EXPLORING CASHLESS FARE COLLECTION IN THE CONTEXT OF URBAN PUBLIC TRANSPORT REFORM IN SOUTH AFRICA

H SCHALEKAMP, M MCLAREN* AND R BEHRENS

Centre for Transport Studies, University of Cape Town, Private Bag X3, Rondebosch 7701; Email: herrie.schalekamp@uct.ac.za, roger.behrens@uct.ac.za
*iCOMMS Information Systems, University of Cape Town, Private Bag X3, Rondebosch 7701; Email: mclmeg003@myuct.ac.za

ABSTRACT

As in many developing countries, in South Africa unscheduled paratransit services dominate urban public transport. Despite the resulting scale of fare revenue, the majority of the country's *minibus-taxis* operate as cash-only businesses. Drivers typically keep the balance of fare revenue after vehicle rental and fuel consumption payments, while owners seldom include vehicle depreciation as a daily operating expense. There are a number of common consequences. Drivers behave recklessly as they seek to achieve as many peak period trips as possible to maximise income. Capital reserves or affordable finance are not available to renew vehicle fleets. Business owners find it difficult to make operating decisions based on an income-expenditure ledger and principles of profit and loss. Paratransit services are poorly integrated into multi-modal systems when passengers pay fares through different structures and media. Moreover, in contexts where crime and corruption are widespread, on-board cash holding makes public transport vehicles particularly vulnerable. The aim of this paper is to explore the potential of various cashless fare collection (CFC) systems to mitigate these problems, and to review the technology alternatives that are available. The paper presents the results of a review of alternative approaches to CFC, and a qualitative multi-criteria evaluation of these technological alternatives. The criteria include: user and operator acceptability; payment and physical infrastructure; information technology requirements; financial and human resources; and transaction and technology complexity. The three CFC systems that achieved the highest scores in the multi-criteria evaluation were all mobile phone-/mobile network-based systems. Of the three lowest scoring CFC systems, two relied on the passenger having a bank account and one on creating a free-standing fare management and payment system. A key recommendation is that CFC systems are implemented collaboratively and incrementally in order to achieve the requisite stakeholder support.

1 INTRODUCTION

Unscheduled paratransit services such as South Africa's minibus-taxis operate mostly as cash businesses. Drivers typically keep the balance of fare revenue after paying fuel costs and the daily vehicle rental (the "target" system), keep a proportion of daily fare revenue (the "commission system"), or earn an income through a combination of both these systems. In the case of owner-drivers a similar model applies, except that all revenue accrues to the same party. Whether owners and drivers are the same person or not, vehicle depreciation is seldom included as an operating expense. There are a number of common consequences, as documented in detail in Cervero (2000), Behrens et al (2016) and elsewhere. Drivers behave recklessly as they seek to achieve as many peak period trips as possible to maximise income. Capital reserves are limited and instalment finance often attracts punitive interest rates, and thus fleet renewal is a challenge. Business owners find it difficult to make operating decisions based on an income-expenditure ledger and principles of profit and loss, particularly as the majority of transactions are in cash and fare collection is left in the hands of the driver. Paratransit services are also poorly integrated into multi-modal systems since passengers pay fares through multiple different structures and media. Moreover, in contexts where crime and corruption are widespread, on-board cash holding makes paratransit particularly vulnerable.

Since the mid-2000's there has been much interest in reforming public transport systems in South African cities, notably through the introduction of Bus Rapid Transit (BRT) to replace and incorporate existing road-based public transport services (National Department of Transport [NDoT, 2007). The resulting Integrated Public Transport Network (IPTN) programme is supported by the National Land Transport Act (NLTA, Act 9 of 2000) and a dedicated grant administered by the National Treasury, now known as the Public Transport Network Grant (PTNG). Amongst others, until recently the aim of the IPTN programme has been to replace and incorporate (i.e. "formalise") existing paratransit services into BRT. National standards were also set for the new services' cashless fare collection systems, which rely on bank-issued smartcards conforming to the Europay-MasterCard-Visa (EMV) standard (NLTA, Regulations 2011).

