The role of ICT-based innovations in transforming intermediate transport in African cities. The cases of Cape Town, Nairobi, and Addis Ababa

Virginie Boutueil, Gaele Lesteven

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Virginie Boutueil[a], Gaele Lesteven[a*]

[a]*Université Paris-Est, Laboratoire Ville Mobilité Transport, UMR T 9403, Ecole des Ponts ParisTech – IFSTTAR – Université Paris-Est Marne-la-Vallée, 6-8 Avenue Blaise Pascal, 77455 Marne-la-Vallée cedex 2, France*

Abstract

Over recent decades, intermediate modes of transport (also known as paratransit, which includes taxis, moto-taxis, collective taxis, ride-hailing services, etc.) have gained momentum in the fast-expanding cities of the developing world. They now commonly are a significant, though often informal, component of mobility systems in these cities. On top of rapid demographic growth, cities in South and East Africa are enjoying higher levels of economic growth and political stability than cities in other Sub-Saharan countries. Such trends translate into a dynamic development of heavy infrastructures, private motorisation as well as mobility innovations of various sorts.

Paratransit services –with their intrinsic qualities of innovation-readiness (besides flexibility and labour-intensiveness)– could remain a key element of future, more sustainable urban mobility systems. The main assumption underlying this research is that mobility innovations using Information and Communication Technologies (ICTs) could play a significant role in this consolidation process.

The paper first presents an overview of the mobility systems of three cities in South and East Africa and their respective ICT background: Cape Town, South Africa (3.7 million residents), Nairobi, Kenya (3.1 million residents), and Addis Ababa, Ethiopia (3.3 million residents). It then analyses the place of intermediate transport modes in each of the three cities. Finally, it presents a set of ICT-based innovations developing in these cities and discusses the role of such innovations in the modernisation, upgrade and expansion of paratransit services.

This study combines an extensive review of academic and grey literature with the insights gained from 32 in-depth stakeholder interviews carried out by the authors during a field trip in March-April 2017.

Keywords: ICT-based innovations; paratransit; urban mobility; Africa

* Corresponding author. Tel.: 33 1 81 66 88 67
E-mail address: gaele.lesteven@enpc.fr

1 Introduction

As of 2017, 1.3 billion people live in Africa. This represents 17 per cent of the world population. More than half of the world population growth by 2050 is expected to occur in Africa, meaning the African population would double and would represent 26 per cent of the world population by then (UN, 2017). Africa is also set to be the fastest urbanising region in the coming decades. In 1990, one third of Africa's population was urban. By 2050, the figure is projected to reach 56 per cent. Today, 60 per cent of the population is under 25 and 41 per cent under 15. Africa appears as a region of massive changes, not only in terms of demography and urban development, but also regarding the adoption and use of Information and Communication Technologies (ICTs). At the end of 2016, there were 420 million unique mobile subscribers in Sub-Saharan Africa, a penetration rate of 43%. The rate was 27% in 2010. Only 6 years later, Sub-Saharan Africa almost reached the 2010 global average penetration rate (46%, which rose to 66% in 2016). Smartphone connections in Sub-Saharan Africa have doubled over the past two years to nearly 200 million, accounting for a quarter of mobile connections in 2016 (GSMA, 2017).

Intermediate transport refers to all means of transport between the individual use of the private car and mass transit. Intermediate transport services, also called paratransit, are heterogeneous, ranging from licensed minibus services operated on a prescribed route by a formalised company to illegal motorbike services run by informal one-person businesses. They also have seen the recent addition of shared mobility services proposed by fast-growing transportation network companies (TNCs), such as Uber. In many African cities, paratransit services now commonly are a significant component of the mobility system. As motorisation rates are still low and road networks are highly congested and dangerous for cyclists and pedestrians (Sietchiping *et al*., 2012), they are often the only means for many urban dwellers to travel. They are often subject to vehement criticism related to their reckless driving of overloaded vehicles, even armed violence, and collusion with corrupt police (Pirie, 2014). Nevertheless, thanks to their intrinsic qualities –flexibility, labour-intensiveness, and innovation-readiness (Lesteven and Boutueil, 2017)–, paratransit services are a key asset for urban mobility systems to be able to cope with fast-increasing demand on the short term.

