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To What Extent Can E-Ticketing Foster Multimodal Integration Of Transport Systems? – A Maputo Case Study

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ABSTRACT

Based on the implementation of a new e-ticketing system on public buses in Maputo, Mozambique's capital city, this research explores the extent to which electronic ticketing can foster the integration of multiple modes in a transport system. In particular, the characteristics of transport systems in the Global South and Sub-Saharan Africa are examined, to strengthen the understanding of the role that e-ticketing can play in integrating paratransit into Maputo's public transport system. As in many other cities in developing countries, an accelerated urbanization has led to a severe increase of urban sprawl and demand for travel in Maputo, which cannot be satisfied by the public transport system. This resulting gap has mostly been filled by means of paratransit and informal transport. Thus, integrating paratransit into a functioning multimodal transport system to achieve equity and safe and affordable access to sustainable transport for the entire population constitutes a desirable objective. This study builds on a critical literature review and five semi-structured interviews with experts on multimodality, e-ticketing and Maputo's transport system. It discovers that e-ticketing can be a powerful tool to facilitate the integration of paratransit. However, whilst digital ticketing can allow a more reliable cooperation between different operators and stakeholders, informal structures and highly fragmented interest groups within the paratransit sector pose significant challenges for its integration. Furthermore, the change of established habits and an increased transparency of the stream of money induced by the introduction of digital payment instead of cash will provoke resistance from affected parties, that see themselves disadvantaged because of the change. Therefore, a successful inclusion of paratransit into Maputo's e-ticketing system should be accompanied with a wider set of strategic policy measures, the consolidation of the semi-formal transport sector, extensive educational work and a constructive dialogue between all stakeholders. Finally, it appears to be worth studying how this sector can be consolidated and if the data from the existing e-ticketing system on public buses can contribute to boost acceptance and usage of a digital payment system in Maputo.

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ABBREVIATIONS

AFC	Automatic Fare Collection
AMT	Agency for Metropolitan Transport
BRT	Bus Rapid Transit
CBD	Central Business District
EMV	Europay, Mastercard and Visa
GDP	Gross Domestic Product
NGO	Non-Governmental Organization
OMT	Observatory of Mobility and Transport of Mozambique
PPP	Public-private Partnership
TPM	Transportes Publicos de Maputo
T-SUM	Transitions to Sustainable Urban Mobility

A. INTRODUCTION

Developing countries all over the world have seen their urban areas expand at ever growing rates (Cavoli, 2021). Especially low-income countries across the Global South have demonstrated this acceleration (UN-HABITAT, 2010; United Nations, 2018). Such rapid urbanization often comes with increased urban sprawl and motorization, leading to a higher demand for travel and often a shift from sustainable, collective modes of transport to private vehicles (Cervero, 2014). It is important to take meaningful actions, such as higher density living or prioritizing and improving public transport systems, to prevent this trend and improve the sustainability and liveability of existing and new urban developments (Kenworthy, 2006). Changing from a car-oriented trajectory to a focus on people and places by promoting public transport and active travel can have a significant impact on successfully tackling common climate and urbanisation issues and lays the foundation for an economically, environmentally and socially sustainable city (Cervero, 2014; Arimah, 2017).

For many cities in the sub-Saharan Africa region, controlling the fast growth and altering the urban mobility trajectory, while dealing with inequality, poverty, limited resources and corruption issues, has proven to be a major challenge (Massingue & Oviedo, 2021). Often, that has resulted in a decline of the public transport systems (Sietchiping, Permezel & Ngomsi, 2012). This has frequently led to a lack of reliability, coordination and overall service provision of the state public transport system (Gumbo & Moyo, 2020) and caused an increase in motorized and private trips in African cities (Cervero, 2014). Therefore, the gap, caused by insufficient public transport provision, has mostly been filled by informal means of transport (Cervero & Golub, 2007). The importance of public transport for the total volume of trips has decreased to the point where it accounts for less than five percent in most sub-Saharan cities (Cervero, 2014). Subsequently, such dependency on private and informal transport has triggered an amplification of social exclusion, as those without access to individual or private transport – often the poor, older and young people or disabled persons – cannot fulfil their mobility needs and access certain opportunities (Sietchiping et al., 2012; Cervero, 2014).

In Maputo, the capital of the south-east African country Mozambique, a majority of the population is required to take on unsafe and long commutes in order to participate in a social life and access jobs, school or healthcare (Massingue & Oviedo, 2021). The most frequented means of transport are semi-formal minibuses called ‘Chapas’, followed by informal and unregulated trucks known as “MyLoves” (Massingue & Oviedo, 2021). Hence, to target the goal of equity as well as safe and affordable access to sustainable transport for the entire population, integrating the semi-formal minibuses into a multimodal system should be a top priority for city planners in Maputo. Particularly, because Chapas are the dominant and most important form of transport in the city (Klopp & Cavoli, 2019). Therefore, data on the Chapas should be gathered and made available to the public transport authorities to foster collaboration and understanding of the minibus system and improve the integration of the transport system as a whole (Klopp & Cavoli, 2019).

Principally, the introduction of an electronic ticketing system is considered to be a useful tool to facilitate the data collection and thus improve the service quality of a transport service (Mezghani, 2008). Moreover, it provides the possibility of integrating the fare payment of multiple transport modes into one shared system, which is a key characteristics of integrated transport systems (Chowdhury & Ceder, 2016). In Maputo, public authorities have introduced an electronic ticketing system in 2020 in collaboration with a private operator, that replaced all cash payments from public buses. However, as the public bus system only plays a minor part in the entire transport network, the total usage has been relatively low so far (T-SUM, 2021; Arroyo-Arroyo et al., 2021).

This research paper attempts to answer the question, to what extent an electronic ticketing system can foster the integration of multiple modes in a transport system and whether e-ticketing can be a viable tool to facilitate this integration for semi-formal transport in Maputo's public transport system. Firstly, existing literature on e-ticketing systems, multimodal integration and the characteristics of transport systems in the global south and Maputo was reviewed. Secondly, the methods for the data collection and the qualitative analysis are explained. Next, the results of the five semi-structured interviews with experts in the fields of paratransit, e-ticketing and Maputo's transport system are presented. Subsequently, the analysis of the interviews in combination with the theoretic research perspective were discussed to help shed a light on urban transport systems in the global south, and particularly Maputo, and how multiple transport modes, including the paratransit sector, can be integrated in the transport network with the help of electronic ticketing.

B. LITERATURE REVIEW

1. Integrated Multimodal Transport Systems

Public transport usually refers to services that are accessible to all people without excluding or restricting any individual from accessing the service (Chalumuri, Nath & Errampalli, 2018). In most transport networks, there are several modes available to the users, resulting in mode choices and the planning and coordination of the different available modes and interchanges. Within one transport system, that is called multimodality (Mezghani, 2008). For such a system to have a high perceived value for the passengers, the transition between modes and services has to be coordinated to be as seamless as possible (Merkert, Bushell & Beck, 2020). When different transport pillars such as travel information and timetables and ticketing for the various transport modes are combined in one offering, it is an integrated transport system (Mezghani, 2008). However, several forms of integration should be differentiated. These are physical integration of interchanges and stops where various means of transport meet, strategic integration of policy vehicles such as land-use and integration of government bodies and transport authorities. Common objectives should initially be agreed to model an integration of public transport systems that aims to serve these shared targets instead of integration being the sole purpose itself (May, Kelly & Shepherd, 2006).

Generally, there are many factors that can impact the decision form of transport to use, such as trip purpose, time and regularity. Moreover, demographic characteristics like age, gender and income level were proven to be influential as well (Ye, Pendyala & Gottardi, 2007). On top of that, network specific attributes like the quality of service, connectivity or the lack thereof, travel cost, distance from stations and between home and work are considered (Galdames, Tudela & Carrasco, 2011). Public transport can only really prove to be a viable or even superior alternative to private mobility means, when a performant integrated multimodal system is in place (Maxwell, 1999; Vassallo, Di Ciommo & García, 2012). The goal of integrated transport systems is to provide a maximum array of travel choices that are conveniently, safely and affordably accessible (Luk & Olszewski, 2003; Ülengin et al., 2007).

Therefore, seamless and synchronized transfers naturally play a key role (Ceder, 2016), as one of the huge advantages of private travel is the reduction or elimination of transfers, which are proven to negatively impact trip choices and convenience (Guo & Wilson, 2004). Nevertheless, transfers are a necessity for a resilient transport system, as it decreases route duplication and increases operational efficiency (Ibrahim, 2003). Thus, transfers should be modelled as intuitive and smooth as possible to be a beneficial cornerstone of integrated transport systems (Navarrete & de Dios Ortúzar, 2013; Chowdhury & Ceder, 2016). This can be achieved through better coordination of the transport operators and the creation of a homogenous eco-system with clear and agreed responsibilities (Merkert, Bushell & Beck, 2020).

Most of the research on this topic has focused on the operational side, with behavioural and policy measures to increase ridership on routes with transfers being rather underrepresented. So far, reliability and transfer duration have drawn significantly more research interest than fares and ticketing in integrated transport systems (Chowdhury & Ceder, 2016).

2. E-Ticketing in Transport Systems

2.1. Smart Cards and Automatic Fare Collection

(Chowdhury & Ceder, 2016) have identified the integration of fares and ticketing as one of five main categories of integrated transport systems, along with network integration, information integration, physical integration of stations and integrated timed transfers. A key role of smart ticketing is to standardise the contracting and allow cheaper and more reliable cooperation of different operators and stakeholders through technological mechanisms (Merkert, Bushell & Beck, 2020). Fundamentally, the purpose of ticketing is to apply the tariff and fare system to concrete means of payment and fare collection (Mezghani, 2008). Therefore, electronic ticketing (e-ticketing) indicates the automatic fare collection (AFC) based on information and communication technologies and replaces the conventional paper ticket with a digital version (Mezghani, 2008). It presents a more efficient and reliable method of ticket provision and processing for operators and users alike with a wide range of advantages (S. Kazi et al., 2018). In integrated networks, smart ticketing describes the combination of different operators and modes into one system and making it accessible to the transport user, while allowing them to be unaware of the tariff structure and still participate in the transport network (Puhe, 2014). The purchasing and storage of a ticket via electronic devices such as smart cards or mobile phones constitutes smart ticketing (Puhe, 2014). It simplifies the provision of multimodal and multi-operator tickets, making it not only suitable for well-integrated transport systems, but also for cities and regions with a lesser degree of mode and service integration (Mezghani, 2008).

E-ticketing can generate and collect a variety of different individual data (Pelletier, Trépanier & Morency, 2011) which has the potential to improve the transport services significantly (Arnone et al., 2016; Arroyo-Arroyo et al., 2021). Further, it can provide a secure way of user validation and fare payment that enhances data quality and allows flexible and innovative fare structuring (Dempsey, 2008). In comparison to more traditional forms of payment like cash, and magnetic cards, smart cards are more convenient, durable and allow faster, contactless processing (P. Blythe, 1998; Smart Card Alliance, 2010). They also offer flexibility and interoperability, as fares can be reprogrammed and services can be added almost instantly, making them a valuable enabler for integrated transport systems (Pelletier, Trépanier & Morency, 2011).

For Authorities	For Operators	For Passengers
▪ Creation of seamless journeys in PT networks ▪ Unification of ticketing ▪ Source of new marketing data ▪ Better control of revenues & subsidies ▪ Extend the scheme to other players (eg. taxis) ▪ Projects with political connection value ▪ Improve PT image ▪ Reduce cost of selling tickets	▪ Gain new customers with modern approach ▪ Increase medium term operating profit and reduce fraud ▪ Reduce the use of cash ▪ Reduce cost of selling tickets ▪ Reduce maintenance costs ▪ Improving cash flow ▪ Increase speed at boarding (buses) ▪ Valuable opportunities to add "new services" ▪ Source of marketing data for PT management	▪ Convenience & speed, no cash ▪ Seamless journeys in multimodal, multi PT schemes ▪ Easier ways to reload value or renew passes ▪ New card when it has been lost or stolen ▪ Additional appreciated services when available

Figure 1: Advantages of e-ticketing over traditional payment methods
Taken from: (Mezghani, 2008)

In contrast to the advantages listed in figure 1 and mentioned above, smart cards and e-ticketing tend to have a slow social acceptance rate and usually require a large capital investment for the equipment on the vehicles and at the stations, as well as for the IT system, infrastructure and staff (Pelletier, Trépanier & Morency, 2011). Additionally, with increased complexity of the infrastructure, the reliability of the system will decrease, making it desirable to keep the intricacy low (Blythe, 2004). On top of that, privacy concerns and data protection can be an issue and require more attention compared to conventional ticketing systems (Pelletier, Trépanier & Morency, 2011). In general, the distribution of responsibilities and risks plays an integral role in the operation of any automated fare collection venture.

With evolving technology, mobile payments are taking over an increasingly big share of total transactions in high income countries and are often substitutes for card-based payment systems (Arroyo-Arroyo et al., 2021). These systems can operate on a QR-Code basis, allowing for a cheap infrastructure where the user only has to ensure a cellular connection. Additionally, more comprehensive functions like direct communication with the customer can be included (Mantelero, 2015). In Africa, card-based systems are the most frequently used payment technology in transit systems, as not everyone has access to suitable phones is comfortable using it as a way of payment. Furthermore, projects featuring a back-office-centric system must yet prove themselves to be successful in African cities (Arroyo-Arroyo et al., 2021).