As a public transport reform strategy, BRT roll-out has been slow (see Schalekamp, 2015), and a key concern has been that the most utilised BRT system by daily ridership in the country – that of MyCiTi in Cape Town (Timm 2016) – estimates a substantial 75% operating subsidy in the 2016/17 financial year (Van Ryneveld, 2016). This deficit takes into account the full cost of running the vehicles, stations and information technology (IT) costs, a major component of which is the fare collection system. Should the interest in BRT implementation persist in the county, as is still the case, then the resulting quantum of operating deficits that municipalities would have to fund would be an issue of national concern.

Indeed for the current 2016/17 financial year Van Ryneveld (2016) points out that the National Treasury has modified the wording of the PTNG purpose and outcomes (as per the schedules of the Division of Revenue Act [Act 3 of 2015] and the Division of Revenue

Bill, 2016). These changes are significant for IPTN projects. Firstly, municipalities must prove that public transport projects funded through the PTNG are fiscally and financially sustainable. Clearly, in the context of a limited national fiscus, indefinite operating subsidy commitments funded from national sources are being curtailed. Secondly, rather than requiring the installation of formalised, scheduled services – which was mostly assumed to imply BRT – national funding support should result in safe, convenient and affordable public transport services. This mode-neutral stance allows for investing in the upgrading of existing public transport services. Due to paratransit's dominance, focussing such investment on this mode may hold widespread benefits to the travelling public.

There is thus significant scope for investigating public transport infrastructure and service improvements that include the dominant mode, i.e. paratransit. The aim of this paper is to explore the potential of cashless fare collection (CFC) as a mechanism to bypass paratransit's cash-based target-commission system, which in turn might lay the groundwork for cross-modal fare integration. To this end, the paper presents the results of a review of alternative CFC mechanisms, and a qualitative multi-criteria evaluation of these technological alternatives. Where applicable, examples of prior attempts at introducing these CFC systems to public transport or paratransit operations are provided. The criteria include: user and operator acceptability; payment and physical infrastructure; information technology requirements; financial and human resources; and transaction and technology complexity. The paper concludes with a discussion on which approaches hold particular promise, and with recommendations on how they might be explored further and tested.

2 RESEARCH PROBLEM, AIMS AND METHOD

The national discourse around CFC has been focussed on EMV-standard cards as the basis for CFC systems. The NLTA Regulations (2011) provide little leeway in this regard, and thus government-initiated systems such as MyCiTi in Cape Town and Rea Vaya in Johannesburg have complied with the standard in implementing their CFC systems. The South African National Taxi Council's (Santaco) commercial arm, TaxiChoice, has also followed this standard with the launch in 2016 of its FairPay CFC system, after two previous unsuccessful attempts at popularising CFC amongst Santaco's members and their passengers (FairPay, 2017a; Moore, 2016).

The 2007 Public Transport Strategy (NDoT, 2007) set the scene for the IPTN programme and is closely tied to the NLTA, yet it makes no mention of any specific CFC technology. Rather, it variously refers to pre-board, automatic and electronic fare collection, which are generic descriptors. In the preparation for this paper no document, argument or comparison could be unearthed to provide insight into why EMV-standard CFC became the preferred technology between 2007 and promulgation of the regulations in 2011. The search included online general and archival searches for the terms “fare system”, “fare collection”, “AFC” and “CFC”. Since SATC is the foremost academic and practitioner forum in the country, the same search was conducted on its proceedings repository (UPSpace, 2017), spanning the years 2000 to 2016. The latter search similarly produced no discussion or evaluation of alternative means of fare collection. Moreover, technology has moved on significantly since the 2007-2011 period, with the emergence and growth in both alternative payment platforms and mobile phone functionality in the years since.