The aim of our project is to discuss the role of ICT-based innovations in the modernisation, upgrade and expansion of paratransit services. Our main assumption is paratransit services –with their intrinsic qualities of innovation-readiness besides flexibility and labour-intensiveness– could remain a key element of future, more sustainable urban mobility systems, with the help of the current boom in ICT-based mobility innovations. On top of rapid demographic growth, cities from South and East Africa are enjoying higher levels of economic growth and political stability than cities in other Sub-Saharan countries. Such trends translate into a dynamic development of heavy infrastructures, private motorisation as well as mobility innovations of various sorts. For this study, we selected three cities of similar size but presenting different national and local political settings: Nairobi, Kenya; Cape Town, South Africa, and Addis Ababa, Ethiopia. The diverse levels of maturity of the three cities regarding ICT infrastructure and services helps provide a broad view of possible barriers to, and enablers of, the transformation by ICTs of the industry(ies) of intermediate transport in Africa.

The paper is organised as follows. The next section presents the methodology and provides background information on the urban, transport and ICT contexts in the three cities. Section 3 discusses the role of paratransit services in the cities. Section 4 provides an overview of ICT-based innovations in the urban mobility systems considered. The final section discusses their impacts on the paratransit sector, as vectors for a more sustainable mobility, and offers some concluding remarks.

2 Methodology and general background

2.1 Methodology

This study combines an extensive review of literature with the insights gained from 32 in-depth stakeholder interviews carried out by the authors during a field study in March-April 2017 in Nairobi, Kenya, Cape Town, South Africa, and Addis Ababa, Ethiopia. Interviewees included representatives of public authorities (5 interviews), transport operators (4 interviews), international development agencies (3 interviews), consultancies (2 interviews), NGOs (2 interviews), IT start-ups (8 interviews), and researchers (8 interviews). The recruitment was not exhaustive but diverse enough to collect different positions on the debate. The interviews were all

transcribed. The survey findings were complemented by field observations and an extensive literature review of scientific papers, policy documents, and local newspapers (for lack of better sources).

2.2 Three Sub-Saharan cities

Nairobi, Cape Town and Addis Ababa have approximately the same population size (between 3 and 4 million inhabitants). All three cities have been shaped by the development of railways in the 19th century. If spatial segregation is a common historical feature in Nairobi and Cape Town, it is a more recent development in the case of Addis Ababa. The capital of Kenya, Nairobi, is located in the fertile central highlands. The city has been created by the British as a commercial place on the Uganda-Mombasa railway. Since Independence in 1963, population has grown to reach 3.1 million people in the Nairobi City County. The Western side of the city, that is the former colonial city, remains a wealthy area. Low-income populations live in the eastern and southern part of the city and jobs are mainly located in the CBD. The racial segregation of early Nairobi has evolved into the current social segregation pattern (Klopp, 2012).

Cape Town is older than Nairobi. Created three centuries ago, it is located in a spectacular setting in the south-western part of South Africa. The building of a railway line to the Southern suburbs during the 19th century shaped the urban growth of the city. Accelerated urbanisation occurred in the 1940s and resulted in large informal settlements populated by Black African populations in the peripheries. The 1960s and 1970s were marked by low-density suburban expansion along the city's freeways. The city proved very attractive, with a population growth of 30% over the last decade, reaching 3.7 million inhabitants (TCT, 2015). The current structure of the city still reflects the legacy of Apartheid and the associated policies of deliberate segregation.

Like Nairobi, Addis Ababa is a capital city. Located in the central highlands of Ethiopia, the second most populated country in Africa, it is its principal commercial centre. Addis Ababa is also an important regional and international transportation hub as the Addis Ababa-Djibouti Railway has been influential in the development of the city and Ethiopian Airlines has established itself as the largest airline in Eastern Africa. The population of the city has almost doubled every decade since the 1980s. It has reached 3.3 million. The city has experienced rapid sprawl, due to informal squatter settlements and forced relocation of population in the peripheries.

2.3 Urban mobility systems

The three cities are contrasted in terms of infrastructure development, motorisation rate, and modal share. In Nairobi, 30% of households own a car. The modal share of private cars is 14%, and 5% for motorised two-wheelers (JICA, 2014). Traffic congestion is heavy as all road traffic converges towards the CBD and by-roads have not been completed yet. The car culture is more strongly established in Cape Town where more than half of households own a car. The city counts 306 cars per 1,000 inhabitants. The private car has a 37% modal share (TCT, 2015). Congestion occurs at peak hours on the intra-urban freeway system built in the 1960s and 1970s (Wilkinson, 2000). Car ownership in Addis Ababa is lower than in Cape Town and even Nairobi. But the city has lately seen a rapid increase in car ownership with 130 vehicles per 1,000 people in 2015 against 65 in 2012 (World Bank, 2016a and 2014). Addis Ababa City Roads Authority (AACRA) initiated in 1998 the construction of a ring road to alleviate congestion on the city's roads.