2.2. The Role of E-Ticketing in Integrated Transport Systems

The core idea of integrated ticketing is to unite several transport operators and providers and their products and services on one medium to achieve a higher convenience for the customer and greater efficiency of the network (Kos-Łabędowicz, 2014; Puhe, 2014). Which business model is best suited for a city depends on the organisation of public transport in the area with factors like multimodality, number of operators and their importance playing a role. Usually, there is a variety of stakeholders like public authorities, transport providers, system suppliers, banks and other intermediaries, and passengers involved in the planning and operation of an e-ticketing system (Mezghani, 2008; Puhe, 2014). Due to a large number of involved parties and interests, clear objectives and a realistic assessment of costs and advantages are crucial in establishing a working integrated e-ticketing system (Arnone et al., 2016).

Fundamentally, a fully integrated e-ticketing system should not charge additional costs for transfers and all modes and services should be accessible via the same interface (Sharaby & Shiftan, 2012). This interface also be used to include private modes into the public offering more effectively, hence, increase the interoperability and service level of the network (Merkert, Bushell & Beck, 2020). This added service level has the potential to boost the usage of public transport and offer new possibilities for standardization and collaboration of transport providers and markets, which could prove beneficial to all stakeholders. (Mason, Friesl & Ford, 2017). Moreover, a standardized e-ticketing system delivers valuable data on passenger behaviour, that can be used by planners and researchers to improve the performance of the transit system in place (Pelletier, Trépanier & Morency, 2011). If the information about the travelers allows an optimization of the transport system, the service and the bankability of the system, this data generation can be considered one of the most valuable benefits of an e-ticketing system (P. T. Blythe, 2004; Arnone et al., 2016; Arroyo-Arroyo et al., 2021).

3. Transport Systems in the Global South

3.1. Challenges of Transport Systems in the Global South

In regions where the formal public transport system is often limited, unreliable, hard to access or expensive, the more flexible, private and semi-formal or unregulated offerings have burgeoned (Schalekamp & Behrens, 2009). They form a semi-formal transport sector that does not operate on determined routes or follows fixed schedules (Schalekamp & Behrens, 2009; Schalekamp & Behrens, 2010). These forms of transport, characterized by personalized transportation and not complying to routes or timetables, can be summarized as paratransit (Schalekamp & Behrens, 2009; Klopp & Cavoli, 2019). They play a vital role for the passenger transport, especially where formal public transport services remain limited, like in many developing countries. In a positive case, they are demand-responsive supplements to the formal offering, in other instances, they act as rigorous competitors on similar routes and their unregulated services can have negative impacts on the public transport systems (Schalekamp & Behrens, 2009; Alcorn & Karner, 2020).

In many urban areas in the global south, the proportion of trips in paratransit has steadily increased in comparison to the formal modes of transport over the last decades (Schalekamp, 2017). Paratransit is a substantial part of the passenger transport landscape in the global south, and it would make sense to integrate it into the existing public transport networks. However, there are many cases that demonstrate that this is a lengthy and difficult endeavour. One of the main obstacles is the fragmentation in the organization and ownership of the paratransit sector (Wilkinson, 2008). Usually, it would require a formalization prior to the integration into the network. However, paratransit operators are often reluctant to give up their autonomy due to a fear of deteriorating their financial position (Schalekamp, 2013). In case of a failure of the formalization, leaving their previous situation and independence behind could mean losing their jobs and livelihood (Salazar Ferro, Behrens & Wilkinson, 2013).

Policy makers and transport authorities in the global south need to recognize semi-formal transit as an essential component of the public transport system. A healthier relationship between the different shades of formalization in transport should be promoted. Providing the best possible hybrid public transport system that serves its users should be have priority for the public authorities (Salazar Ferro, Behrens & Wilkinson, 2013). The aim of combining the structural benefits of both the structured formal and the demand-responsive informal sector can lead to the best possible individual transit provision (Alcorn & Karner, 2020). Therefore, operator associations in the semi-formal sector would present a common base for interaction and communication with the authorities. Additionally, these associations could serve as partner in the attempt of integrating paratransit into formal ticketing systems. However, this would require in-depth engagement of all informal stakeholders as well as the general public (Alcorn & Karner, 2020). Thus, a complete overhaul of the informal transport sector to achieve an integrated transport system in the short run appears to have little chances of success and acceptance. Instead, a hybrid system combining formal and informal transport to provide complementary services has significantly higher chances of delivering the best multimodal transport system possible in urban areas in the global south (Salazar Ferro, Behrens & Wilkinson, 2013).

3.2. E-Ticketing in Semi-Formal and Informal Transport

When trying to understand how e-ticketing can affect a whole transport system, the governance and accountability of different transport modes within the system should be defined. Formal transport describes institutions that adhere to legal standards whereas semi-formal and informal means of transport are less controlled or not bound to the law at all (Rye et al., 2018). Semi-formal transport systems are sometimes summarized under the term paratransit and they are characterized by fluently changing stops and adjustable schedules and routes (Klopp & Cavoli, 2017). In African cities, semi- and informal minibuses account most of the public transit load (Klopp & Cavoli, 2019; Massingue & Oviedo, 2021). As formal transport services cannot sufficiently satisfy the need for mobility and travel, offerings emerged

in the informal sector to accommodate the demand. These informal transport services can differ vastly in their form of ownership, service level, vehicle type and legal authorization (Finn, Kumarage & Gyamera, 2011). Thus, paratransit should be integrated into the broader transit strategy rather than replaced (Salazar Ferro, Behrens & Wilkinson, 2013). However, this integration can prove to be quite challenging due to the particularity of the power structure and the business models within the paratransit sector (Schalekamp, 2017; Arroyo-Arroyo et al., 2021). Usually, and especially in Sub-Saharan African cities, the paratransit sector is strongly fragmented and consists of a variety of individual players and small groups or alliances on many levels. The lack of hierarchical structures and little to no consolidation of the sector require a highly disaggregate communication between the stakeholders (Barrett, 2003; Schalekamp & Behrens, 2009).

In most cases, means of transport in the paratransit sector can be grouped into three categories: big buses owned by small companies or individuals, larger numbers of minibuses operated by associations or collectives and small vehicles owned and run by individual entrepreneurs (Finn, Kumarage & Gyamera, 2011; Schalekamp, 2013). A usual business practice involves the vehicle or fleet owners lending the vehicles to the drivers and conductors for a fixed daily fee (Finn, Kumarage & Gyamera, 2011). The drivers, effectively taking on the revenue risk, will then try to make as much money on a given day as possible with their service, which often leads to them selecting highly frequented routes. Routes will be selected to maximize the daily passenger load. Due to the cash-based fare payments, the owners have no knowledge or control over the daily revenue or passenger load (Schalekamp & Behrens, 2010). Changing the business model when introducing an electronic fare payment system would also shift the power structure within the entire sector. The revenues would become more transparent and visible for many stakeholders. It would also redirect the cash flow. Before, money flowed from the passenger to the driver to the owner, whereas in a digital system it would then be the vehicle owner paying the drivers and conductors. That would effectively disempower the crews. However, it could also allow pooling the fares to prevent the drivers goal of passenger maximization and in turn create incentives that target the collective efficiency, which would benefit the passengers (Barrett, 2003; Schalekamp & Behrens, 2010).

However, such a structural change would also require an extensive overhaul of the organizational structure within the paratransit sector, for instance, creating a need for formal labour relations with the drivers (Barrett, 2003). Generally, an e-ticketing system can prove to be an effective tool in the change of the business model of paratransit. However, switching from cash-based to digital payment alone, without embedding it in a broader set of structural changes, is unlikely to be successful, primarily because of the rejection from the drivers and conductors (Schalekamp, 2017; Arroyo-Arroyo et al., 2021). When it comes to the national government involvement, they should be providing resources but remain in a supporting role, because they often do not fully understand the complex structures of the local transport systems. Municipalities and transport authorities on the other hand are well positioned to steer the structural change of paratransit structures in the integration process. They could moderate the private and public interests, while having the best interests for the people and transport users at heart (Arroyo-Arroyo et al., 2021).

4. City Profile of Maputo

4.1. Urban Planning & Land-use

This paper aims to address the question, to what extent e-ticketing can facilitate the integration of a multimodal transport system. Particularly, it will examine whether it is a viable tool for the integration of formal transport and paratransit in the metropolitan area of Maputo. Therefore, the details and characteristics of Maputo and its existing transport system will be examined in the following chapter. Maputo is the capital of Mozambique, a country located on the southeast coast of the African continent. Mozambique, a country that consistently ranks among the world's poorest, exhibits an unemployment rate of around 25% prior to the Covid-19 pandemic, of which the young population is above average affected (Tvedten, Roque & Bertelsen, 2013; T-SUM, 2021). In contrast however, the unemployment rate in the greater Maputo area amounts to 45.2% (Tvedten, Roque & Bertelsen, 2013). In general, Mozambique's population is growing by 2.8% per year and 57% are under the age of 20. The share of the urban population is about one third, with a strongly increasing tendency (INE, 2015).

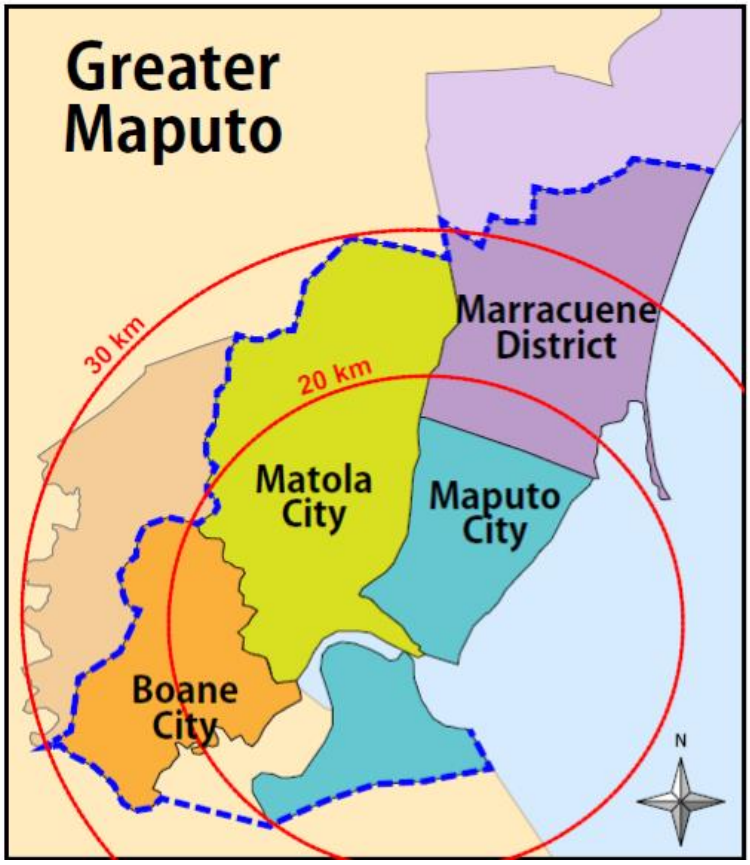

Figure 2: Map of the Greater Maputo Area
Taken from: (Japan International Cooperation Agency, 2014)

Maputo is the political and economic centre and it has experienced a growing territorial expansion in residential and industrial areas, seeing it increasingly merge with the adjacent cities of Matola, Boane and Marracuene (see figure 2) (Japan International Cooperation Agency, 2014). The developed area is very closely linked, which is why it is mostly referred to as Greater Maputo Metropolitan Area (Japan International Cooperation Agency, 2014). It counts around three million in population and is expected to continue growing to 3.7 million by 2035 (Japan International Cooperation Agency, 2014; Arroyo-Arroyo et al., 2021). It is responsible for over 20% of the national GDP (Arroyo-Arroyo et al., 2021). Administratively, the city of Maputo has an independent province status, same as the Maputo Province with its capital Matola City (T-SUM, 2021).

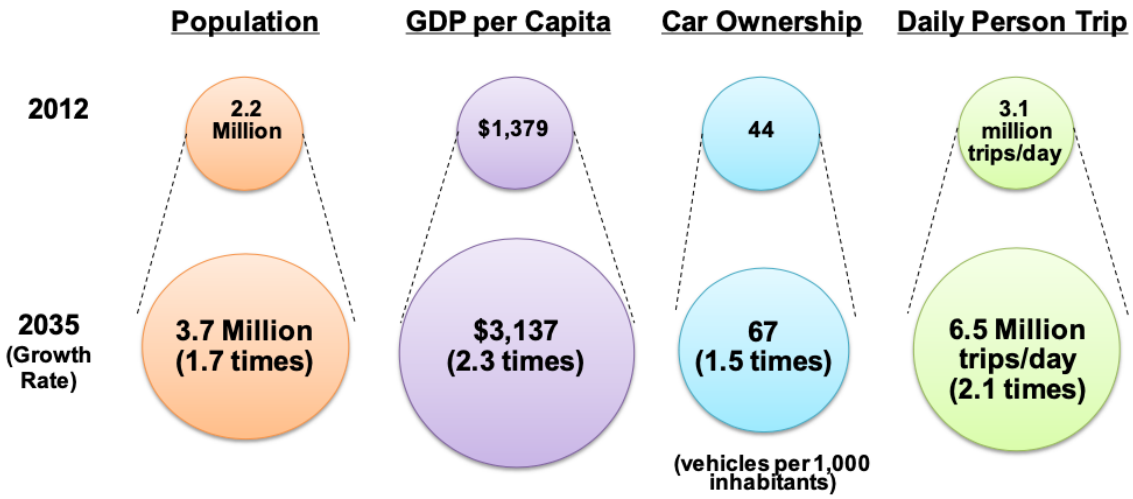

Figure 3: Projected Growth in Population, Economy and Travel Demand by 2035
Taken from: (Japan International Cooperation Agency, 2014)

Growing uncontrolled urbanization is a severe issue in Maputo which, due to insufficient urban planning, has resulted in poor land-use. Especially remote informal settlements suffer from social and spatial segregation due to poverty and a lack of adequate collective transport provision (Tvedten, Roque & Bertelsen, 2013**;** Jenkins & Mottelson, 2020). Most of the commercial activity and offices are concentrated in the CBD in southern Maputo City. The low degree of decentralization puts a lot of stress on the city centre and the main transport arteries connecting it to the rest of the metropolitan area (Andersen et al., 2013; Jenkins & Mottelson, 2020). However, as the high density of the CBD does not allow further expansion, development in the surrounding areas is expected to increase strongly in the near future. Maputos' issues caused by the prevailing land use and urban planning at large are directly cross-linked with the assignments for urban transport planning (Japan International Cooperation Agency, 2014).