Thus the first aim of the research: to identify and compare different forms of CFC as, besides the NLTA regulations, there is no clear argument why EMV should be the only technology in the public transport arena. Secondly, the focus of the research was on the impacts of CFC on paratransit as a mode. This mode is widely utilised and thus improvements that address road and passenger safety hold significant public benefit. However, introducing a CFC system on a minibus is not only a question of issuing fare payment media to passengers, installing fare collector or reader devices on the vehicles, and providing administration support. A change in the fare system impacts on the whole business model and relations between operators, labour and passengers. Thus a review of alternative systems must look at the effects a change might have on all the involved actors. (This may also shed light on why the efforts of Santaco, the paratransit industry's representative body, have not yet led to a widespread shift away from cash fare payment.)

The research reported on in this paper forms part of an ACET (African Centre of Excellence in Public and Non-Motorised Transport) project undertaken during 2014-2016 to investigate operational and regulatory alternatives with the potential to reform paratransit services. Building on prior ACET research on this subject (as captured in Behrens et al [2016]), as part of the project the research team engaged in formal and informal exchanges with paratransit operators, consultants and academics engaged in public transport reform processes in South Africa, Kenya, Tanzania and further afield on the topic of CFC. From this process four potential forms of fund sources underpinning public transport fare payment systems were identified: cash-based, with a subset being prepaid multiple ride paper vouchers; free-standing accounts; bank-mediated systems; and mobile network operator (MNO)-mediated systems.

Subsequently, understanding mobile phone and bank account availability were key considerations. National data on access to banking products and mobile phones are captured as part of the annual FinScope Consumer Survey funded by the National Treasury and various financial services providers. The survey draws on respondents aged 16 years and older. The latest available results (FinScope 2015) indicate that 88% of the adult population use a mobile phone. 51% of the adult population uses a smartphone (i.e. 58% of all who use mobile phones) and 40% use smartphone apps (i.e. 45% of all mobile phone users, or 78% of all smartphone users). 77% of the adult population is banked: 58% of the adult population has an actual bank account (or three-quarters of the banked population), and 19% has a social security agency (SASSA) account (or one-quarter of the banked population).

Bearing the aforementioned in mind, the project team then set out to identify all potential CFC technologies with relevance to the paratransit "ecosystem" and the overall public transport context in South African cities. The task also involved describing the different physical, operational and technological components of these fare collection systems, as well as impacts on and relationships to vehicles, passengers, operators, authorities and infrastructure and network providers. The final outcome of this task was captured in a matrix, after which each system was evaluated in terms of implications for passengers, paratransit owners, drivers (or on-board conductors), and regulating authorities. These results are presented and discussed in the next section of this paper.

3 RESEARCH RESULTS

The research results are presented in three parts. The first part describes each identified CFC system's base technology and typical payment process. The second part presents the findings of the multi-criteria evaluation, which spans physical, transactional, and operational considerations. The final part focuses on general considerations and commonalities across the systems informing preparations for testing CFC in practice.

3.1 Potential CFC systems

Overall nine potential CFC systems were identified, each of which is described below in terms of the underlying technology and how a typical public transport fare transaction would work as the passenger boards the vehicle. Also, a number of the below technologies have been applied in public transport or paratransit settings (whether experimental or at larger scale); examples of such application are mentioned at each instance. It should be noted that in practice paratransit drivers fulfil the role of both vehicle operator and conductor. However, it is not uncommon for drivers to employ on-board conductors (touts) to collect fares and generally interact with passengers leaving the driver to focus on vehicle control. If a conductor is employed on-board then the conductor can manage the fare transaction and related equipment. For the purposes of the below descriptions the driver and conductor are assumed to be the same person.

Premium SMS (Short Message Service) base technology: an SMS containing reference text is sent from a mobile phone to a unique number, and a predefined charge that has been associated with the number is deducted from the phone's airtime. Fare transaction example: The passenger sends an SMS to the short-code number (e.g. "12345"), and an associated value is deducted from their airtime. The driver would provide the reference text that the passengers needs to input in the SMS, for example a vehicle's registration number. The passenger receives a confirmation SMS that can be shown as proof of payment to the driver. At month end, the short-code provider reimburses earnings to the vehicle owner after deducting their percentage of the earnings. This system has been employed on buses in the Czech Republic city of Hradec Králové (Hradec Králové, 2012), and there are Service Providers (SPs) in South Africa providing general support.

