, the cheapest one to produce is QR codes, which can be printed or generated on a screen of the user's devices at little or no cost for the operators for the fare media itself. Cards are more expensive, with white label EMV standard cards being priced around US$2 per card, which is about double the price of a standard MiFare card. However, taking into account the whole system, the initial investment can be offset by the operating cost.

Operation Cost

Together with the initial installation costs including the fare media itself, it is essential for the long-term sustainability of the solution to consider the ongoing operating costs of the system, including any maintenance and upgrades that may be required over time. However, account-based systems allow different kinds of fare media to be used, so their impact on the actual operation cost should be minimal.

Resilience against fraud and fare evasion

Fare collection media plays a role in fraud and fare evasion loopholes. In the past, there have been cases of fraud. For example, in Mexico City a device to charge smartcards has been stolen and unlawfully used to top-up and sell cards on the black market. Another example is the abuse of transfer discounts of smart cards in Bogota. In abuse people purchase cards and sell them during the 90-minute time frame during which a discount is applied. New systems are opening up new loopholes - account-based systems let riders use their cards, even with insufficient funds, this is due to the need of online transactions, which may not be possible to recognize this situation in real-time. Before upgrading a system and fare media it is necessary to reflect on the local conditions and the risk of fraud and evasion the new system might bring along.

Privacy considerations and other policy issues

Depending on the local legal context and social awareness and perception of privacy the choice of fare media will vary. Cards might be seen as least invasive, while face recognition can be easily associated with surveillance and criminal watchlists. Despite China's unique context, it can be worthwhile to study the lessons learnt of deploying biometric applications for transit payments, especially the less invasive technology of palm vein scanning.

Beyond the fare media that is selected, transit agencies and operators also have a decision to make on not just *what* to do, but *how* and *when* to do it. For example, a gradual approach with voluntary acceptance, where several fare media options may be offered alongside traditional media and cash, allows operators to evaluate the uptake of various fare media options and ensures that access is maintained for financially and digitally excluded riders, but it may be more costly since infrastructure, training and systems investments will be required for each fare media option that is introduced. Further, if usage is voluntary, adoption may be slower, especially if there is a perception that significant time is required for registration, which may impact payback period if volumes are slow to transition. On the other hand, a mandatory transition would likely be more cost-effective for service providers, but it is important to ensure that communication about the transition be clear, that sufficient time is given for adaptation, and specialized services provided to help riders who might have a challenge adapting to new procedures and/or meeting new requirements, such as linking to a bank account or registering an account online.

The following table shows the outlook for each of the fare media presented in this report and the outlook on the considerations mentioned above. The evaluations of each media are an approximation and evaluations depend on the way the fare media is implemented and embedded in an automatic fare collection system.

Table 4: Fare media and potential outlook on key considerations

Fare media/ Consideration	Transaction Time	Integration	Set-Up	Usability & Comfort	Cost of Media	Operation Cost	Fraud Resilience	Privacy
Cash	Negative	Negative	Neutral	Negative	Positive	Negative	Negative	Positive
QR Codes	Neutral	Neutral	Positive	Neutral	Positive	Positive	Negative	Neutral
NFC Card	Positive	Neutral	Neutral	Positive	Neutral	Neutral	Positive	Positive
NFC Mobile wallet	Neutral	Positive	Neutral	Positive	Positive	Neutral	Neutral	Negative
Contactless Bank Cards	Positive	Positive	Neutral	Positive	Positive	Neutral	Neutral	Negative
Bluetooth In/out	Neutral	Neutral	Neutral	Neutral	Positive	Neutral	Neutral	Neutral
Face Recognition	Negative	Positive	Negative	Negative	N/A	Neutral	Neutral	Negative
Palm Vein Scanning	Positive	Neutral	Neutral	Positive	N/A	Neutral	Positive	Neutral

7. Conclusions

New ticketing services include a broader range of stakeholders than the cash-based fare collection, which in its most basic form is the rider paying the driver or collector in cash. Updating the fare collection system and fare media can act as a catalyst and creates a great number of opportunities if they are actively pursued and integrated into the upgrade. There is not one favourable fare media and it is possible to offer users several options to choose from, based on the local culture and the user's preference and profiles.