4.2. Public Transport

The increased demand for passenger and freight transport has had a deteriorating effect on the traffic and road conditions in the greater Maputo area over the last decades (Japan International Cooperation Agency, 2014). While household car ownership levels are still relatively low with around 13% (Japan International Cooperation Agency, 2014), the rising travel demand has resulted in highly congested roads and a steep drop in the road-based public transport service level (Arroyo-Arroyo et al., 2021). On top of that, roads are only paved within the main municipal area, while those in more remote and informal settlements are often unserved by the formal and informal bus systems due to bad conditions. Therefore, flatbed trucks or pick-ups - called "MyLoves" - where people can loosely jump on and off the back of the vehicle, and motorcycle taxis are the only transport means that can adequately service these areas (Arroyo-Arroyo et al., 2021). Further problems in Maputo's road network are shown in figure 4 below.

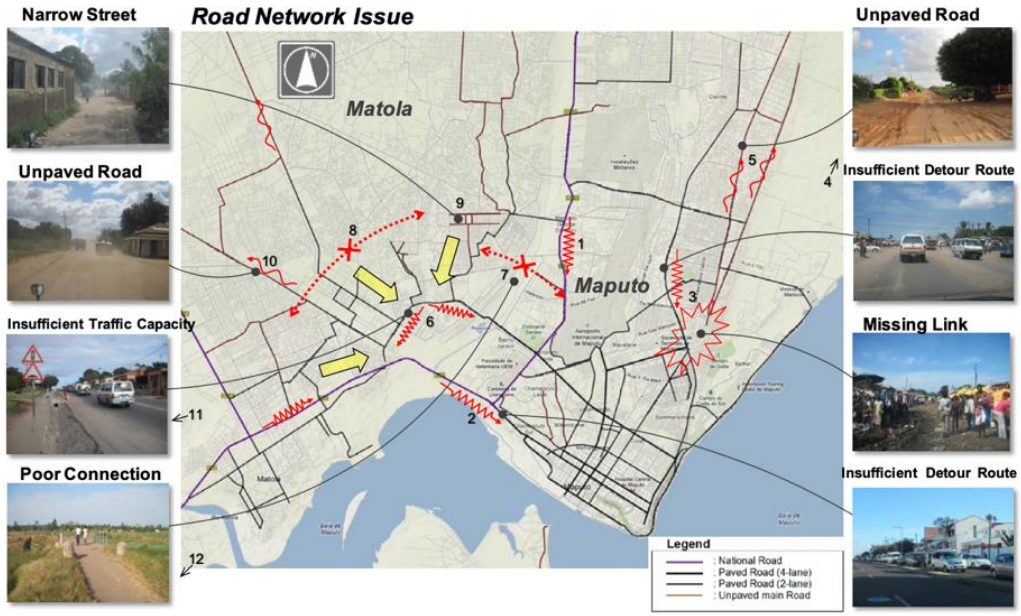

Figure 4: Maputo's Key Road Network Issues
Taken from: (Japan International Cooperation Agency, 2014)

Non-motorized travel is making up the biggest percentage of overall trips in Maputo with around 45%. Next, around a third of all trips are conducted by minibuses with 15 to 25 seats called "Chapas" – a form of paratransit that is only faintly regulated (Klopp & Cavoli, 2019; Arroyo-Arroyo et al., 2021). The last significant pillar of the public transport system are the public buses, which can carry up 80 passengers, and are responsible for 17% of all motorized trips (Nathan, 2006; Japan International Cooperation Agency, 2014).

As they execute around 75% of all motorized trips, the Chapas are clearly the dominating form of transport in Maputo (T-SUM, 2021). 2435 vehicles of the informal minibuses are registered, operating on around 130 routes across the Metropolitan area (Japan International Cooperation Agency, 2014; T-SUM, 2021). They are predominantly owned by private individuals, who

often only own one or a few vehicles, and rented out to crews of a driver and a conductor or money-collector for a daily fixed charge (Nathan, 2006). The crew carries the main economic risk, as they aim to make a profit from the fare charges while accounting for the costs of operation and some repairs. Due to their interest in maximizing their profit, Chapas typically operate along the main traffic arteries where the demand is highest and ignore remote areas with lower traffic volume (Japan International Cooperation Agency, 2014; Arroyo-Arroyo et al., 2021). Also, Chapas do not adhere to schedules. Instead, they wait at the main terminals for the buses to fill before departing (T-SUM, 2021). This practice regularly results in long queues of people waiting to board along the routes (Nathan, 2006). Furthermore, bad vehicle conditions and safety standards as well as lacking reliability and poor accessibility are among the main points of criticism of the Chapas system (Japan International Cooperation Agency, 2014; Arroyo-Arroyo et al., 2021; T-SUM, 2021).

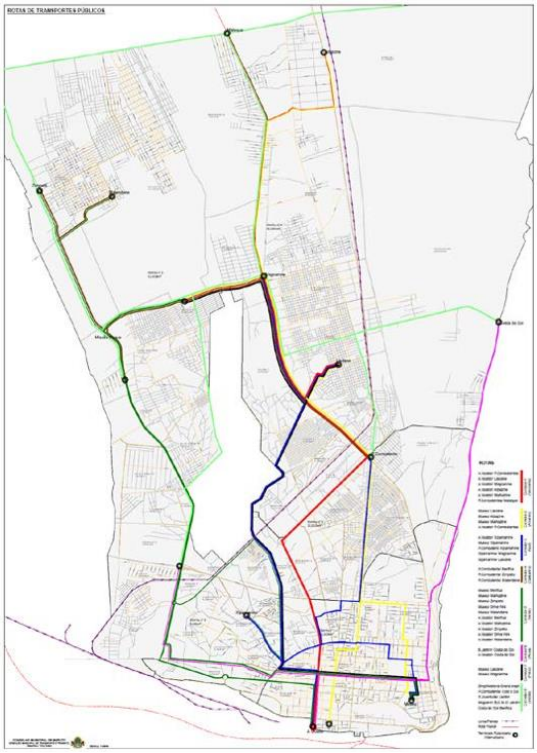

Figure 5: Main Chapa Routes and Terminals in Maputo
Taken from: (Japan International Cooperation Agency, 2014)

The public bus network is owned and operated by Transportes Publicos de Maputo (TPM). They account for around 17% of all motorized trips (T-SUM, 2021) and their fleet counts 400 full-sized buses with over 50 seats each. 50 of these belong to private individuals and are operated like Chapas, the other 350 run on defined schedules on 60 designated routes, most of which are identical to the Chapas routes (T-SUM, 2021). However, due to maintenance issues or being unserviceable, only 150 out of 400 buses are fit for service (Nathan, 2006; Japan International Cooperation Agency, 2014).

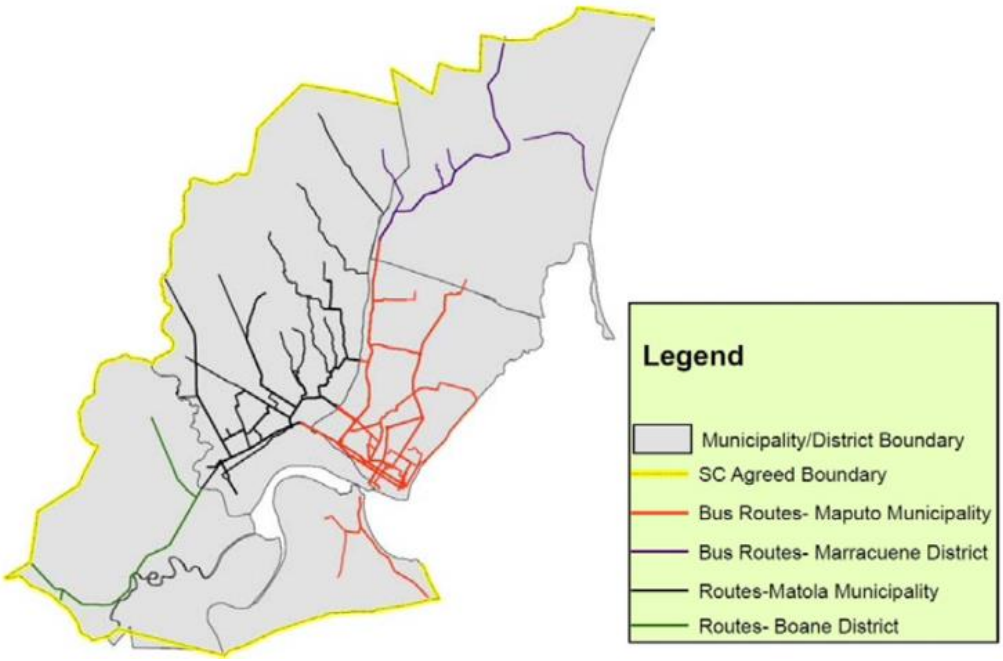

Figure 6: Maputo's Public Bus Routes
Taken from: (Japan International Cooperation Agency, 2014)

Recently, the Maputo city council decided to merge their public bus and rail services with a map of the Chapas routes to create an integrated and intermodal map of the city's public transport system (see figure 7). What can be interpreted as readiness to take ownership of a formalized map by the city council also constitutes an attempt to formalize the Chapas system, which is characterized by high demand responsiveness and flexible stops and routes (Klopp & Cavoli, 2019).

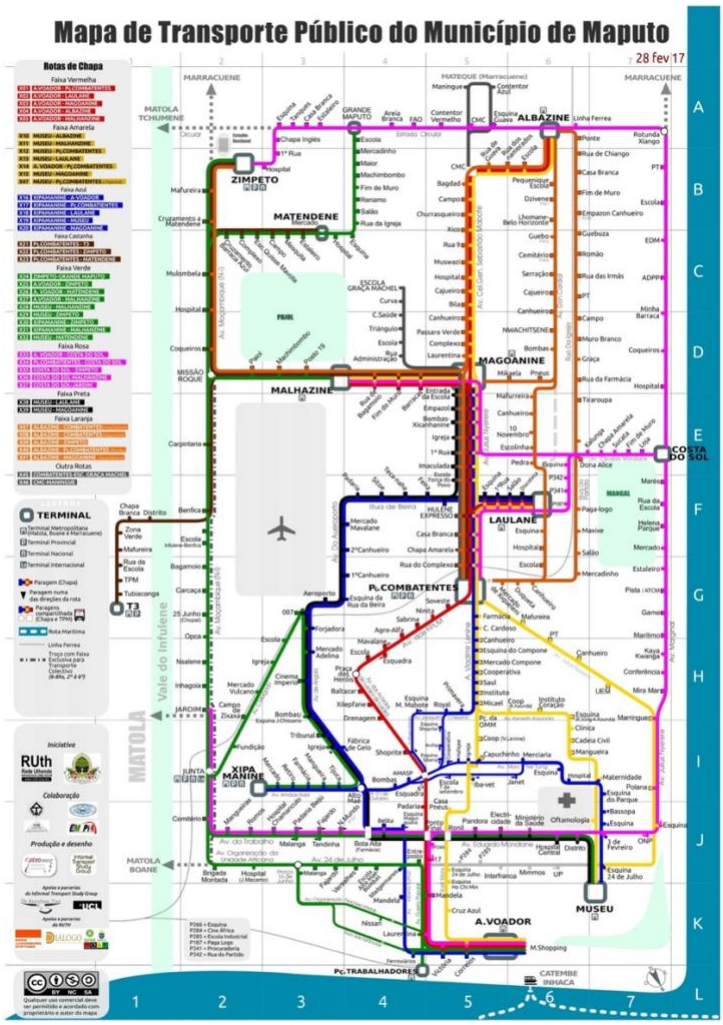

Figure 7: Maputo's map of public transport
Taken from: (Klopp & Cavoli, 2019)

4.3. The E-Ticketing System: Famba Card

Implemented over the second half of 2020 and beginning of 2021 by a Public-Private Partnership (PPP) including Maputo's Metropolitan Transport Agency (AMT), the new electronic ticketing system called 'Famba' was installed on all public buses (T-SUM, 2021; Arroyo-Arroyo et al., 2021). The Famba card is a smartcard system that has some information stored locally on the card to instantly grant or deny access if insufficient funds are available on the account. However, most of the account data being stored in a central back-office (Mezghani, 2008; Han, Van Dender & Perkins, 2012). Users must hold their smartcard close to the validator or reading devices installed in the vehicle when they get on and off. AMT currently has set up 52 stations across the metropolitan area to obtain and top up the Famba card by using cash, banking cards or mobile payment services. Once the electronic ticketing system is in operation in a vehicle, the conductor and driver were instructed not to accept any fare payments in cash (Arroyo-Arroyo et al., 2021). The PPP plans to expand their e-ticketing service in the future across other formal and paratransit modes in the Metropolitan area and

eventually Mozambique to create an integrated transport service, accessible with the same form of electronic payment (Arroyo-Arroyo et al., 2021). A further advantage of the system is that it could enable third party micropayments in the future. This would allow the user to pay, for example, for hospital or utility bills and receive government grants via their Famba account (Arroyo-Arroyo et al., 2021).