USSD (Unstructured Supplementary Service Data) base technology: A number framed by "*" and "#" is dialled (e.g. "*123#") from a mobile phone. This triggers the opening of a basic menu of options. Once a menu item is selected, a predefined charge associated with that menu item is deducted from the phone's airtime. Fare transaction example: The passenger dials the USSD number and is presented with a menu of options to select from. These options would likely be a vehicle identifier such as the registration number, followed by a list of cash deduction amounts. The passenger selects the appropriate options from the menu, on guidance from the driver, and the amount is deducted from the passenger's airtime. The passenger receives a confirmation SMS to show as proof of payment to the driver. The Magic Bus Ticketing system in Nairobi (recently rebranded as BuuPass) makes use of this technology on paratransit vehicles (Magic Bus Ticketing, 2016), while its experimental application in paratransit South Africa has been tested (ITWeb Africa, 2013; Destiny, 2014).

Direct mobile/WAP (Wireless Application Protocol) billing base technology: These are two similar forms of technology in which funds are deducted directly from the mobile phone airtime balance. In the case of WAP, a web link is opened from a mobile browser to initiate and approve the deduction of funds from the phone's airtime. The deduction amount may be pushed from another device (i.e. the customer merely approves a specific value) or it may be entered by the customer. Direct mobile payment is similar in that it also relies on network carriers to deduct funds from the customer's airtime on behalf of a third party, but it differs in the process and tools to approve the deduction. For direct mobile billing, the transaction and mobile number from which the funds should be deducted are captured on a separate device, triggering an SMS to the customer's phone with a unique authorisation code. The code must then be entered back into the initiating device to approve the deduction from the customer's airtime. Fare transaction example: The vehicle has a smartphone or tablet installed and enabled to access the internet. The driver inputs the start and end point for the passenger, and the mobile number of the client, which triggers an SMS to the client's phone with a unique code. The code is input back into the tablet to verify the deduction from the passenger's mobile airtime. In the case of WAP billing, an SMS is sent with a link to a mobile website. The passenger selects and opens the link, and captures the details of the transaction. Confirmation is sent to the driver and funds are deducted from the mobile account. Since 2016 travellers in Helsinki can use this payment method on the regional public transport network (NFC World, 2016).

QR (Quick Response) code payments base technology: A QR code is used to convey information about a transaction when it is scanned by a cellphone camera that has the payment application installed. The QR code may either be generated at the time of transaction to include transaction specific information (e.g. the fare price) or may be a static QR code to include identifying information for the seller, e.g. the vehicle route or vehicle number. It is linked to a bank account or credit card. Fare transaction example: The vehicle has a smartphone or tablet enabled to access the internet. Either the driver or the passenger generates a QR code that the other party scans, and the passenger inputs a PIN to authorise payment (PIN functionality can be turned off for transactions under a specified value). If a static QR code is displayed as a sticker in the vehicle, then the passenger scans it and inputs a PIN and the transaction amount to authorise payment. The driver receives an SMS to confirm payment made. In a pilot project in Pretoria, TaxiChoice's FairPay system offers QR code fare payment on paratransit vehicles as an alternative to paying using its EMV card (FairPay 2007b; see also the EMV-type technology below).

Credit card billing base technology: This is the traditional credit card payment method where a card is linked to a bank account with access to funds. The account details are interpreted by a card-reading machine. The reading is done in one of three ways: via the card's magnetic stripe; via a microchip embedded in the card; or via Near Field Communication (or 'NFC') in which case a short-range wireless signal is read when the passenger touches the card to the card reader. A unique PIN is input to authorise the payment, though for NFC transactions PIN functionality can be turned off for transactions under a specified value. Fare transaction example: The passenger climbs on board the vehicle with his/her credit or debit card. The vehicle has a phone equipped with a card reader, potentially linked to a mobile phone, and the driver inputs the amount to deduct from the card. The passenger swipes the card, inputs a PIN and the amount is deducted from the passenger's account. Though their prevalence and utilisation in the transport sector is unclear, SPs in South Africa providing mobile card readers that can be used in conjunction with smart phones include iKhokha (2017), Sureswipe Move (Sureswipe, 2017) and Yoco (2017).