In all three cities, the urban organisation is inadequately compensated by the public transport system, especially as far as the mobility needs of the poorest portions of the populations are concerned. Nairobi mainly relies on its minibus services, called 'matatus', as the public bus services failed in the 1980s. Besides matatu services, 'boda-boda' motorbike-taxi services are expanding, and so are TNC services. Uber and its local competitor LittleCab respectively operate about 4,000 and 5,000 for-hire vehicles in the capital [interview with an operator]. Matatus account for 28% of daily trips, as compared with 12% for buses (JICA, 2014). A commuter train operates but its use remains marginal. The creation of the long-awaited Nairobi Metropolitan Area Transport Authority in 2017 may help materialise the plans for implementing BRT corridors. The modal share of paratransit in Cape Town (in the form of minibus taxis) is relatively low compared to other South-African cities (15%, as compared with 70% in Johannesburg). Minibus taxis are increasingly taking market share from the historical transport mode of the poorest, namely the commuter rail (11% modal share) (TCT,2015), owing to persistent problems of under-investment in railway infrastructure, decaying rolling stock, inadequate policing and vandalism (Pirie, 2014). Buses, public or otherwise, hold a 15% market share in Cape Town. MyCiti BRT, the latest addition to public transit services in Cape Town, started in 2011 and progressively opened new routes. Though emblematic as an

urban project, the BRT has had a limited impact on demand (<1% modal share) so far. Uber started operating in Cape Town in 2015. Contrary to Kenya, there are no moto-taxi services in South Africa. Finally, in Addis Ababa, the transit and paratransit fleet is diversified. It includes 8,500 Saloon taxis, 7,500 blue and white minibus taxis, 1,800 buses (private and public, standard and express), and 22 trains to address the mobility needs of 2.5 million persons (*Addis Fortune*, 2017 and 2015). Minibus taxis had a 34% modal share in Addis Ababa in 2006, as compared with only 6% for buses and 6% for taxis (Addis Ababa city government, 2012). The latest additions to the public transport system in Addis Ababa are two Light-Rail Transit (LRT) lines. Launched in 2015 as an emblematic project for the city, they have not yet reached their expected full capacity of 15,000 passengers per hour per direction, which will require completing the purchase of the 41 trains as originally planned. Non-motorised transport (NMT) in Nairobi and Addis Ababa respectively accounts for 42% and 44% of daily trips (in Nairobi, NMT is involved in 70% of road accidents). The situation differs in Cape Town, where the modal share of NMT is half what it is in the other two cities.

Table 1. Key data on the three cities

	Nairobi	Cape Town	Addis Ababa
Perimeter	Nairobi City County	City of Cape Town	City of Addis Ababa
Population (million inh.)	3.1	3.7	3.3
Area	696 km^2	2,445 km^2	540 km^2
Mini/midi bus fleet	~10,000	7,576	~10,400
Metered Taxi/TNCs fleet	> 9,000	n.a.	> 6,500
Trips/day/person	2.34	2.37	1.02
Public transport share	40%	41%	46%
Incl. Mini/midibus share	*28%*	*15%*	*34%*
Private mode share	19%	37%	9%
NMT share	42%	21%	44%

Sources: For Nairobi: Kenya National Bureau of Statistics - Census 2009 & Nairobi City County Statistical Abstract 2015, JICA, 2014 (2013 modal share); for Cape Town: Transport for Cape Town, 2015 (2013 modal share); For Addis Ababa: Addis Ababa city government 2012 (2006 modal share), World Bank, 2016, *Addis Fortune*, 2015 and 2017.

2.4 The ICT background

Mobile networks cover more than 90% of the African population, with more than half also covered by high-speed mobile broadband networks (GSMA, 2017). The transition to mobile broadband is driven by network deployment and expansion, more attractive prices for data transfers, and greater availability and affordability of smartphones. Numbers of subscribers will continue to increase as the population is still very young, and fewer women than men currently own a mobile phone. South Africa is among the top five countries of Sub-Saharan Africa for mobile penetration (all with a penetration rate of 68%-69%): 37.5 million inhabitants are unique mobile subscribers. Kenya ranks 11th on the subcontinent, with a rate of 59% (28.3 million subscribers) and Ethiopia ranks 34th with a rate of 34% (34.7 million subscribers) (GSMA, 2017). In South Africa, 52% of the population use Internet versus 47% in Kenya and only 12% in Ethiopia. Telecommunications are an open market in South Africa and Kenya where the main operators are respectively Vodacom, MTN and Cell C; Safaricom, Airtel, and Telkom. In Ethiopia, the industry consists in a monopoly, Ethio-telecom. The Ethiopian government has shut down mobile Internet repeatedly in 2016-2017, to quell anti-government sentiment.