However, a substantial challenge of the Famba system is bringing the transport operators on board and establishing a relationship of trust. In addition, connectivity issues and detailed financial agreements must be resolved (Schalekamp, 2017; Arroyo-Arroyo et al., 2021). Particularly the attempt to run a fare system, that was effectively installed by public authorities, in informal transport environment will likely create friction and require extensive communication from all affected stakeholders (Arroyo-Arroyo et al., 2021).

C. METHODS AND DATA

1. Research Objectives

Maputo's transport system is highly fragmented and can be characterized by a multitude of institutions, authorities and individuals involved as well as a high importance of paratransit. The significance of the informal transport sector due to an insufficient formal public transport provision is a common theme for many sub-Saharan cities in Africa. Maputo's initiative to implement an e-ticketing service on public buses and the ambition of extending the service to incorporate multiple transport modes in the future vindicates the interest in exploring the potential effect of an e-ticketing system on multimodal integration into a transport system in a sub-Saharan city.

First, this paper outlines the methods used to highlight the key factors of e-ticketing systems and multimodal integration with respect to Maputo's transport system and explains the ethics considerations involved in the research as well as the procedure of the data collection. Second, it summarizes the main results of the Expert Interviews. Third, the new findings are critically discussed and compared to existing hypotheses and knowledge from literature and research. Lastly, it draws conclusions from the conducted study and states potential new findings, practice implications, shortcomings and further questions arising from the research.

2. Data Collection

2.1. Expert Interviews

To collect data on the aforementioned topics, five semi-structured interviews with experts in different fields of the transport spectrum were conducted. The participants' backgrounds ranged from independent transport consultants with experience in countries of the Global North as well as the Global South to experts on paratransit and a professional in a Sub-Saharan public transport and e-ticketing provider. The main objective in the expert selection was to cover the three main pillars of the research topic, i.e., 1) multimodal transport, 2) e-ticketing and 3) Maputo's transport system, as broadly and extensively as possible. The experts were selected according to their relevant work in one of the fields and proximity and familiarity with Maputo's transport system. Members of the T-SUM project, a partner in this research study, were advising and assisting in the selection process of the participants. For the purpose of this study and ethical considerations as well as data protection, the participating experts were pseudonymised and numbered from E1 (Expert 1) to E5 (Expert 5).

Table 1: Overview of the experts their fields of work

Expert	***E1***	***E2***	***E3***	***E4***	***E5***
Profession	Independent Transport Consultant	University Lecturer and Researcher	Independent Research Consultant	Researcher and Consultant	Executive for E-Ticketing Provider
Field of work	40+ years of experience in public transport, e-ticketing and emerging countries Close work on Famba-Card project	Lecturer in Maputo in Economy and Sociology Research interest in governance of transport systems, regulations, actors, power balance and passenger perception	Previously a University researcher on paratransit reform in Africa Consulting on paratransit and climate response in Africa	Consultant for AMT Involved in observatory of mobility and transport of Mozambique (OMT) Contributor to T-SUM project and project for transition of informal transport	Responsible for PPP working on e-ticketing provision for AMT in Maputo

2.2. Semi-Structured Interviews

Interviews were selected for this research purpose to gather expert knowledge and background information as well as subjective assessments and opinions of relevant experts (Harrell & Bradley, 2009; Kvale & Brinkmann, 2009). For this matter, the semi-structured approach to the interviews was selected, as it allowed the experts to answer freely and the researcher to ask follow-up questions while also a certain degree of control over the experts' answers by guiding the interview along fixed questions (Harrell & Bradley, 2009; Kvale & Brinkmann, 2009).

The topic guide (see Appendix 1) used for all interviews consisted of seven parts. The first three parts were administrative questions and explanations of the procedure. In part four, the experts were invited to talk about their relevant experience regarding the research topic. The parts 5 to 7 constituted the majority of the interview and dealt with questions on E-Ticketing, multimodal transport and particularities of these in the global south and Maputo respectively. The interviews were conducted via electronic meeting and communication tools, including Zoom and Microsoft Teams.

3. Data Analysis

As a qualitative study, the aim of the research was to test the data for diversity within the participants answers (Bryman & Teevan, 2007). In the first step, the recorded interviews were written out and transcribed. Next, relevant words, fragments of sentences or quotes were highlighted. In the subsequent step, these parts were labelled according to a potential overarching theme. Mentions that were surprising, repetitive, or related to literature and other research were labelled accordingly. The goal of this process of openly coding relevant interview fragments was to identify common or diverging views in the experts' answers (Bryman & Teevan, 2007; Bryman, Becker & Sempik, 2008).

In the second step, related codes were bundled into associated categories (Bryman et al., 2008). This segmentation of the data added meaning and context to the individual labels (Corbin & Strauss, 2008; Jansen, 2010). This procedure is called open upward coding because it merges similar information and thereby increases the abstraction (Jansen, 2010). Thus, this form of data analysis can help identifying the relationship between pieces of data from the interviews and the targeted findings of the study (Jansen, 2010).

In the last step, common answers by the participants were unified to erase duplications and allow a clearer depiction of the categorized answers to the respective topics. This consolidated form of the answers is the contribution to the study from the participants' perspective (Bryman et al., 2008). The following sections will reflect on the ethical considerations and the research process in practice, before presenting the results of the study in chapter D.

4. Research Ethics

When conducting any research study, the researching staff need to be aware that there is risk involved, especially when humans and their data are part of the project (Bryman et al., 2008; Kvale & Brinkmann, 2009). Hence, any ramifications of ethical nature caused by the research must be heeded and mitigated (UCL, 2021). As this study project has been conducted by researchers from the University College London and Imperial College London, it has been reviewed and approved by the UCL Research Ethics Committee to ensure that all necessary steps were taken to minimize the ethical implications to the participants and researchers. Full details on the mitigating measures and research procedures, methods and safeguards can be found in the appendix 2 and 3.

5. Reflection on the Research Process in Practice

Although the interview process and the outcome were satisfactory, unstable internet connection, particularly on the side of experts based in Mozambique, complicated the interviewing via web tools at times and forced the researcher to repeat questions or relocate the interview to a different tool. Due to the severe implications of the Covid-19 pandemic, travel

to Maputo, Mozambique, was impossible at the time of the research. Gaining an impression locally and in person of the transport system, as well as talking to some of the experts face-to-face could have potentially opened up a more extensive view on the situation and progress in Maputo. It should be mentioned that due to the expert selection and their coverage of relevant perspectives, the passenger or user side of the e-ticketing system in Maputo was only indirectly and not explicitly covered. Including the points of view of a local user of the transport system could have made a valuable contribution to the research.

D. RESULTS

In this section, the experts' answers to the questions from the topic guide as well as their views, opinions and assessments on the research topic are presented in a consolidated view. This allowed identifying overarching themes and obtaining an extensive view on their influencing factors or details, while filtering out repetitive mention of certain factors. First, the experts' general view on e-ticketing, multimodal integration regarding Maputo is analysed. Second, electronic ticketing in urban transport systems in general is broken down. The third section focuses on the factors influencing the integration of multiple transport modes into one transit system. Next, the experts' assessment of e-ticketing systems for multimodal systems in countries located in the global south is studied. Lastly, Maputo's currently deployed e-ticketing system and its potential of integrating paratransit are analysed.

1. Experts' Perspective on E-Ticketing and Multimodal Integration in Maputo

An e-ticketing system, just like any other form of ticketing in a transport network, has two pivotal tasks: 1) Facilitating transport for the people wishing to use the means and collecting the money in exchange for the service and 2) it can serve as a source of collecting data on travel behaviour and characteristics. Furthermore, Maputo's initiative to form a metropolitan agency dedicated towards overseeing all transportation matters is seen as a strategically beneficial move by several experts. The e-ticketing system 'Famba card' currently only covers public buses, however, it is planned to implement it in a potential new BRT system and to integrate additional formal and non-formal means of transport in the future once a higher degree of utilization of the Famba card is achieved.

2. E-Ticketing

2.1. The Effect of E-Ticketing on Transport Systems

A strong consent of all experts became evident that a change from a cash-based to an electronic ticketing system has far-reaching effects on the entire transport system. One Expert even said E-Ticketing "changes everything utterly" (E1, 2021). This strong effect can be traced back to a multitude of reasons. Two of the most-mentioned results were a shift in the dynamic and distribution of power, especially within the highly ambiguous informal transport sector, and the reversal of the direction of cashflow and revenue distribution. The latter means that the migration of the money from the crew on the vehicles to the vehicle owners and then the transport agencies in a cash system is reversed, which is effectively "turning the financing structure on its head" (E1, 2021). Additionally, a digital system collects and records data on travel and payments, which on one hand can be used to improve the planning of transport services and on the other hand creates a more transparent system. That allows governmental taxation and complicates money leakage, which can attract more investors in transport

infrastructure. However, almost all experts noted that, when it comes to any form of change, resistance from different sides always should be expected, as some people object changing their habits and parties who will be worse off, like potentially the vehicle crews, might oppose an electronic payment system. Conversely, informal working relationships between crews and owners would have to be changed into formal contracts "including a fixed salary" (E4, 2021).

Table 2: Effect of E-Ticketing on transport systems (compared to cash)

Questions	***Effect of E-Ticketing on transport systems (compared to cash)***
Consolidated Expert Answers	Change of power structure in the transport sector Reversing the cashflow direction Brings transparency to the system Formalization of labour Allows collection of transport data Requires change of habits Different beneficiaries

2.2. Enablers of E-Ticketing

To facilitate a successful introduction and operation of an e-ticketing system, the purpose of the project and the societal problem should play a central role in the planning. An e-ticketing system should "benefit all parties involved" (E3, 2021) and serve the societal wellbeing. Furthermore, four out of the five experts identified a consolidated transport sector, a structuring authority and a constructive culture of communication between them as important factors for success. Also, having a working transport and digital infrastructure, like top-up and information centres and cheap mobile data, in place was named as an enabler by two participants. Moreover, there is a "safety aspect of not carrying cash" (E3, 2021), especially in countries with high rates of violent crime, as carrying cash can make vehicles and citizens targets for robbery.

Table 3: Enablers of E-Ticketing

Questions	***Enablers of E-Ticketing***
Consolidated Expert Answers	Consolidation of the transport sector Transport Authority Societal purpose of the project Transport and digital infrastructure Disadvantages of cash Constructive communication culture

2.3. Barriers of E-Ticketing

In contrast, there is a multiplicity of attributes that can act as barriers to a functioning e-ticketing system. Many of them are effectively the inverse of the aforementioned enablers, such as lack of a transport authority, little structure combined with a high ambiguity and informality within the transport sector and potentially even mistrust among the stakeholders. At times, the mistrust can be directed at the government authorities due to corruption or the perception they are not serving the public, which would significantly harm the chances of success for an e-ticketing system as two experts stated. Another barrier can be "silo thinking" (E5, 2021) from the authorities and other players, where everyone only sees their own benefits and issues and disregards the bigger picture. Besides, higher infrastructure and operation costs compared to a cash-based system and reservations regarding the change to electronic ticketing from stakeholders like the vehicle crews, owners or passengers can prove to be significant obstacles.

Table 4: Barriers of E-Ticketing

Questions	***Barriers of E-Ticketing***
Consolidated Expert Answers	High degree of informality Stakeholder fragmentation Complex power structure Lack of authority Resistance from operators and crews Insufficient investment in infrastructure Distrust of government Silo thinking

3. Multimodal Integration

3.1. Enablers of Multimodal Integration

According to the experts, some of the factors that act as enablers for e-ticketing also facilitate multimodal integration of a transport system. Three experts name a structuring authority that sets the rules and can enforce the adherence to contracts and a basic level of trust between the actors as a prerequisite for a successful integration of different means of transport into one system. Besides, trust between the involved players and fare agreements between the transport operators play an important role towards a successful multimodal integration, according to most experts. Three experts stated physical integration as an enabler. It describes that "interchanges and stops are shared by different transport modes or close to each other" (E3, 2021). Also, the intended scale of the integration should be "fit for purpose" (E1, 2021), not overambitious and focused on addressing the peoples' fundamental need of transportation.