Contactless NFC (Near Field Communication) card (EMV-type) base technology: This is the same as credit card billing, except that the card is linked to a distinct account with a ring-fenced allocation of funds in a dedicated "travel wallet", instead of being linked to the passenger's regular bank account. Cards of this type also commonly allow general purchases through the bank payment system. As these cards usually rely on NFC technology, the cards do not have to be swiped or placed into the on-board reader, but are identified through NFC. Fare transaction example: The passenger touches the card to a card reader installed in the vehicle on embarking and disembarking, or on embarking in the case of a flat fare. The appropriate fare for the trip is deducted from the card. The card is purchased and charged through public transport and/or bank infrastructure. Examples of this technology's application in South Africa include MyConnect (MyCiTi, 2017), Rea Vaya Smartcard (Rea Vaya, 2017), A Re Yeng Connector (City of Tshwane, 2017) and FairPay (FairPay, 2017a).

Contactless NFC card (closed system) base technology: This is similar to credit card billing and EMV transactions, except that the card is linked to a free-standing independent account only linked to the public transport system. Thus, no purchases can be made with the card outside of the public transport system that it is linked to. The card relies on NFC technology as described above. Fare transaction example: The passenger touches card to a card reader installed in the vehicle on embarking and disembarking from the vehicle, or once only in the case of a flat fare being charged. The appropriate fare for the trip is deducted from the card. Passenger must purchase the card from the system's operator and pay to have it charged with funds. The Gautrain Gold Card (Gautrain, 2017) employs this technology on its rail and bus services.

Contactless NFC (linked to mobile) base technology: Reliant on NFC technology, but instead of making use of a card to provide the identification, a chip located within a flat sticker is affixed to a mobile phone to provide the reciprocal communication. Fare transaction example: The passenger has an NFC chip sticker attached to his/her phone. The passenger taps the phone to an on-board NFC reader and funds are deducted from his/her mobile airtime or bank account, and the passenger receives a prompt on his/her phone to input a PIN to confirm the deduction (though as with the previous systems this functionality may be conditionally suspended). For a time/distance-based fare the passenger taps his/her phone again when disembarking from the vehicle and is only charged when reaching this point. The Dar es Salaam Rapid Transit (DART) system is considering this technology to manage fares on its trunk buses, and it is expected to be rolled out on linked feeder services run by the paratransit operators, amongst whom the technology has already been trialled (personal communication with DART project consultant, 7 March 2016).

Near sound data transfer base technology: A mobile phone emits a unique inaudible audio signal that another device equipped with a microphone hears and uses to identify the presence of that device. Fare transaction example: The vehicle carries a smart phone or tablet. The passenger climbs on board, the driver inputs the applicable charges as well as the passenger's phone number on a smartphone. The passenger's phone must be brought close to the vehicle's phone, and it will emit an inaudible sound that confirms the transaction. Money is deducted from the passenger's bank account. The passenger receives an SMS to confirm payment has been made and a confirmation message is displayed on the driver's device. Though not yet tested on public transport services, an example in the general payment space is the TagPay platform (TechCrunch, 2011; Biztech Africa, 2016; TagPay, 2016).

3.2 Qualitative evaluation of potential paratransit CFC systems

Key considerations in the comparative evaluation of each system were the following:

- the extent to which each system might impose an additional financial burden on the passenger when compared to making use of cash fare payment on current paratransit services;

- the current financial and technological means at passengers' disposal, which assumed widespread basic mobile phone ("feature phone") ownership, greater access to and use of mobile phones than bank accounts, and in the last instance limited smartphone use (though not limited ownership) due to high mobile data costs;

- the ease with which a new technology might be understood and adopted by passengers, drivers and on vehicles, focussing on the current financial and technological barriers that passengers and drivers may encounter in practice; and

- the major operating costs that installing and operating the new systems might impose on paratransit business owners and public authorities, assuming that capital costs could be covered separately out of national and local reform programme budgets and that authorities would partner with business owners to drive change.