Mobile technology is the only available platform for the majority of the population in Sub-Saharan countries to get online. Therefore, ICT-enabled service innovations mostly rely on mobile technology. Among these services, mobile money is very popular, especially in Kenya. M-Pesa, the very popular mobile money platform of Safaricom contributed 27% of the company's service revenues in 2016 (GSMA, 2017). M-Pesa is still largely used via SMS and USSD, which is driving engagement levels among non-smartphone users.

Parallel to mobile network infrastructures, Africa is also developing tech hubs, i.e. spaces mainly focused on developing a digital entrepreneurship ecosystem, and tech incubators. The World Bank's mapping project for tech hubs and incubators in Africa registered 173 entities as of June 2016, with the greatest contributors being South Africa (32), Kenya (16) and Nigeria (15) (World Bank, 2016b). Depending on the cases, initiatives such as tech hubs and tech incubators can be led by government, civil society, academia, or a combination of them. Through the Kenya Vision 2030 (released in 2007) and the Kenya National ICT Master Plan 2014-2017

documents, the national government has set a clear framework and direction for the ICT industry to develop fast and for the economy to reap the benefits of such development. Nairobi concentrates the vast majority of tech hubs and incubators in the country (World Bank, 2016b), and universities are involved in several of them [interview with a researcher]. In South Africa, the National Integrated ICT Policy White Paper (released in 2016) sets the framework for government support to digital technology hubs nationwide but local initiatives were one step ahead and the civil society has developed several functional tech hubs in Cape Town in particular. In Ethiopia, progress has been slower, but 2 tech hubs have developed, partly supported and funded by the diaspora, that seem to get things moving forward, despite the current restrictions on Internet access [interview with a start-up; interview with an NGO].

3 Intermediate transport services as a key component of urban mobility systems

Paratransit services present common features in the three cities examined here. First of all, the size of the paratransit fleet is comparable among all three cities: about 10,000 minibuses for a 4-million city (see Table 1). Interestingly, the same ratio holds for the 'daladala' minibuses in Dar-es-Salaam, Tanzania, 4 million inhabitants (Rizzo, 2014). Yet, as already mentioned, the modal share of paratransit varies from 15% to 30% in the three cities. This section provides an overview of the history of paratransit services development in the three cities and discusses two of the most prominent common features of paratransit services, namely: their flexibility and their labour-intensiveness.

3.1 To the origins of large paratransit fleets

In South Africa and Kenya as in Tanzania, paratransit emerged to address the unmet travel needs of the indigenous population. After independence, the Kenyan government allowed 'private taxis' to operate, first informally then as registered Public Service Vehicles (PSVs) from the 1980s onwards. At the time, the bus and commuter train services, with dated technologies and management, were unable to handle increasing passenger demand. These services eventually collapsed in the 1990s, in a context of structural adjustment programmes, reduced government budgets and privatisation [interview with an operator] (Klopp and Mitullah, 2016). In Cape Town, the minibus-taxi industry developed during Apartheid mostly to carry poor people living in the townships to workplaces in the CBD. It started operating, illegally, to compensate bad commuter train services. Following transport deregulation in 1987, the industry rapidly expanded and overcapacity led to 'taxi wars' (Dugard, 2001; Lomme, 2008). The situation became less violent in the post-Apartheid era. The industry became regulated but the quality of service decreased. Like in Cape Town, attempts at regulating the industry in Nairobi have reduced the violence and the number of cartels and gangs have declined since 2010 (McCormick *et al*., 2016).

The situation in Addis Ababa is somehow different judging by the historical process, but not so much by the outcome. Because the Italian occupation of Ethiopia was short-lived (1936-1941), Addis-Ababa was not moulded by colonial segregation considerations to the same extent as other cities on the continent (Ouallet and Giorghis, 2005). Besides, the city has managed to preserve its public large-bus company, Anbessa, owing to strong public support. Yet, paratransit services in the form of minibus taxis, locally known as '*wuyeyet*' (Voukas and Palmer, 2012), have developed alongside public transport to absorb the fast demographic growth of the city.