Table 5: Enablers of Multimodal Integration

Questions	***Enablers of multimodal integration***
Consolidated Expert Answers	Structuring transport authority Fare agreements Shared stops and interchanges Trust between stakeholders Reasonable scale

3.2. Barriers of Multimodal Integration

Setting goals that are too ambitious should be avoided, as that can hinder the projects' success. Copying projects from other sectors, geographics or use-cases without sufficient thought how and if it can be applied can lead to irrational decisions (E1, 2021; E3, 2021). Furthermore, a lot of planning and communication between the stakeholders can be required to integrate various modes in one system. Hence, factors complicating that dialogue, like a fragmented stakeholder landscape and lack of authorities or trust can be barriers to that, according to almost all experts. Moreover, three experts see a lack of compatibility of the fare structures and deployed technology between the individual means as well as the absence of a viable and profitable business case for every player involved as harmful to a successful integration.

Table 6: Barriers of Multimodal Integration

Questions	***Barriers of multimodal integration***
Consolidated Expert Answers	Stakeholder fragmentation Mistrust between players Lack of authority Technical incompatibility Overambitious goals Lack of viability

3.3. How E-Ticketing can Improve Multimodal Integration

Most experts state that the overall costs for the service providers and in return the customers can be decreased by eliminating transaction costs between the individual means of transport. In addition, the collected data can be used to boost the quality by allowing better planning and harmonization of the services. It can also enable smaller operators to take on bigger roles in the transport system, which they would otherwise not have access to because of a lack of know-how or financial barriers.

Table 7: How E-Ticketing can improve Multimodal Integration

Questions	***How can e-ticketing improve multimodal integration?***
Consolidated Expert Answers	User convenience & pricing Data collection improves service quality Removal of barriers for smaller operators

4. The Global South

4.1. E-Ticketing in Multimodal Systems in the Global South

Firstly, the global south is a summarising term describing diverse regions such as Latin America, Africa and South East Asia, that can differ significantly and each show distinct forms of informality in the transport sector (E1, 2021). When focusing on sub-Saharan Africa, there is currently no transport system that successfully unites an e-ticketing system and a multimodal transport system, according to two experts. In general, the participants mostly agree that the step towards electronic ticketing should be taken first, before subsequently attempting to integrate several modes of transport into one system.

Table 8: E-ticketing for multiple modes in the Global South

Questions	***E-ticketing for multiple modes in the Global South***
Consolidated Expert Answers	Ambiguity of the Global South No functioning multimodal e-ticketing system in Sub-Saharan Africa yet E-Ticketing First, Integration Second

4.2. Barriers to Multimodal E-Ticketing Systems in the Global South

Countries in the global south and particularly the sub-Saharan region in Africa often exhibit several unique institutional and societal traits, which can prove to be difficult obstacles to overcome when implementing an e-ticketing system for multiple transport modes. While the above-mentioned general barriers for e-ticketing (2.) and multimodal integration (3.) equally apply in the global south, a few characteristics are either particularly distinct or should additionally be considered. For example, three experts mention a high degree of informality that can facilitate corruption, bribe taking and money leakage, not only in the transport sector. In general, involvement of the government can be a substantial barrier, yet "global agencies, outsiders and NGOs come with the mindset that the government is a good actor" (E3, 2021). However, Expert 3 (2021) argues that the "faith in the government of holding societies' best interests at heart is extremely misplaced". Further, the absence of neutral authorities has led to organized cadres that control the power dynamic in the informal transport sector and establish an "equilibrium of permanent competitive tension" (E1, 2021) between the involved entities. A substantial change in the power structure caused by a change from cash-based to electronic ticketing could disturb the balance and result in riots and conflicts. Also, the crews which are in control of the receipt of money in a cash-based system could actively sabotage an e-ticketing system on the vehicles, should they see a higher risk of instable or fewer income, according to two experts. Finally, transport projects in the global south are frequently financed by international investors. As these projects have to be approved by the financiers, the funder might decide with their plan in the case of conflicting ideas instead of listening to the local experts.

Table 9: Barriers to Multimodal E-Ticketing Systems in the Global South

Questions	***Barriers to Multimodal E-Ticketing Systems in the Global South***
Consolidated Expert Answers	Significant degree of informality Stakeholder fragmentation Bad governance Lack of authorities Resistance of crucial stakeholders Overambitious goals

5. Maputo: Paratransit Integration and the Famba Card System

5.1. Paratransit Integration in Maputo

In Maputo's transport network, Chapas are carrying most passengers and are the dominant form of transport. They are licensed, but do not operate in a formal way 100 percent of the time, which is why they should be referred to as paratransit. However, it is vital to acknowledge their role and importance and to tailor the e-ticketing system to the requirements of the Chapas to facilitate their inclusion, according to the experts' consensus. In fact, one expert argues that the correct question should be "how to integrate formal modes into the Chapas system?" (E3, 2021). Further, loans and funding should be made accessible for the associations and owners of Chapas to finance maintaining and improving service and safety of their operation as well as infrastructure investments for road repairs.

On the other hand, almost all experts agree that MyLoves do not adhere to any safety regulations or transport authority and should not be considered for integration into the public transport system. Nevertheless, they can only be replaced if the road conditions, especially in informal settlements further outside of the city centre, were improved drastically. This would allow means of formal transport to access these regions, which is not possible currently. Should Maputo keep growing at the same speed as it has recently, informal and paratransit means will likely persist. The question for the purpose of e-ticketing and multimodal integration and in what form it can address the pressing societal and urban problems should be central. Afterall, the transport system should serve the people and allow them to satisfy their need for mobility as convenient as possible, without overcomplicating the process of transportation. Hence, some experts regard an integration beyond a physical stage, where high-demand transport hubs serve as interchanges between different modes of transport, as difficult in the current situation.

Table 10: Important factors for paratransit integration in Maputo

Question	***Important Factors for Paratransit Integration in Maputo***
Consolidated Expert Answers	High degree of informality
	Fragmentation of stakeholders and interests
	Lack of structure and consolidation in the transport sector
	Importance of Chapas
	Role of MyLoves
	Physical Integration of formal transport and paratransit

5.2. Benefits and Opportunities of the Famba Card System

In the next step, the experts were asked to give their opinion on the benefits and opportunities as well as the drawbacks and challenges of Famba and then elaborate on their view if Famba currently fosters the integration of paratransit means into its system. The majority of experts agree that one benefit of the system is that it introduces a prior unknown level of formality to the system that could possibly allow a more precise mapping and inclusion of Chapas and other transport means in the future. It also could set the standard for a national ticketing system across municipal borders. It features a reliable and standardized pricing model and has the potential of enable third party payment options in the future to broaden the field of application of the Famba card. In addition, the data that the e-ticketing system gathers can be used to improve the service planning and resource allocation, which could benefit the transport system in its transition to being physically better integrated, while the new level of visibility enables governments to tax the companies in a fairer and appropriate way.

Table 11: Benefits and Opportunities of the Famba Card System

Questions	***Benefits & Opportunities of the Famba Card System***
Consolidated Expert Answers	Added level of formalization Increases transparency throughout the system Service Improvement Reliable Pricing

5.3. Drawbacks and Challenges of the Famba Card System

On the other hand, Famba in its current form also displays some drawbacks and has to deal with many of the challenges mentioned in the sections before. Particularly the acceptance of the passengers and the resistance from the vehicle crews are a challenge and will require a lot of educational training and dialogue between the affected parties. Some of the reservations regarding Famba from the user side are constituted in some peoples' unwillingness or inability to participate in the banking system, which is a requirement for the Famba card. Others can be attributed to the change of habits that is required. Most people are used to paying by cash and the Famba system complicates travel for them. It could further exclude people who are not familiar with paying digitally, like elderly, those who come from outside of Maputo and have to change between two ticketing systems and poor people who are living from daily budgets and cannot charge their Famba cards in advance. Lastly, the incapacity to produce the necessary hardware needed for the Famba system creates a "dependency on foreign countries or companies" (E4, 2021).

Table 12: Drawbacks & Challenges of the Famba Card System

Questions	***Drawbacks & Challenges of the Famba Card System***
Consolidated Expert Answers	Resistance from key stakeholders Informality and lack of bank accounts Profitability of the operation Government involvement User inconvenience and change of habits Social exclusion Infrastructure costs Dependency

5.4. The Extent to which Famba can facilitate Paratransit Integration

Finally, the experts weighed in on the question whether the current e-ticketing system facilitates the integration of paratransit into the transport system. Generally, it was emphasized by most experts that e-ticketing can be a central tool to integrate informal means into a formal system and that licensed means should be included as they frequently play an important role for the public transport system. Furthermore, collecting data of the paratransit means would benefit the degree of understanding paratransit and their service and physical integration. It would also free the way for potential investor and government financing, which is usually reserved for formal means only due to the required level of transparency and legitimacy. Moreover, profits and revenue can be distributed more accurately and reliably along the service chain, because of a more traceable cashflow. Nevertheless, Expert 2 states that the current Famba system "makes the integration of non-formal means into the transport system harder" (2021), for example, because it requires a bank account. This can be seen as one of the main reasons for the slow adaptation of the project, as many people opt for alternative ways to evade Famba like onetime QR-code based payments. The required change of the users' habits presents an obstacle that might take a long time to overcome, but the utilization rate of Famba, and thus the integration fare payments for paratransit, could be elevated by incorporating mPesa – a mobile payment solution from Vodafone - to top-up the Famba card or pay on the vehicle. However, the latter would entail a loss of transparency, as mPesa payments are hard to trace for the authorities.

Table 13: Extent to which Famba facilitates the Integration of Paratransit

Questions	***Extent to which Famba facilitates the Integration of Paratransit***
Consolidated Expert Answers	Inclusion of licensed transport Understanding of paratransit Featuring of mobile payment solutions Current Famba system hampers paratransit integration Enables access to formal financing Facilitates revenue distribution

E. DISCUSSION

1. Multimodal Integration in Maputo

This chapter considers the findings outlined in chapter D: Results and interprets them in relation to the current positions of literature and research on the study topic. Firstly, to achieve an integration of paratransit, particularly the Chapas, into the public transport system of Maputo, their role and importance has to be recognized by policy makers and authorities. Therefore, a homogenous eco-system with agreed responsibilities and roles should be created (Merkert, Bushell & Beck, 2020), as it could foster the trust between the involved players and set the ground rules for a constructive dialogue. Currently, this vital relationship of trust between authorities, operators and the crews is a substantial barrier (Schalekamp, 2017; Arroyo-Arroyo et al., 2021), rooted mainly in highly diverse interest groups and the informal organization and business practices in the transport sector. The Metropolitan Transport Agency (AMT) could act as a structuring authority, which could mediate between the players and ensure that the rules within the transport system are followed, and the responsibilities and roles of the individual players are accepted. This has proven to be a key enabler for both multimodal integration and e-ticketing alike. The AMT would also be well positioned to lead potential negotiations about fare and revenue distribution between the e-ticketing provider and the public transport and paratransit organisations.

The lack of trust and transparency in the transport system were identified as two of the major obstacles for multimodality in Maputo by all the experts. Equally, they noted that the introduction of electronic ticketing has a beneficial effect on the visibility and transparency of the entire system, in particular the cashflow and revenue distribution. In turn, a more transparent system due to e-ticketing allows the government to collect taxes more precisely and would make it more attractive for investors and loans from banks, compared to an obscure and informal cash-based system. In general, this could benefit the operators financially and the influx in funds could benefit the transport users, if it is used to improve the service quality.

Moreover, payment and user validation can be executed significantly faster in a smartcard system, which would come with the added value of being more secure for the user than carrying cash. Subsequently, higher quality transport and behavioural data allows a more precise and predictable fare charge, thus a reliable pricing system.

Another major benefit of electronic ticketing which could directly benefits the integration of paratransit in Maputo is the data that can be collected from the vehicles and passengers due to the smartcard system (Pelletier, Trépanier & Morency, 2011). It could grant the planning authorities new insights on the formal and the paratransit network to attune the two to each other in terms of schedules and interchanges. Especially the physical integration of common stops and interchanges to allow a seamless transition between public buses and Chapas at transport hubs is a vital part for the multimodal integration in Maputo (Ceder, 2016; Merkert, Bushell & Beck, 2020), according to research and the participants in the study.

2. E-Ticketing in Maputo

Generally, a common fare system spanning across several integral modes of transport is universally considered a cornerstone to a working integrated multimodal transport system (Chowdhury & Ceder, 2016). The operator of Maputo's Famba system, while it is currently only in use in public buses, are planning on including additional formal and informal transport modes in the medium-term. Interestingly, in the case of Maputo, some of the apparent advantages of e-ticketing found in literature and research prove to be barriers for the acceptance and successful implementation in practice.

First, the change from cash to Famba has not led to the anticipated usage rate in the population. Many users perceive it to be less convenient than cash for a variety of reasons. For example, "the effort of the top-up process is too high" (E1, 2021) and charging stations are often not easily accessible for everyone. This could be attributed to the high initial investment necessary for the digital infrastructure on the vehicles and at the stations as well as the many physical charging points required, if mobile or remote top up is not enabled.

Also, the reliability and consistency in pricing do not leave room for price negotiations, especially when someone wants to transport goods with them, which decreases the utility of using Famba. People were used to negotiate their fares, especially when carrying goods or purchases on the vehicles. Nevertheless, the e-ticketing system would technically allow the providers to adjust the structuring flexibly and include a surcharge for goods as well as add services almost at an instance (Pelletier, Trépanier & Morency, 2011). Most notably however, user expenses for transport when paying with Famba are often higher than paying with cash, which is a fundamental barrier for its success in a city, with a relatively high level of poverty and unemployment and plenty of people living of daily budgets (E1, 2021).