The aforementioned considerations also informed score weighting. Since the largest affected group in changing to CFC would be passengers, any criteria that practically or financially impacted this group received a double weighting. Drivers (and conductors where such are employed) would have to facilitate each transaction, and thus a change in CFC system would also heavily affect this group, which resulted in a double weighting for related criteria. Since operating costs are crucial elements in the long-term financial sustainability of public transport services (as highlighted in Section 1), related criteria also received a double weighting. Lastly, business owners in partnership with public authorities would have access to greater financial resources than passengers or drivers, and thus no weighting factor was applied to these criteria.

After taking into account the above considerations, each CFC system was evaluated according to the below qualitative criteria. The resulting evaluation is presented in Table 1 (where a lower score indicates the most promising, positive or beneficial option).

Fund sources: CFC systems that allow a passenger to draw on multiple fund sources for fare payment allow the greatest flexibility. Widespread mobile phone usage translates into broad access to airtime as a fund source, while bank accounts might be less attractive due to higher barriers to individual uptake (e.g. monthly account fees, administrative burden). Independent accounts allowing fare payment need to be set up so are not as readily available as mobile airtime, but might not impose the same barriers as bank accounts. (See also Section 3.3 on bank account and mobile phone usage rates in South Africa.)

Table 1: Multi-criteria evaluation of potential paratransit cashless fare collection systems

Criteria[1]		Score[1] = 1	Score = 2	Score = 3	Score = 4	Weighting[1]	Premium SMS	USSD	Mobile / WAP billing	QR code	Credit card	NFC card (EMV)	NFC card (closed)	NFC (linked to mobile)	Near sound data transf.
Fund sources[2]		Multiple	Mobile airtime	Independent account	Bank account	**2**	2	2	2	4	4	3	3	1	4
Fare points-of-sale (POSs)		Widespread POSs	Existing bank infra.	PT & issuer bank POSs	PT & dedica-ted POSs	**2**	1	1	1	2	2	3	4	1	2
Existing service providers (SPs) in SA		Existing in PT	Experimen-tal in PT	General SP	None	**2**	3	2	3	3	3	1	1	1	4
Transaction complexity		Low	Medium	High	-	**2**	3	3	3	2	2	1	1	1	2
Fare structure		Time/dist./ flat & diff'd	Time/dist. & flat fare	Adjustable flat fare	Pre-prog'd flat fare	**2**	4	4	3	3	3	1	1	2	2
Technical literacy	Passenger	Low	Medium	High	-	**2**	1	2	2	1	1	2	2	1	1
	Driver	Low	Medium	High	-	**2**	1	1	2	1	2	1	1	1	1
	System operations[3]	Low	Medium	High	-	**2**	1	1	1	1	1	3	3	1	1
Operational costs	Passenger	None	Mobile airtime	Mobile data	Account service fees	**2**	1	2	2	3	4	1	1	1	1
	Driver	None	Mobile airtime	Mobile data	Account service fees	**2**	1	1	3	3	3	1	1	1	3
	System operations[3]	SP appointment	Occasional internal HR	Frequent internal HR	Frequent HR & SP appm't	**2**	2	2	2	2	2	4	3	1	1
Hardware / media	Passenger	Mobile phone	Dedicated card/device	Smart phone	Debit/credit card	**2**	1	1	1	3	4	2	2	2	1