3.2 Flexible transport services to address a diverse demand

The fundamental asset of paratransit services is their essential flexibility. Notwithstanding regulation, paratransit services are, to a greater or lesser extent, flexible in time (no schedule, adaptability to peak and off-peak hours) and in space (no fixed routes, or no fixed stops along routes, adaptable routing in peak/off-peak hours, capacity to reach city outskirts and informal settlements). Depending on the context, on the choice of vehicle, on the fare structure, etc., paratransit is also adaptable to different categories of users, from very poor to middle-income classes. This 'gap-filler' (Cervero and Golub, 2011) provides accessibility to demand segments that are not addressed otherwise.

Matatus in Nairobi are privately run and demand-driven services. They receive no subsidies from public authorities. Fares vary according to the route, the condition and aspect of the vehicle and even the weather [interview with a researcher]. On rainy days, fares could triple on a given journey. This fare structure excludes the very poor from using the minibus services and occasionally encourages the shift of wealthier users to TNC services. Mostly operated by young men, boba-boda moto-taxi services target matatu users who would want to

escape traffic jams as well as lower-income customers (as they are cheaper). As their income increases, middle-class users usually switch to private cars or TNCs. Regulations on matatu registration (to be filed through a matatu association) and routes allocation (to link each vehicle licence to a specific route) were made more stringent in 2010 with a view to improving the organisation and quality of service. The National Transport and Safety Authority is currently implementing electronic licensing [interview with an operator].

In Cape Town, local authorities saw in the planning of BRT services an opportunity to replace paratransit services by a trunk-and-feeder network in which all remaining operators would be formal bus companies (Behrens *et al*., 2012). Although some would argue that the current BRT system is a success story –as it is considered the first reliable bus system, with a cost recovery close to 50%, and much appreciated too by some portions of the population [interview with a consultant]–, others criticise it as both over expensive for users and costlier than anticipated for public authorities, as well as inadequate to actual travel needs of the target population. It is inflexible with regards to stops for pick-up and drop-off, not serving some of the poorest, most populated areas, and using very rigid, high-tech ticketing (based on Europay-Mastercard-Visa cards) [interview with a researcher x2]. For these reasons, the minibus-taxi services are still operating on feeder lines for the BRT. The City of Cape Town has recently been operating a shift in perspective, and is now considering the integration of paratransit services into the BRT project [interview with a consultant].

In Addis Ababa, minibus taxi fares are controlled by the city government, and so is the route allocation process. Besides minibus taxis, Higer midi-buses (27 seats) have operated on 24 designated main routes since 2007. They qualify as paratransit as they can flexibly choose their stops along the way (Voukas and Palmer, 2012). With the delays in BRT implementation so far (World Bank, 2014), and the rapid expansion of the city (including major settlement projects far beyond the reach of the LRT system) (Meshesha Fenta, 2014), minibus taxis and other forms of intermediate transport services –such as 'bajaj' auto-rickshaws in the peripheries– play a major role in the supply of transport services in many areas of the city [interview with a researcher]. Besides, congestion on the LRT is already very high and safety (theft) and health (lice) issues have arisen on board the trains, which are reflected in the preference of many passengers for paratransit over LRT [interview with an international institution; interview with a researcher].

3.3 Job providers

Local socio-political conditions are considered to have an influence on the development of transport services (Rizzo, 2015). In the type of cities considered here, employment is a major concern and paratransit, being highly labour-intensive, is a valuable source of income to tens of thousands of people locally. Depending on the context, it provides jobs to '*drop-outs*' but also graduates (cf. the minibus-taxi industry in Nairobi) [interview with an operator], to township residents as well as immigrants (cf. respectively the minibus-taxi industry and the TNC industry in Cape Town) [interview with a researcher], and thereby contributes to alleviating poverty and empowering low-income populations. The opportunity to '*run their own business*' is even the main argument made by Uber in Cape Town and Nairobi to recruit '*driver partners*' [interview with an operator].