While the prospect of the Famba system to include Chapas appears to be a tool to break up the informalization, fragmentation of power and lack of authority within the paratransit sector, such a complete overhaul is likely not going to result in a thriving transport system where all actors are benefiting. Such a structural reform would require an incorporation in a wider arrangement of policy and organisational changes, like the formalization of labour relations and defined contracts for the crews and operators (Barrett, 2003). As an isolated measure, integrating paratransit into the e-ticketing might raise more problems than it is trying to solve.

F. CONCLUSION

1. Reasoned Conclusion

In principle, e-ticketing can be a powerful measure to change the business model of paratransit and facilitate its integration into the formal public transport system. Nevertheless, the change from a cash-based system to a digital payment scheme also brings a substantial shift in the power structure of the entire sector with it and it is a challenging task for any institution that attempts to do so. The structures and dynamic within the paratransit sector have grown over many years and disrupting the equilibrium that has been established will trigger resistance from those players, that see themselves disadvantaged because of the change. As a standalone measure, the introduction of e-ticketing on semi-formal modes to formalize them is likely going to fail. A more strategic set of policy and organisational measures, combined with constructive communication, patience and educational work will be needed, if a successful integration wants to be achieved.

Generally, e-ticketing as a tool to foster multimodal integration should never originate from in an overambitious endeavour to modernize a transport system, without considering the needs of the passengers and society. In the case of Maputo, policy makers and the transport authorities made the correct step in recognizing the importance of the Chapas to the city's transport network, when they integrated their routes into the official intermodal public transport map. Such a public transport network can be a hybrid system with a combination of formal and paratransit means, where the common agreed goal is to provide the best possible transport service for the metropolitan area of Maputo (Salazar Ferro, Behrens & Wilkinson, 2013). In such a system, the transport authority would likely be best positioned to moderate the structural change and collaboration between the diverse stakeholder interests, because of their commitment to both the public as well as the private interest (Arroyo-Arroyo et al., 2021). For the time being, formal transport and paratransit can exist as complementary services that offer the best service when physically integrated, by sharing interchanges and facilitating switching between the separate means physically and financially.

2. Implications for Policy and Practice

Before thinking about the integration of additional modes into the Famba system, the slow acceptance of electronic ticketing and preference of cash of crews and passengers should be tackled. There is little sense in building a fully integrated and digitized system that does not serve the people, as the chances of acceptance will be low. Hence, increasing the appeal of the current e-ticketing system to the broad public should be the first step from the AMT's and Famba provider's perspective. This could be achieved by setting up more information and top-up points throughout the city and the suburbs. Additionally, enabling mobile top-up from home or on the go via the mPesa service would likely increase convenience and familiarity for many,

since mPesa is widely used and accepted as a mobile payment service and could eliminate the need for a bank account or cash top-up.

Once a higher usage rate is achieved, Famba will be more attractive for other operators to join because they want to benefit from the passenger numbers. This pull-effect can facilitate uniting different operators behind the shared objective of delivering the best possible service and play a vital role in the collaboration and potentially formalisation of the separate paratransit institutions. Therefore, consolidating the paratransit sector should be given a high priority and the formation of collectives and operator associations of the Chapas owners and crew should be incentivized to battle the diversity and fragmentation within the sector. Moreover, enabling semi-formal modes to qualify for government loans and funding, if they adhere to the rules and responsibilities of the Famba system, could foster their interest in further integration. However, it should be remembered that a full formalization of the Chapas would also require labour contracts between operators and crews. Such a structural change is unlikely to be successful at this stage. That is why e-ticketing, while it is a great tool to integrate multiple formal modes into a transport system, can only foster the full integration of paratransit if it is embedded in a wider set of measures and patiently implemented to give the users time to get used to them.

3. Shortcomings and Further Questions Arising from the Research

In its initial phase, this study aimed to analyse the data gathered by the e-ticketing system on the public buses in Maputo to bolster the research with quantified findings. Unfortunately, it was not possible for the research team to get access to this kind of data, which is why it was decided to alter the study approach to a more explorative design. Due to its qualitative nature, the problem arises that the findings, which originated from the analysis of several individuals rather than an entire population, can hardly be generalized. Also, the selection process of the participants and the data analysis naturally include some subjective influence from the researcher and not appear to be fully transparent at times (Bryman & Teevan, 2007). However, this study was designed to allow an explorative and open-minded research process and the findings work out several interesting topics worth researching in more depth. For example, conducting a quantitative study on the Famba usage on the public bus system in Maputo could help in understanding the low usage rate and quantify the travel behaviour. Furthermore, it would be worth exploring how operator collectives and associations for the crews and drivers can be established in fragmented and informal landscapes like the paratransit sector, as that was clearly identified as one of the major obstacles to multimodal integration and the implementation of e-ticketing.

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APPENDIX

Appendix 1: Topic Guide

LONDON'S GLOBAL UNIVERSITY

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Semi-structured Interview – Topic Guide

Research Question: *To what extent can e-ticketing systems foster multimodal integration? – A Maputo Case Study*

Researchers: Julian Kling, Student (UCL & Imperial College London)
Dr. Clemence Cavoli (UCL, Primary Researcher/Supervisor)

Topic Guide & Questions for Participants:

1. Qualitative Interview Introduction

   a) Format: Set of questions, semi-structured, follow-up questions are possible
   b) Length: around 30-45 minutes
   c) Primary Goal: Better understand the role of e-ticketing in transport systems (in the global south primarily) and assess its potential to facilitate the integration of multiple transport modes – including semi-formal – taking Maputo, Mozambique as a case study city

2. Verbal Consent
   a) *Would you like to participate in this interview?*
      Yes / No
   b) *Do you agree for the interview to be audio/video recorded, for the purpose of transcription only? The recording will be stored securely, deleted immediately after transcription, and will only be seen by the research team.*
      Yes / No

3. Personal Information
   a) Name
   b) Contact Details (e-mail address, telephone number)
   c) Job Specifications (employer, job title/description)

4. Background Information
   Invite participant to briefly talk about his/her/their experience and perspective on the research topic

5. E-ticketing in Transport
   a) *In your opinion, how does electronic ticketing and payment affect urban transport systems compared to conventional, cash-based ticketing (in Global North and in particular in South cities)?*
   b) *What are the enablers for e-ticketing systems in urban transport?*
   c) *What are the barriers for e-ticketing systems in urban transport?*

6. E-ticketing for multimodal transport systems
   a) *What are the enablers for the integration of multiple modes into one urban transport system?*
   b) *What are the barriers for the integration of multiple modes into one urban transport system?*
   c) *In which way can an e-ticketing systems improve the integration of multiple transport modes in urban areas?*

   In the Global South:
   d) *From your experience, how does e-ticketing work when multiple transport modes are to be included?*
   e) *What are the most common institutional, implementation and operational barriers faced by multimodal e-ticketing systems? - Any other barriers?*

7. Ramifications for Maputo
   a) *In your opinion, what needs to be considered when trying to integrate semi-formal transport into the formal, public transport system?*
   b) *What are the benefits and what the drawbacks of the FAMBA e-ticketing system?*
   c) *What are the opportunities and what the challenges?*
   d) *In your opinion, to what extent could the current e-ticketing system facilitate the integration of non-formal means of transport?*

Appendix 2: Participant Information Form

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PARTICIPANT INFORMATION SHEET FOR ADULTS

UCL Research Ethics Committee Approval ID Number: 21115/001

YOU WILL BE GIVEN A COPY OF THIS INFORMATION SHEET

Title of Study:
To what extent can e-ticketing foster multimodal integration of transport systems – A Maputo Case Study
Department:
Civil, Environmental and Geomatic Engineering
Name and Contact Details of the Researcher:
Julian Kling, julian.kling.20@ucl.ac.uk
Name and Contact Details of the Principal Researcher:
Dr. Clemence Cavoli, clemence.cavoli@ucl.ac.uk
Name and Contact Details of the Data Protection Officer:
Alexandra Potts, data-protection@ucl.ac.uk

1. **Invitation Paragraph**
   You are being invited to take part in a research project. It is important for you to understand why the research is being done, and what your participation will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask us if there is anything that is not clear, or if you would like more information. Take time to decide whether or not you wish to take part. Thank you for reading this.

2. **What is the project's purpose?**
   This study is part of the researcher's intercollegiate transport MSc at UCL and Imperial College London. The aim of the project is to discuss the extent to which electronic ticketing and payment systems can improve and facilitate multimodal integration of transport systems in cities. In particular, the city of Maputo, Mozambique, will be used as a case study city. Therefore, the role of e-ticketing in urban transport, and with respect to multimodality, as well as the current transport system in Maputo, will be assessed. With the help of the information gathered during the expert interviews, conclusions for the city of Maputo will be drawn.
   The dissertation project is undertaken in the context of the research project T-SUM, Transitions to Sustainable Urban Mobility in Sub-Saharan Africa (further information can be found https://www.t-sum.org/)
   The project is planned to take place until 06.09.2021.

3. **Why have I been chosen?**
   Participants (experts) are selected based on their experience and knowledge of relevant transport-related topics such as multimodal platforms, integration of electronic ticketing and payment systems into the wider transport environment and

know-how concerning local transport networks in Global South and Global North cities, and in particular in Maputo.

4. **Do I have to take part?**
   It is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep (and be asked to sign a consent form). You can withdraw at any time without giving a reason and without it affecting any benefits that you are entitled to. Should you decide to withdraw, you will be asked what you wish to happen to the data you have provided up to that point.

5. **What will happen to me if I take part?**
   You will be asked a variety of questions during a semi-structured interview. The interview will be conducted via a remote video-chat application (such as Zoom or Microsoft Teams) This will likely take around 45 minutes of your time. There will be no follow-up appointments intended and you will not be contacted for future research. Your personal data will not be passed on to fellow researchers. Your consent will be recorded via a separate "Informed Consent Form" and only your name, contact details, like e-mail and telephone number, as well as employer and job title and description, will be recorded as personal data.

6. **Will I be recorded and how will the recorded media be used?**
   If you consent, the interview can be recorded for the sole purpose of transcription. As soon as the transcription process is completed, the audio/video recording of the interview will be deleted permanently. The recording will not be stored, published or broadcasted.

7. **What are the possible disadvantages and risks of taking part?**
   The interview will require some time (allow up to one hour) and a topic guide with the core questions might be sent to you in advance to allow for preparation. Apart from that, no risks or disadvantages should arise from the participation.

8. **What are the possible benefits of taking part?**
   Whilst there are no immediate benefits for those people participating in the project, it is hoped that this work will contribute to building a better understanding of the researched topic and therefore benefit the wider public and, in particular, the residents and users of the transport network in Maputo, Mozambique.

9. **What if something goes wrong?**
   In case of the emergence of any unwanted events during or in the time following the interviewing process, the participant can contact the Principal Researcher (stated above) to express their complaints. Complaints may contain the treatment by the researchers as well as serious events occurring during or following the participation in the project. Should you feel like your complaint has not been handled to your satisfaction, you can contact the Chair of the UCL Research Ethics Committee – ethics@ucl.ac.uk.

10. **Will my taking part in this project be kept confidential?**
    All the information that we collect about you during the research will be pseudonymised and stored securely. Only members of the research team will have access to the personal data. You will not be able to be identified in any ensuing reports or publications.

11. Limits to confidentiality

Confidentiality will be respected subject to legal constraints and professional guidelines.

Please note that assurances on confidentiality will be strictly adhered to unless evidence of wrongdoing or potential harm is uncovered. In such cases the University may be obliged to contact relevant statutory bodies/agencies.

12. What will happen to the results of the research project?

As the study is part of a Master Thesis, the dissertation is unlikely to be published in any form. The final thesis will be handed in by 06.09.2021 and participants can request a copy of the study from the Researcher or the Primary Researcher. Outputs from the study might contribute to the T-SUM project (further information can be found at https://www.t-sum.org/). Participants will not be identified (unless specified) in any report or publication.

13. Local Data Protection Privacy Notice

Notice:

The controller for this project will be University College London (UCL). The UCL Data Protection Officer provides oversight of UCL activities involving the processing of personal data, and can be contacted at data-protection@ucl.ac.uk

This 'local' privacy notice sets out the information that applies to this particular study. Further information on how UCL uses participant information can be found in our 'general' privacy notice:

For participants in research studies, click here

The information that is required to be provided to participants under data protection legislation (GDPR and DPA 2018) is provided across both the 'local' and 'general' privacy notices.

The categories of personal data used will be as follows:
Name
E-mail address
Telephone number
Employer
Working title/Position

The lawful basis that would be used to process your *personal data* will be performance of a task in the public interest.

Your personal data will be processed so long as it is required for the research project. If we are able to anonymise or pseudonymise the personal data you provide we will undertake this and will endeavour to minimise the processing of personal data wherever possible.

If you are concerned about how your personal data is being processed, or if you would like to contact us about your rights, please contact UCL in the first instance at data-protection@ucl.ac.uk.

14. Contact for further information

Dr. Clemence Cavoli
E-mail: clemence.cavoli@ucl.ac.uk

Thank you for reading this information sheet and for considering to take part in this research study.