Digitalization of the fare collection and the introduction of new fare media does not only consist of the implementation of new technologies, but also a change of behaviour and culture in order to succeed.

Amongst the stakeholders required to adjust are:

- **Transit operators (including conductors)**: It will require them to digitalize their schedules and fare structures, inventory management and show an openness to data-driven methods and digital payments. An open data infrastructure, which enables mobile app developers can drive innovation further. Need for a commitment to full transparency about activities and payments.

- **Regulators**: Digitalization and fintech services require regulations and incentives for innovative services. Those should include digital payment and ticketing services for transit operators, a road map to ensure accessibility for the unbanked population, coordinate and integrate transit services (inter-urban, cities beyond the capital) and complementary actions, such as revision of fares and subsidy strategies and structures.

- **Riders**: Would need to change their behaviour and trust in cashless payment methods. Also, high mobile adoption is needed for mobile payment methods.

- **Private enterprises (Banks, IT, e-commerce)**: In the case, no mobile money service is available they would need to innovate and generate new services including the option to pay for mobility-related services. They are also required to collaborate with the transit operators, regulators and customers.

The preferences for cash and perception of privacy vary widely and inherent differences marked by history and culture. Together with the trust needed for financial transactions of any kind they create a unique context taken into account. Thus, each city or region will be presented with their

unique challenges when taking the decision to move forward with a modernized fare collection system. The solution working best for one city may involve a combination of different fare media, different timeframes for their rollout depending on the stakeholders. Despite solutions need to fit the context, lessons from successful implementation and failed implementations should be considered.

Leapfrogging

Like with other technology-related topics, fare collection is an area which proves that leapfrogging, and therefore advancing to a state of the art technical and managerial service without moving through phases transit operators in cities as London, Barcelona or New York have been passing through or are passing through. New York's MTA is rolling out a new contactless payment system, replacing the magnetic stripe card over a time frame of six years between 2017 and 2023 with the introduction of the new account-based system and an app planned for 2021 (TransitCenter, 2017). Similarly, at London's TfL the introduced open-loop payment system, accepting contactless bank cards is currently running parallel to the Oyster card's closed-loop system.

For Latin-American transit operators and authorities, there are plenty of learning opportunities from the regional and international experiences in the implementation of a fare collection system update. Despite being the base of a MaaS system, an account-based system itself requires a base of established services not being directly related to transit services and operations, such as a reliable IT and telecommunications infrastructure and network coverage in the entire area vehicles are operating.

Operators can move from cash payments, skipping paper tickets, magnetic cards and other outdated systems without using resource and time intense transition periods from one system to another. There are various options of combining new fare media with a new system, such as running stored value in parallel with an account-based system, which can work both off- and online. No matter which solution is chosen in the end, transit regulators and operators should be conscious that goal is not to test or roll out a new technology for its own sake, but to improve the transit system, its efficiency and service level to attract and retain more customers, serving low-income population with an equally high quality as mid- and high-income population.

As new product development is not the core competency of transit operators, solutions will need to be found in other ways, such as collaboration, joint ventures, the creation of a new company or acquisitions. Initially, the cost for a new system will increase but can potentially be offset by offering other services and show the potential of long-term financial gain. However, it is necessary to have a solid plan and understanding in place. In the case of new transit infrastructure or service projects, it is an advantage to inbuilt the cost for a ticketing system, including maintenance, into the total project cost.

The introduced fare media technologies are of different technological maturity. NFC-based systems and their choice of media, may it be in the form of a ring, card, bracelet or smartphone, are already being deployed successfully and technologically mature. For biometric solutions, it seems that further testing and piloting is needed, especially due to a large number of riders in public transit, accuracy and speed are key for transactions. Furthermore, biometrics is invasive for human beings and their sense of privacy, which adds to further complexity. However, with rapid progress and first rollouts in Chinese metro systems, biometric validation should be considered when piloting new fare media.

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