Contrasting with the common description of a demand-driven, flexible model, some experts would go as far as describing intermediate transport as a '*supply model*', where '*the basis of the business is employment*' [interview with a consultant]. One particular aspect of this model is the 'target system' –still in use in Cape Town and Nairobi, like in many other contexts (for daladala minibuses in Dar-es-Salaam, see: Jerven and Johnston, 2015; for rickshaw runners in Calcutta, see: Breman, 2003)–, whereby a fixed income amount (target) has to be paid to the owner by the crew daily. Increasing competition for expansion leading to increasing misbehaviour on competitive routes, minimal standards of safety and quality of service have been difficult to uphold. In its shift to integrate paratransit to the BRT system, the City of Cape Town, with support from the University of Cape Town, has organised training sessions for managerial capacity building with minibus-taxi operators, helping them create a reliable service for non-scheduled operations (Schalekamp, 2015). In Nairobi, while there is high compliance with regulations concerning registration, routes, and payments for use of terminals, the matatu industry shows low compliance with regulations related to labour and is reluctant to abandon the 'target system'. The National Transport and Safety Authority plans surprise inspections to control drivers and improve road safety, and offers some support for mechanical training, but no management training yet [interview with a researcher x2].

Major issues are yet to be dealt with for paratransit to remain a key component in future, more sustainable urban mobility systems, including, but not limited to, reckless driver behaviour, poor vehicle maintenance practices, poor management capabilities (Behrens *et al.*, 2016; Pirie, 2014). The following section discusses the role that ICT-based innovations may play in supporting the modernisation, upgrade and expansion of paratransit services in fast-evolving urban mobility systems.

4 ICT-based innovations

ICTs are now widely acknowledged to be major contributors to the ongoing changes in mobility systems and to offer significant opportunities for further improvement in the overall performance of said systems (TRB Committee for Review of Innovative Urban Mobility Services, 2015). Due to the rapid diffusion of mobile ICTs in the developing world, it has also become a common topic of research over the last decade to explore whether these technologies could '*bridge and connect what is conceptualised as 'North' and 'South'*' (Pfaff, 2010).

From the demand-side perspective, ICTs can help individuals make more informed choices, access a greater number of mobility options, be more flexible in their choices of options, have greater trust in the reliability of services, become actors of the supply and quality of service of mobility services, etc. From the supply-side perspective, ICTs can trigger the development of new services, improve the performance of existing services and facilitate the integration among services and modes. Finally, from the regulatory-side perspective, ICTs pose many challenges to regulators by way of the development of new mobility services half-way between public and private (e.g. in terms of infrastructure planning and appraisal, or in terms of right of access to road and parking infrastructure), the rise of a largely informal sharing economy (e.g. in terms of safety regulation, or in terms of tax policy), and the development of unprecedented massive data bases (e.g. in terms of privacy protection, intellectual property and data ownership, dynamic traffic regulation, real-time transport planning).

It can be argued that innovation-readiness is another main asset of paratransit's, besides flexibility and labour-intensiveness, in the context of cities in the developing world. This section analyses a wide set of ICT-based initiatives in the paratransit industry in the three cities examined here, to illustrate the role of ICTs in the modernisation, upgrade and possible expansion of the industry.

4.1 Mapping networks and tracking operations with ICTs

Because most paratransit services have remained informal for a long time (they sometimes still are) and because they do not operate along precisely-fixed routes or schedules, information about the service provided in a given city by the industry as a whole has long remained impossible to consolidate (e.g. in the form of network maps, or planning tools for multi-legged journeys). Paratransit users would then have to rely on their own expertise or on the expertise of relatives to plan multi-legged journeys. Under such circumstances, it is probable that even public authorities would base regulations on partial data complemented by experience and hearsay.

Most famous of all the paratransit mapping projects, Digital Matatus, an initiative led by a team at MIT, University of Nairobi, Columbia University, and the consulting firm Groupshot, achieved in 2014 the first consolidated visualisation of over a hundred matatu routes serving the city of Nairobi. This project demonstrated the possibility to use cell phones to develop an open source database on non-traditional transit in an adapted version of GTFS (General Transit Feed Specifications) format. The expectation was that, based on the data collected, new technology and services, e.g. transit routing apps, could in turn develop. The collection method involved the creation of a community of users in the field (mostly students), which was also an important result of the project (Williams *et al*., 2015).

Around the same time the Digital Matatus project was launched, the private company TaxiMap was created in 2013 and started mapping minibus-taxi routes in Cape Town and Durban (more than 600 routes on the website for the two cities). An app was used for data collection, but no crowdsourcing was involved (the founders rode the taxis themselves). The website provides user-oriented information on operating hours, fares, variability of routes (during peak / off-peak hours), exact origin and destination locations (including street view pictures), etc. Update of the information is a challenge, but operations are quite steady over time and user feedback can be used in the process [interview with a start-up].