Appendix 3: Participant Informed Consent Form

LONDON'S GLOBAL UNIVERSITY

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CONSENT FORM FOR ADULTS IN RESEARCH STUDIES

Please complete this form after you have read the Information Sheet and/or listened to an explanation about the research.

Title of Study: To what extent can e-ticketing foster multimodal integration of transport systems? – A Maputo Case Study
Department: Civil, Environmental and Geomatic Engineering
Name and Contact Details of the Researcher(s): Julian Kling; julian.kling.20@ucl.ac.uk
Name and Contact Details of the Principal Researcher: Dr. Clemence Cavoli; clemence.cavoli@ucl.ac.uk
Name and Contact Details of the UCL Data Protection Officer: Alexandra Potts; data-protection@ucl.ac.uk
This study has been approved by the UCL Research Ethics Committee: Project ID number: 21115/001

Thank you for considering taking part in this research. The person organising the research must explain the project to you before you agree to take part. If you have any questions arising from the Information Sheet or explanation already given to you, please ask the researcher before you decide whether to join in. You will be given a copy of this Consent Form to keep and refer to at any time.

I confirm that I understand that by ticking/initialling each box below I am consenting to this element of the study. I understand that it will be assumed that unticked/initialled boxes means that I DO NOT consent to that part of the study. I understand that by not giving consent for any one element that I may be deemed ineligible for the study.

		Tick Box
1.	*I confirm that I have read and understood the Information Sheet for the above study. I have had an opportunity to consider the information and what will be expected of me. I have also had the opportunity to ask questions which have been answered to my satisfaction *and would like to take part in an individual interview*.	
2.	*I understand that I will be able to withdraw my data up to *4 weeks after interview*	
3.	*I consent to participate in the study. I understand that my personal information *(name, email address, telephone number, job title, job description)* will be used for the purposes explained to me. I understand that according to data protection legislation, 'public task' will be the lawful basis for processing.	
4.	**Use of the information for this project only** *I understand that confidentiality cannot be guaranteed during the interview due to the limited size of the participant sample. I understand that my data gathered in this study will be pseudonymised and stored securely.	
5.	*I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason. I understand that if I decide to withdraw, any personal data I have provided up to that point will be deleted unless I agree otherwise.	
6.	I understand the potential risks of participating and the support that will be available to me should I become distressed during the course of the research.	
7.	I understand that there are no direct/indirect benefits of participating and no promise or guarantee of benefits have been made to encourage participation in the study.	
8.	I understand that the data will not be made available to any commercial organisations but is solely the responsibility of the researcher(s) undertaking this study.	
9.	I understand that I will not benefit financially from this study or from any possible outcome it may result in in the future.	
10.	I agree that my pseudonymised research data may be used by others for future research.	
11.	I understand that the information I have submitted will be published as a report and I wish to receive a copy of it. **Yes/No**	

12.	I consent to my interview being audio/video recorded and understand that the recordings will be destroyed immediately following transcription. Note: If you do not want your participation recorded you can still take part in the study.	
13.	I am aware of who I should contact if I wish to lodge a complaint.	
14.	I voluntarily agree to take part in this study.	

_____	_____	_____
Name of participant	Date	Signature

Appendix 4: Interview Analysis: Framework Matrix

Topic	Background Information	E-Ticketing	
Question	pespective on e-ticketing and multimodal integration	effect on transport systems (compared to cash)	enablers
	E-ticketing fundamentals enabling transportation get people where they have to go payment collection collect money data collection mechanism customer interface Can attract or annoy people	"Electronic ticketing system changes everything utterly" Change of power structure "COMPLETE CHANGE OF POWER STRUCTURE" Key: "Very different stakeholders in the informal sector" Very strong power structure! Crews, Terminal staff & managers not part of a union / consolidated, Financiers: banks, companies, individuals like family members, People in maintenance, service, support facilities, cleaners All separate people that have to get paid I many entities in tension with each other Reversing of cashflow "turning financing structure on its head" E-ticketing: Money enters through external point and is redistributed through back-office instead of coming physically through the entry point at driver or ticket terminal accounting system: associations, banks (repayments), system managers then migrates downwards to veh owners & drivers last Transparency NOT tracable vs 100% transparent Upside: bring level of formality & visibility that never existed before Taxation Allows govs to collect taxes etc	Consolidation Associations: consilidated collectives Authority Transport or legal authority: somebody needs to be in charge supported by structure
	Project goal Famba implementation in planned Maputo BRT system (currently in feasibility study phase)	Change of habits Slow acceptance E-ticketing is a new system, acceptance takes time for new systems goas against their normal used way to pay and use money No Bargaining, flexible pricing normally negotiation and bargaining of fares charge for transport of goods Customers often transport goods on chapas for extra fee! how to pay for extra goods electronically? Different beneficiaries Conductors and drivers prefer cash, can take out a higher share for themselves without the vehicle owner knowing extra fee for goods is kept by the collector exclusively! Not recorded revenue disadvantaged crew With e-ticketing: no more price negotiation & no more higher share of revenue for crew e-ticketing Effect: gov positive, owners of chapas etc positive and negative, conductors negative	Authority Main enabler: existence of AMT (metropolitan agency of Maputo) Transporters/providers are very diversified with complex power structure Only entity to bring all together is AMT I Famba hosted within AMT AMT Role: convince transporters to accept new ticketing system, enforce change and negotiate terms like: more funding & subsidies available from gov if system is accepted

Consolidated Expert Answers	Metropolitan Agency creation of Metropolitan area with one institutional body Maputo created metropolitan area and AMT body, good concept Multiplicity of Players Gov deploys buses through cooperatives Additionally commuter rail, chapas minibuses and ferry Project Status Quo 6 corridors across metropolitan area, validators installed on 365 buses, 50 ticketing stations/kiosks, zone and distance based hybrid fare pricing system currently 120,000 Cards distributed User convenience Mobile payment & top up is integrated System supports QR code based onetime tickets (not planned, goal was not to sell tickets on bus, but people kept boarding with cash only) integration of proven payment technology, minimizing user effort Project Goal integration into one system, currently only public buses with e-ticketing Plan: distribute 500,000 famba cards total	Social Differences Why people use cash? Who uses cards and who cash? difference in social classes! Poorer households largely use cash social differences in attitude towards and usage of cash Theory vs Practice Minibuses: basically all payments are cash based Mismatch between peoples cash handling practices and external view of academia, consultancies, and policy circles who see digital payments as the way forward ambition of taking next step in logical development (digital) vs actual practices of organizations at operator level ambitious development goals vs actual practices Purpose Paratransit majority of public transport in sub Saharan Africa Key question: what's the purpose/goal of e-payment? Is it just modern and looks nice or does it help solve a real practical problem? Systemwide Standardization cashless system only useful, if used across entire system How do you get the money to the individual owners if its not cash on a day to day basis like in cash system challenge: extensive fragmentation of ownership in paratransit/PT	Purpose Enablers link to the purpose -> societal good no sense if it doesn't solve a real problem Beneficiary for all benefit all parties involved government support could be loans, financing, policy Infrastructure Kiosks for rollout, information, top-up cheap mobile data Disadvantages of cash negative enabler: petty and violent crime cash makes vehicles targets for robbery safety concerns with carrying cash Lots of cash leakage "money disappears" from customer payment to where owner gets their target payment
		"Amazing impact" Reversing of Cashflow Main change is the way money flows Reversing Cashflow direction Until now bottom up: passengers to crew to owners/cooperations to AMT With eticketing: passenger to AMT then downwards (central government agency) to owners/operators/cooperatives to crew Formalization of Labour Before; drivers agree with owners to rent the vehicle for daily fixed charge, Drivers keep the surplus from daily revenue, No formal contracts With eticketing: formal contract needed: contract with crew including a fixed salary Data Collection Buses are GPS tracked to allow precise validation process (at which stops passengers board and get off) and fare charge behavioural and transport data can improve resource allocation, service planning	Pricing Keeping fares and prices structure the same or reduce them when changing from cash to e-ticketing to avoid confusion/rejection no fare increase Communication Cultural dialogue between different players politics, operators, crews, municipalities... to resolve problems and conflicts of interest (attitude and willingness to find common ground & agreement is vital) Technological Infrastructure proven technology available Technology already around, not new, implemented around the world I consolidated and proven Western Support Technical assistance, resource provision and funding from western countries Authority metropolitan agency has great role and effect (AMT since 2018) user Convenience top up via mobile phone

		Transparency Improves fare collection and profitability of whole transport system all fares actually recorded, complicates money leakage "owner is not getting all the money they are supposed to get (in cash system)" higher service predictability for providers and passengers Visibility for government I better planning Investor attraction will attract investments in public transport system if money is clean Change of habits change management required as some people are benefitting from cash system, these people will be reluctant to back the change to e-ticketing if they loose out on money Resistance to change user convenience no topping up via mobile phone or agent/kiosk is needed additional, unknown processes	Gov Support Will of the government is essential as big change with many people are involved Unified will power, not just driven by one institution Communication Training/education to make everyone see advantages Beneficiary for all Incentives for operators and vehicle crews to drive operators and vehicle crews to use the system

		Multimodal Integration
barriers	**enablers**	**barriers**
Informality "Significant degree of informality" Stakeholder Fragmentation many players from many sides Complex Power structure Very strong power structure! Changing anything will disturb equilibrium and create turmoils	7 layers of integration: Network: broad concept Service: specific routes, timetables, making them "meet" Physical: stations, connection points, hubs, "same place" Fare payment: collection, money side Information: customer service Financial: business model, how to combine costs & distribute revenues Institutional All points must be in place, not hierarchical, if one is missing, others are impossible to maintain functioning: all have to be addressed Fare payment technical interoperability and fare agreements between the players Authority Transport or legal authority: somebody needs to be in charge supported by structure Government support subsidies if needed, loan offerings Trust within the system between the players, at least ensured by contracts	Stakeholder fragmentation central interests & disinterests of people and organisations opposing interests No working together, but against each other lack of collaboration and communication Lack of authority Lack of structure within industry itself to allow work & processes in consistent way Non-viable business case Lack of viability, if money side doesn't work, all else will fail: fundamental barrier Technological incompatibility different technology, fare systems Mistrust mistrust between involved players overambitious Irrationality, trying to implement something from other sectors without thinking about how it can work
Complex Power structure Different transporters have different powers Lack Of authority Some could accept changes, others might not, no union or unified associations of all providers, no one can FORCE them If not advantageous for them, will not choose to back eticketing system some Owners against it because to conceil income to not be taxed informality Crew resistance conductors/drivers will switch off or break the validators and claim the eticketing isn't working to make people pay in cash Active Sabotage Fare Pricing Too high price, needs to be cheaper than cash fare	Associations Both formal and informal means have very diverse and unconsolidated power structure (negotiation power, rule defining etc), consolidation, regulations, organizations	Inconvenience for users Missing link of mobile payment mPesa lack of multiple forms of payment

Infrastructure investment High cost of mobile data Operational costs of electronic system infrastructure, banking costs Electronic systems require maintenance and running costs Government involvement "Faith in government of holding societies best interest at heart is extremely misplaced" misplaced faith in governments Political machinery (milk corrupt money, ie in RSA) corruption Global agencies and outsiders, ngo's come with mindset that gov is good actor and doesn't need to be worried about move things along without gov if needed	Communication education how the new system will work, where and how they will get their money A level playing field is important Physical integration Is most common form of integration of multiple modes: shared stops and interchanges or next to each other "Any other more sophisticated form, ie contracted interchange, fare integration is extremely difficult because of the very different organisational structures that dictate how money flows" Reasonable Scale	Stakeholder Fragmentation Huge problem! Fragmentation of ownership physical and fare integration Interchanges and fare integration between scheduled and unscheduled system is very difficult Overambitious High ambition and target of a full multimodal integration is a problem and current state is very far from it "the funder dictates" can set operation up for failure, when one specific way is seen as only acceptable solution and enforced since someone is paying stubbornness, ego lack of purpose not addressing the main problem the core that needs to be solved
Stakeholder fragmentation for implementation all little parts and issues of ticketing and transport system have to be taken care of: status of operators, ticketing booths... Crew Resistance Fear of loosing livelihood Crew takes all money they collect and gives it to owners (other way round) Crew salary is not much! loss of complementary salary means not enough income Loss of supplementary income for crews Resistance to change Not too many changes at the same time, as it will turn people against the measures I change is hard General resistance to change of people Mistrust Suspicion because of universal corruption everywhere Q: where does the money go? Intransparency for passengers with e-ticketing Inconvenience for users Issues with validation of getting on and off: both required, especially peak hours Too many people try to access buses on both gates, atm	Acknowledgement of paratransit Depending on the place, formal and informal transport may vary (licensing, routes, schedules, associations, labour agreements...) chapas are semi-informal: have licenses, routes, some associations, but drivers don't necessarily follow the rules officially recognized as transport form by gov (not enough capacity to meet demand) physical integration Sharing bus stops and interchanges Trust Close relationship between operators and government officials Communication User convenience validator works both ways (check in and out) easy validation crew incentivization Creating incentives for drivers/crews to support the eticketing system	financial viability Price capped by gov to keep it accessible for population -> income doesn't cover operational costs, making it unviable for operators user inconvencience Missing link of mobile payment mPesa missing mobile payment option Different ticketing systems, technological & fare incompatibility