	Driver	Mobile phone	Verification device	Smartphone	Card device/ reader	**1**	2	2	3	3	4	4	4	4	2
	System operations[3]	Mobile or bank SP	Independent SP	SP & IT system	Independent IT system	**1**	1	1	1	1	1	3	4	2	1
Software required	Passenger	None	-	Mobile application	-	**2**	1	1	1	3	1	1	1	1	1
	Driver	None	-	Mobile application	-	**1**	1	1	1	3	3	1	1	1	2
	System operations[3]	None	Proprietary software	Payment website	Custom software	**1**	1	1	3	3	2	2	4	1	1
						Unweighted score	27	28	34	41	42	34	37	23	30
						Weighted score	**49**	**51**	**60**	**72**	**74**	**58**	**61**	**38**	**54**

Notes:
[1] See Section 3.2 for explanations of criteria, scoring and weighting
[2] See Section 3.3 for bank and mobile phone utilisation rates in South Africa
[3] Parties overseeing CFC system, e.g. vehicle owners and/or public authorities

Fare points-of-sale (POSs): i.e. fare recharge points; widespread existing POSs, such as at shops, kiosks, banks and online, scored better than where new, dedicated POSs would have to be installed. (Munoz & Gshwender [2008] provides an example of the impact of insufficient recharge points in the context of Santiago's then-new bus system).

Existing service providers in South Africa: CFC systems provided by SPs who already have a local presence in the public transport space might be implemented more readily than where technology is still at an experimental stage or where no local expertise exists at present.

Transaction complexity: the more steps there are to completing the fare payment transaction (e.g. manually entering fare values, searching through menus, or requiring PINs, vs. simply tapping a card) the more it might frustrate passengers and drivers and increase dwell times.

Fare structure: systems that could allow flat and variable fare structures and differentiate between different user types could accommodate changing operating conditions, integration between modes with different operating parameters (e.g. scheduled/unscheduled and fixed/flexible routing), and provide built-in functionality to identify passengers who might qualify for financial support.

Technical literacy: a system that is simpler to understand for the parties using and overseeing it (as opposed to SPs who can be expected to have technical knowledge) might present fewer obstacles to it being readily adopted; conversely, complex systems might require extensive education for both users and system overseers, which adds to the cost and complexity of its implementation.

Operational costs: these are the basic recurring costs that passengers, drivers and system operators (owners and/or authorities) would incur for running or accessing the fare system; for passengers and drivers these centre on network access or account fees, while for the system operator it pertains to managing an appointed SP and/or building in-house human resource capacity.

Hardware/media: for passengers this ranks the availability of the device or medium that would be required to pay fares; for the system operator an external service provider could be appointed to provide the information technology (IT) system to manage fare payment and allocation, and/or dedicated IT hardware (e.g. servers and computers) needs to be acquired for in-house use.

Software required: CFC systems present obstacles to adoption if they require passengers and drivers to first install an application on their mobile phone, and might incur data costs to download; the system operator might be able to choose from existing proprietary software to manage the system, or may need a custom-developed online payment site or software.

3.3 General considerations and commonalities across CFC systems

Certain criteria require quantitative evaluation or do not readily lend themselves to qualitative evaluation. Such criteria might include: the overall administrative costs of running each system; actual fare transaction costs; pre-/post-assessment of fare levels and ridership; and the processing time between on-board fare payment and actual receipt of funds by the operator (important for paratransit operators used to cash income on a daily basis). These criteria have not been included in the scoring as they would need to be tested in practice, might be influenced by economies of scale, and/or might require negotiations between the involved parties before costs or impacts might be known.

Though it was considered qualitatively in the evaluation, a detailed quantitative investigation of smart/mobile phone and bank account penetration amongst current and prospective public transport passengers would also be warranted. The FinScope (2015) survey referred to in Section 2 only draws on a small sample (n=5000) to represent the national adult population. In considering a CFC system that relies on mobile airtime or a linked bank account, a more detailed analysis needs to include the population of a specific case's geographic location, as well as the segment under 16 years of age so as to include the school-going population.