Following in the footsteps of Digital Matatus, the Cape Town-based company WhereIsMyTransport shifted its business model from developing ICT-based apps (e.g. routing app FindMyWay) to developing an open, integrated platform for transport data (including transit and paratransit) that would serve as a common tool (in the form of an Application Programming Interface) for various stakeholders. The consolidation of data collected from transit operators and from a dedicated collector team (for minibus taxis) enabled the first visualisation of 137 minibus-taxi routes alongside rail and bus networks in Cape Town in early 2017. For minibus taxis, data was proactively collected and later formatted on end-to-end routes, fares and frequencies for weekends, and for peak and off-peak hours on weekdays. Information on route deviation during off-peak hours, as well as common places to get on/off (beyond the rare designated stops), was also collected [interview with a start-up].

Another Cape Town-based start-up, GoMetro, is developing a 'Flexible Mobility Platform', that allows mapping of various kinds of transport services, but is more oriented towards tracking and optimising operations. Data is collected from minibus taxis' clipboard counts and through full-day on-board surveys (using a dedicated app), focusing on boarding / alighting locations, real-time revenue, seat turnover, etc. Data is cleaned and analysed by the platform and can be delivered to the client in different formats [interview with a start-up].

4.2 The ride-hailing revolution brought by ICTs

E-hailing platforms have been developing in Africa over the last few years. As of mid-2017, Uber was present in 16 cities, including 13 in Sub-Saharan Africa (Cape Town, Durban, Johannesburg, Pretoria and Port Elizabeth in South Africa; Nairobi and Mombasa in Kenya). After working for 2 years with the authorities at national level to adapt the metered-taxi regulations to e-hailing operations (no requirement of link to an association, no stipulation of the place of origin), Uber started operating in Cape Town in 2015. Uber 'driver partners' in South Africa must have a Professional Driving Permit (PDP), pass a driving evaluation (specifically in Cape Town and Johannesburg), and vehicle documentation must include an operator's permit from the Department of Transport. Yet, in a little over 2 years, Uber had about 7,800 drivers registered on the platform in South Africa. Uber brought much change to the traditional metered-taxi industry in Cape Town, offering a cheaper service, together with upfront information on the fare to be paid, cashless payment and driver rating [interview with an operator].

The same kind of development took place in Kenya, where Uber vehicles must be registered as Public Service Vehicles (PSVs), vehicle documentation must include a business permit, and drivers must hold a PSV driving license. Uber started operating in Nairobi in 2015 (Mombasa in 2016) and two years later had about 4,000 drivers registered on the platform. Smartphone access being a very low barrier to entry in Kenya, Uber chose not to introduce the USSD feature that exists in other developing countries. On the other hand, Nairobi was one of the first pilot cities around the world for Uber to test cash payment, when Uber realised that only allowing credit card payment prevented growth. Mobile payment to the driver (via m-pesa) is feasible, but there is no m-pesa plug-in into the app. Direct payment to the drivers (via cash or m-pesa) make up the vast majority (80%-90%) of transactions, which raises some new challenges for Uber to collect its service fee. Minimum fare as of mid-2017 was 200 KES (1.7 EUR), and 1 in 4 or 5 trips on average were minimum fare. Uber's main competitors locally, beyond the 1,000 metered taxis, is the Kenyan e-hailing platform LittleCab which launched in 2016, and had 5,000 drivers registered as of mid-2017, a mobile payment option (m-pesa is a shareholder) and a portfolio of vehicle options including moto-taxis. Other competitors have developed locally (Taxi5, MondoRide), all displaying only small variations from the Uber app [interview with an operator].

The reasons why Uber does not operate in Addis Ababa are twofold: *i)* the ICT context is still inadequate (low smartphone penetration, low bandwidth, and more recently mobile Internet shutdown under the 'state of emergency'); *ii)* national laws do not allow international payments (thereby preventing the automatic payment of the 25% service fee to Uber BV in the Netherlands, as is the platform's model) [interview with an operator]. Yet, two local e-hailing platforms have launched in the Ethiopian capital: ZayRide (500 drivers by mid-2017) and ETTA (close to 100 drivers by mid-2017). One of the challenges, beyond limited Internet access (implying adapted content, e.g. low-resolution pictures), is to find alternatives to credit card payment (low penetration and high cost of swiping devices) and USSD payment (high cost of USSD codes and basic telecommunications due to the monopolistic situation). ETTA has developed a partnership with Wegagen Bank for a prepaid card (the first one specifically made for e-hailing). Another challenge is to seal partnerships with the 'right' taxis or taxi associations, possibly taking advantage of the ongoing renewal of the taxi fleet in the capital. Both companies had to set up conventional call centres after the Internet access was shut down under the 'state of emergency', and as of mid-2017 were hoping to negotiate the reopening of their apps [interview with an operator x2].