Stakeholder Fragmentation Huge number of individuals and institutions involved Communication Creating unified voice, consens is hard to reach Government involvement Gov scared of big and unpopular changes because of public perception gov might not be best suited to carry the change Gov barriers for progression Authority Enforcement of rules (from gov/official side) if agreed rules are not followed, what will happen? Current enforcement (eg if cash is still accepted) sending letters and threatening to take away buses and give them away, but no real action so far Silo thinking every party sees their own benefits and issues only, not bigger picture lack of narrating bigger picture	Technology technology is available ready availability of technology High penetration of eticketing is required (pull factor) uptake in use of card based eticketing system open/interoperable ticketing system will bring other modes on board	Stakeholder fragmentation Chapas are mainly unregulated apart from license Wide range of owners and associations, many players involved very disorganized and fragmented Many meetings, dialogues and communication is required

	… in the Global South	
how can e-ticketing improve multimodal integration?	**e-ticketing for multiple modes**	**barriers to multimodal e-ticketing (institutional, implementational, operational…)**
User Convencience Convenience for customers if done well Service improvement provides data for service planning I integration: tracking all movements on and between modes, variations by customer and ticket type source of transport and passenger data Information allows restructuring of services to better serve the customer Formalization binds participants/people/services together will push for better timing of services Enables small operators to new opportunities and empowerment of smaller operators, level the playing field & do things before impossible, ie due to lack of knowhow or access to technology or capital Price reduction can Reduce overall costs for user transaction costs can be eliminated from the system entirely, ie sharing sales points	Definitionof global south What Is "Global South"? I latin America very different to Africa & asia & south east asia Very diverse place & very diverse forms of informality Global South Ambiguity No multimodal e-ticketing system in Sub saharan africa Does it even work in sub Saharan Africa? Full multimodal integration?? Not aware of any system with multiple different modes of transport integrated in one e-ticketing system no structures yet for integrated services in place! No substantial hierarchy step by step focus should be on finding good working fare e-payment system/solution for the services themselves, THEN integration is step beyond this focus on working e-ticketing system first before integrating	informality Much of transport in global south is informal in one way or another "Significant degree of informality" Stakeholder fragmentation many players from many sides, especially when vehicles are owned by individuals/collectives Personal is not part of a union; Financiers: banks, companies, individuals like family members People in maintenance, service, support facilities, cleaners. Terminal staff & managers All separate people that have to get paid I many entities in tension with each other "Very different stakeholders in the informal sector", Very strong power structure! corruption Many side payments, bribe takers etc Cashflow direction "COMPLETE CHANGE OF POWER STRUCTURE" "turning financing structure on its head" I Cadres control unions, vehicle owners, drivers, other operators -> state of permanent competitive tension reached equilibrium. Cadres bring in order to the system! Changing anything will disturb equilibrium -> Reform can lead riots, turmoil
Price reduction E-ticketing must be cheaper & demonstrate that it is advantageous offer individual gain for commuters and frequent users of the service User convenience difficult to charge and if system is broken on the bus, people still have to carry cash simple charging/top-up Many people cannot charge card in advance because they don't have enough money, live on daily budgets instant, free top up of small amounts Link of eticketing with a mobile payment system like mPesa (Vodafone): allows instant transfer and third party payment for you: parents paying for childs if they don't have enough money etc.	step by step RN: famba only available in public buses operated by the AMT Started in katembe because travel demand isn't as high Now everywhere but usage of famba is relatively low	Inconvenience for Users Lack of integration of recharging systems like mPesa or telephone vouchers Allow charging at home expensive top-up process Effort to recharge is too high and inconvenient; have to go to kiosks, only at some bus stops (around 50) Crew resistance sabotage broken or not in operation, drivers often reluctant to use it
government support create reliable basis for funding/financing, policy	Future is about convergence of technologies/standards not either or but both, like emv, smartcard and qr code emv is thing of the past and not well suited for PT in southern africa	bad governance Institutional: slow government responsiveness "Faith in government of holding societies best interest at heart is extremely misplaced" Political machinery (milk corrupt money, ie in RSA) corruption Mistrust Operational side: bad relationship between all parties Everything making their businesses and revenue more visibility to govs (taxation) is a barrier, need for converstions & communication Revenue distribution Practical side: money distribution in fragmented ownership model transaction speed, when people get their money user inconvenience Access to technology for users & all players: passengers, conductors, drivers and owners & associations I not everybody has necessary prerequisites like smartphone vs feature phone
Technical interoperability Pair commuter rail routes (2-3 by metrobus) with feeder buses that share the same ticketing system Other possibility, interoperable ticketing system (similar to withdrawal from atms with different bank cards)		Bad governance Metropolitan governments: competition between municipalities and metropolitan agencies politics, everyone wants big margin and big role in solution finding stakeholder fragmentation To implement eticketing all the little parts and issues of the ticketing and transport system have to be taken care of multiplicity of stakeholders crew resistance Crew salary is not much loss of complementary salary means risk of loosing livelihood, main resistance against eticketing is from crews

	Intermodal system in dar es salaam Bus operators buy and provide buses, staffed with drivers and fare collectors/conductors e-ticketing on buses on BRT system and ferries gov tampering with profitability Gov got involved in fare and pricing decisions Gov had trouble with accurate financial planning of the entire operation	Silo thinking Big egos are involved, everyone wants to own the full service, many "parties think and prefer working in silos" Passengers as customers of a certain transport mode instead of their full cycle and transport needs (potentially different modes required) The longer transport companies are in operation, the bigger the ego usually gets, more ignorance and unwillingness for reformation

Maputo	**Existing E-Ticketing System (Famba)**	
Important Factors for Paratransit Integration	**benefits & opportunities**	**drawbacks & challenges**
No Myloves myLoves shouldn't exist and are not to be considered worth implementing into transport system Chapas 2 channels To bring in informal means: Formalizing, means moving towards big cooperative structures of big buses or become official feeder buses to BRT Authority Attitude Especially towards chapas and their role, them being a necessity to the transport system Recognition of Chapas as vital part of transport system goal of integration Available funding/loans: Roadmap for chapas prospect & integration, will there be money available to benefit them: funding for road repairs, loans for new vehicles & maintenance etc Structure Lack of structure: weak associations, disorganisation, lack of discipline Standardization through e-ticketing, everyone needs to follow standard operating procedures, everything needs to be done in consistent way Neutrality having a Neutral, independent Party in place is important player for fair pricing with public interest in mind	Formalization bring level of formality & visibility that never existed before Allows govs to collect taxes Balance goes through operator: Revenue passes through Famba I Maxcom (gets share) I AMT (gets share) I operator/owner (if applicable) I drivers, conductors Service Improvement data collection for planning and service management, service quality up, no information withholding allows restructuring of services, reliable funding stream for AMT to fulfil tasks it's meant to do	Crew resistance People that didn't take much home in the first place now might have less coming in & higher risk of instability in income potential instability: player cooperation, will they cooperate? User inconvenience does cash removal negatively affect the users convenience (convenience of buying and topping up card), efficiency of boarding (getting on on front door, off at backdoor, what if only one door? Ergonomic and logistical problem?)
Informality Licensed means are formal Informal: unlicensed: mainly myLoves They don't obey anything, not regulated Gov tried to come up with new alternative to myloves: truck with tents and some sort of safety requirements, allowed in city centres Myloves will remain as long as road conditions are horrible in informal settlements and outskirt neighbourhoods Myloves are almost impossible to integrate infrastructure and road improvements are needed to bring formal transport to mylove territory, otherwise can't ban myLoves as they will pop back up	Formalization gov Control and organization of the transport by the gov	social exlusion Not everybody uses e payment or cards People from outside of Maputo have to use cards too to travel Poor people that live from daily budgets are almost excluded from Famba Old people: charging cards, extra trips etc

Chapas Chapas are the dominant transport mode wrong focus: Question should be phrased opposite way How to integrate formal modes into chapas system? find what works for chapas first Purpose Root: social, societal or urban problem that integration should address? physical integration what form of integration should be achieved? Providing interchange facilities at high demand transfer points/hubs Speculation: in future, paratransit will persist as long as cities keep on growing (in Africa) semi formal means will keep on proliferating Will be hard to integrate beyond physical stage		user inconvenience Mismatch between cash handling practices and view of academia, consultancies, policy circles who see digital payments as the way forward flawed view of peoples cash handling practices
Informality Recognition of the role of informal operators and transport services They supply the needed transport service for the population that the public services can't fullfil The system left the people behind, couldn't supply enough transport, so paratransit services filled the gap Cannot be avoided chapas are vital Structure Authorities Works both ways: enforce them to follow minimum rules, responsibilities to be integrated: like follow the routes, take care and provide safety for passengers Sensibilisize them to acknowledge they are part of a system includes role as a public service! support and enforce (both sides) them fulfilling that role Enforcement, Support	Reliable Pricing Buses are GPS tracked to allow precise validation process (at which stops passengers board and get off) and precise fare charge formalization Mapping of routes and fare prices of chapas is an important step towards formalization of Chapas Creates Proper transport system linked network Allows distribution of responsibilities and duties Allows to control and scale a growing system/city network Service Improvement better resource allocation, service planning due to transport and behavioural data Mobile top up possible	Operation Costs Expensive to operate and maintain compared to cash higher operating and infrastructure costs Dependency No capacity to produce own hardware, dependency on other countries/companies Pricing mobile top up for extra charge

Stakeholder Fragmentation Crew/staff on vehicles: conductors and drivers vs owners of chapas different objectives and mission Education Advantages have to be demonstrated to all sides I motivators, give them something they see as an improvement over current situation demonstration & education of advantages and their business case For owners: eg GPS tracking, supervision, transparency, control For conductors: motivation/concern is their income/cash, working relation, contract, formal employment with rights	Service improvement Data collection gives valuable information	User inconvenience Majority of trips paid for by qr codes (one price only, until final station, disadvantage for users still use qr code)
	Service improvement data available for planning and service management, service quality increase Transparency Visibility of cashflow & revenues Upside: level of formality & visibility that never existed before Tax collection Financing: more transparent and easier loaning process for owners, providers	Authorities Attitude of authorities towards chapas and their role, acceptance of chapas being a necessity to the transport system chapas should be moved into more formal bus and feeder bus roles as dominant part of transport system Covid huge negative effect on the roll out Stakeholder fragmentation Number of parties & relationships involved "COMPLETE CHANGE OF POWER STRUCTURE" "turning financing structure on its head" Resistance, some people will not be happy with that Change of Cashflow People that didn't take home in the first place (drivers, conductors, maintenance staff ...) now might have less coming in & higher risk of instable income Informality Bank accounts: to be banked you have to be known, legitimacy Some may want to stay out of banking system by choice to not be known to authorities or force (religious reasons, gender roles
	Standard, Expansion usable for all citizens and throughout city and municipal area other cities might adapt famba too, national standard potential for national expansion	Profitability Famba is owned and operated by PPP, incl. private company (maxcom) Lower prices might not be feasible as it is profit driven operation if not further subsidized

	Service improvement inclusion of most responsive form of transport for fast growing cities private sector inclusion	Authorities/Government Government involvement & planning "Faith in government of holding societies best interest at heart is extremely misplaced" Political machinery (milk corrupt money, ie in RSA) corruption Global agencies and outsiders, ngo's come with mindset that gov is good actor and doesn't need to be worried about Need to Recognize that, and move things along without gov if needed
	Reliable Pricing Buses are GPS tracked to allow precise validation process (at which stops passengers board and get off) and fare charge Service Improvement E-ticketing allows better resource allocation, service planning because of transport and behavioural data	Stakeholder Fragmentation all little parts and issues of the ticketing and transport system have to be taken care of high fragmentation of sector Crew Resistance Crew salary is not much! loss of complementary salary means problem for crew
	Digitalization Step towards digital economy & away from cash system User convenience opportunity for Move into micropayments, merchant payments Service improvement ads on platform/app far in future, additional revenue stream, Monetarization of travel data Improvement of service with live data & travel information	Stakeholder fragmentation Lots of work in change management required Will take longer than initially expected Lots of communication and work to be done with all stakeholders (govs, operators, owners, agencies, crews & passengers)

Extent to which Famba facilitates integration of paratransit
Inclusion Chapas, tuktuks are or semi-formal, have license and operate on routes, controlled to some extent Non-formal: motorcycle taxis, myloves etc Approved (in terms of quality and safety) operators can do last mile connections where roads are poor, unpaved emerging areas, within same payment system mobile payment mPesa (Vodafone owned) Keeps all structures as they were: conductors get money through qr code being scanned, money transferred to account of conductor All the same relations, structures are in place, minimal change Cost of loading and transferring money on mPesa is basically zero, compared to high bank transaction fees mPesa is not tracable, intransparent for authorities
Obstacle right now: famba makes integration of non-formal means into transport system harder formal system (famba) requires a bank account, informal only requires cash Financing Government finances, gives out loans for formal means (buses, chapas) but not informal means (myloves) only gov loans for formal means

key tool
"E-ticketing is one of the main tools to integrate informal transport into public transport system & network"
Chapas should not just be seen as a feeder for the structural public network, but give them more important role
This role is not defined yet

Revenue distribution
E-ticketing is tool to allow redistribution of profit and revenue making the system more profitable and transparent tracable cashflow

Understanding of Paratransit
data collection allows analysis of demand and behaviour enables better service planning

Understanding/Transparency of paratransit
Working on it being the most cost effective way to utilize existing infrastructure to integrate paratransit, especially chapas
Pilot of integrating digital infrastructure in chapas