Full CFC system operational costs also need to be tested in practice under local conditions. Some CFC system providers do not have a local footprint, making it difficult to obtain indicative costs. Part of the value of the above qualitative evaluation is that it provides initial grounds for deciding which systems or technologies might be investigated further or tested in practice even without a local service provider presence. Particular operational and fare cost consideration in the public transport arena are also likely to be case-specific and in need of testing. These include fare reductions through bulk or multi-trip purchases, incentive or loyalty schemes, and inserting demand- or supply-side operating subsidies. Much would depend on the outcomes of concerted discussions between operators, funding and implementing authorities, and the involved service providers. These engagements would need to be mindful of (but importantly may also inform) the public policy and regulatory environment.

Perhaps the most crucial consideration is that the introduction of CFC would fundamentally impact on the relationship between paratransit drivers and vehicle owners. This applies irrespective of which technology might be used. Removing cash from the vehicle means that the role of the driver in the fare transaction is diminished, if not entirely negated. In effect drivers currently pay owners first and then remunerate themselves; the owner's main role is to set the target amount that the driver should pay for the use of the vehicle. This places hard cash, and a sense of power, in the driver's hands. In a CFC situation the owner would receive fare revenue electronically, and the driver would have to be remunerated after the fact. This disturbs the power dynamics in the business. Owners would need to be far more directly involved in the day-to-day management of the business, both through managing labour relations and the CFC system. Drivers would lose the flexibility to determine their level of effort and income. These are not inconsequential changes, and would require concerted engagement between owners and drivers. Such engagement would in all likelihood have to be kick-started by a public authority willing to offer systemic support in exchange for the public-good that CFC might bring about.

4 CONCLUSION

The three CFC systems that achieved the best scores in the multi-criteria evaluation were all mobile phone-/mobile network-based systems: in first place was the tag-based NFC system, followed by the premium SMS service and USSD system which are both in widespread general use. At the other end of the scale, of the three worst scoring systems, two relied on the passenger having a bank account (QR-code, credit card payment) and one on creating a free-standing fare management and payment system (closed NFC card system). The three systems that scored in between these poles were the EMV NFC card system, mobile-based billing, and near sound communication payment.

In view of the prevalence of mobile phone usage in South Africa compared to that of commercial bank accounts, as discussed in the preceding sections of this paper, the outcome of the evaluation is not particularly surprising. None of the three systems that scored best require the user to be banked or to have a smartphone, or for significant physical infrastructure to be put in place. This lowers the barriers to implementation as well as to passenger and operator adoption. The NFC tag system furthermore allows the use of an array of fare funds sources and fare structures, which bodes well for its potential to offer integration across both scheduled and unscheduled public transport modes. This functionality is not shared by the premium SMS and USSD systems; in terms of integration the alternative that perhaps comes closest is EMV technology. Though infrastructure-heavy and cumbersome, in cities where EMV systems are already established as part of BRT operations there is the potential to expand it to other modes. In such instances expansion costs might well be marginal in relation to sunk costs. However, the paratransit industry may well be loathe to be incorporated in a system that in their eyes might be imposed by authorities and associated with the BRT “threat”, nor can it be assumed that support for Santaco’s own EMV system is shared by all operators. The national representative body’s previous failed attempts at popularising CFC support this view, but may also reflect an inadequate general understanding of the barriers to adopting such system.

Ultimately this paper only provides a first exploration of CFC to address problems in the paratransit business model as well as lay the foundation for such services’ integration into multi-modal public transport systems. The paper also set out some of the criteria that might be used to evaluate systems that may hold particular promise for testing in practice. Concerted engagement between the involved and affected parties – passengers, paratransit employees, owners and associations, responsible authorities, and other service providers – would be a necessary precondition. Amongst others, this could involve exploratory and focus group discussions, as well as initial operational surveys. Local area pilot projects would be a next step, in which an authority collaborates with a particular paratransit association or group of associations to implement and document the impacts of a CFC system. From such projects could be derived the quantitative and qualitative impacts that at present are not readily understood or investigable, and which would underpin wider exploration. Allied to ongoing technological innovation, the recent adjustments to the PTNG framework and efforts to rethink the IPTN planning process bode well for new approaches to urban public transport reform, and especially incorporating paratransit in such reform plans, to emerge in years to come.

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