4.3 Providing real-time information to users with ICTs

With safety and reliability (including time reliability) being two of the major issues facing the users of paratransit services, the provision of real-time information through ICT innovations offers promising prospects to improve the perceived quality of service. To reach the greatest possible number of users, such innovations face the challenge of choosing the adequate support for disseminating the information. The Nairobi-based start-up Ma3Route is a spin-off of the Digital Matatus project. They run a crowd-based community that uses very simple phones and performs a real-time information service for matatu users, reporting on traffic conditions and accidents in three different languages through something close to a Twitter feed (using a light-data app). A partnership with NTSA and the Nairobi City Council allows for real-time reporting on bad driving behaviour from matatus as users send the information to Ma3Route [interview with a start-up].

As illustrated by various real-time information initiatives using USSD (e.g. transit traffic information in Cape Town by WhereIsMyTransport), or by the rise of prepaid cards (e.g. for electricity, water, in many cities), low-cost ICT solutions offer major perspectives for improving the perceived quality of service among paratransit users in cities where the cost of smartphones or the cost of data is still sensitive [interview with a start-up].

5 Discussion and conclusion

Surely enough, ICT-based modernisation of paratransit services in the cities examined here has its challenges, as illustrated by the decision of ride-hailing start-ups ZayRide and ETTA in Addis-Ababa to set up conventional call centres after the Internet shutdown under the 'state of emergency' [interview with an operator x2], or by the decision of Uber to introduce cash payment in Nairobi (despite the widespread use of m-pesa mobile payment) [interview with an operator], or yet by the postponed implementation of the cashless fare collection requirement for minibus-taxi licenses in Cape Town (Behrens *et al.*, 2017). The adaptation of ICT-based solutions for mobility to local contexts –taking into account the penetration of mobile Internet, the types of mobile used, the quality of Internet access, the cost of voice, text and data communications, etc.–, is a crucial challenge for their development and massive adoption in cities of developing economies. Yet, the portfolio of innovations is so diverse, and the potential for performance improvement in paratransit so great (both from an operator perspective and from a user perspective), that it seems a fair assumption that ICT-based innovations will contribute to the modernisation, upgrade and expansion of paratransit services. Which forms of paratransit services will most benefit, what type of customers the upgraded services will serve, and what kind of economic, social and environmental benefits will be derived from such developments, are questions yet to be answered.

From a social perspective, under certain conditions of design, ICT-based innovations can foster the empowerment of both, users –through increased participation in the production of the service, including its safety and reliability features– and drivers –through increased productivity (and revenues) allowed by the facilitation of customer access and navigation (Eskenazi and Boutueil, 2016). Again depending on design options, ICT-based innovations can even enable the creation of communities around particular services. Some consideration should however be given by policy makers to the type of labour organisation (i.e. employment model, wage structure, contractual relations, etc.) that the ICT-based solutions will help promote. Additional concerns have been voiced that ICT-based mobility solutions in the form of TNC services would mostly serve in developing countries the needs of a growing middle and upper-class market (Schechtner and Hanson, 2017).

From an environmental perspective, the benefits to be expected from a consolidation or an expansion of paratransit services, will depend on both, the types of services concerned and the operational options taken by said services. Efficient paratransit services in cities of developing countries could help contain the rise in private car ownership and use (with a modal share currently ranging from 10% to 30%, as compared with 80% in cities of developed countries). On the other hand, uncontrolled development of some paratransit services could prove detrimental to more traditional transit modes (bus, light rail or metro) if they ended up competing for the same market and the same urban space without an adequate framework to effectively account for the respective merits and externalities of all modes. Besides, the renewal of paratransit service fleets (mostly second-hand, imported vehicles, some even at end-of-life) has a part to play in the overall sustainability performance of the industry. It is worth noting that vehicle-scrapping policies in several countries or cities in the developing world have targeted taxi and collective taxi fleets (e.g. in Morocco, Cairo, Egypt or Dakar, Senegal). In this direction, international lenders would seem positively inclined towards dealing with paratransit services.

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