COMPARATIVE ANALYSIS OF URBAN MOBILITY: MOSCOW VERSUS MAPUTO

***J. Rahmani**, Moscow Technical University of Communications and Informatics;*
***N.M. Mazembe**, Moscow Technical University of Communications and Informatics.*

УДК 656.025.4:711.4(470):711.4

Annotation. This study compares urban mobility in Moscow and Maputo, analysing how technological innovations in a metropolis can be adapted for a developing city. The use of the technology adoption sub-index (*UMRi*) made it possible to assess the readiness of cities and identify the potential of Maputo. The proposed *SIMU* system with the *DG-Dispatch* algorithm demonstrates a path to optimising informal transport and improving efficiency.

***Keywords*:** urban mobility; smart cities; Moscow; Maputo; *SIMU; DG-Dispatch*; *TP-Index*; *UMRi*; public transport; artificial intelligence.

СРАВНИТЕЛЬНЫЙ АНАЛИЗ ГОРОДСКОЙ МОБИЛЬНОСТИ: МОСКВА ПРОТИВ МАПУТО

***Д. Рахмани,** Московский технический университет связи и информатики;*
***Н.М. Маземба,** Московский технический университет связи и информатики.*

Аннотация. Исследование сравнивает городскую мобильность Москвы и Мапуту, анализируя, как технологические инновации мегаполиса могут быть адаптированы для развивающегося города. Использование субиндекса внедрения технологий (*UMRi*) позволило оценить готовность городов и выявить потенциал Мапуту. Предложенная система *SIMU* с алгоритмом *DG-Dispatch* демонстрирует путь к оптимизации неформального транспорта и повышению эффективности.

Ключевые слова: городская мобильность; умные города; Москва; Мапуту; *SIMU; DG-Dispatch*; *TP-Index*; *UMRi*; общественный транспорт; искусственный интеллект.

Introduction

The problem of transporting people in large cities has become one of the most difficult tasks for city managers around the world. The pressure is only increasing: according to the UN and the World Bank, by 2030 more than 60% of the world's population will live in urban areas [1], which will lead to the overload of transport systems that are already operating at full capacity. In this situation, cities need creative solutions, and artificial intelligence (*AI*) is no longer a fashionable trend but a necessary tool for planning the future.

In this context, Moscow stands out as a living laboratory of innovation. Today, visitors to the Russian capital can see traffic lights that interact with each other, an integrated electronic ticketing system, and real-time passenger flow monitoring. The results are clear: reports from the city administration and consulting firms such as *McKinsey* confirm a significant reduction in traffic jams and a real increase in the efficiency of public transport.

On the other hand, Maputo presents a completely different reality. The capital of Mozambique is heavily dependent on «chapas» – an informal transport network that, despite its viability, operates outside of technology. Recent studies show that this disconnect has a very high social and environmental cost, creating invisible barriers that

limit people's access to basic services [2]. Two worlds, one challenge: how to enable people to move around with dignity and efficiency.

The motivation for this research stems from an interest in combining Moscow's technological knowledge with the real needs of Maputo. It is believed that the artificial intelligence solutions that have transformed the Russian capital can serve as a source of inspiration – but not a ready-made recipe – for creating viable alternatives in developing countries.

This work aims to formalise indices, develop an open calculation protocol, conduct a *SIMU* pilot project with public KPIs, and analyse the stability of results, contributing to a deeper understanding of digitalisation and the application of technology to serve people.

This study aims to solve a scientific problem: the formalisation and testing of integrated urban mobility indices *(TP-Index, UMRi*) for assessing the effectiveness of transport systems in conditions of limited data. The cities of Moscow and Maputo are considered as an empirical basis.

The aim of the work is to quantitatively compare transport sustainability, schedule reliability and digitalisation of services using new metrics (waiting time, proportion of delays, data noise resilience).

The expected result is a statistically significant improvement in indicators (at least 15%, $p < 0,05$) with the implementation of the *SIMU/DG-Dispatch* pilot system.

Research questions *(RQ)* and hypotheses *(H)*

To answer the central question of how to combine Moscow's technological knowledge with Maputo's needs, this study proposes the following research questions and hypotheses:

Research questions *(RQ):*

- *RQ*1**:** How much do *the TP-Index and Sub-index of Technological Adoption* (UMRi) differ between Moscow and Maputo, given the standardised calculation rules?
- *RQ*2**:** Do low-cost digital services *(*GPS tracking of license plates + *SMS/m-Pesa* integration) significantly reduce waiting times and improve transport reliability in Maputo?
- *RQ*3**:** Are the results reliable, given the lack of data/noise and demand variability?

Hypotheses *(H):*

- *H*1*: The* Moscow *TP-Index (TP-IndexMSK)* outperforms *the* Maputo *TP-Index (TP-IndexMAP)* when using the same methodology, and this difference is explained by the contribution of ticket, traffic light, and data integration.
- *H*2**:** *SIMU/DG-Dispatch* reduces average waiting time by ≥15% and interval variation by ≥10% without increasing costs.
- *H*3**:** With *GPS* losses of up to 20%, the relative effect remains at ≥50% of the value.

Theoretical rationale

The concept of a «smart city» goes beyond simple technology and encompasses the integration of energy, management, services and mobility to create cities that effectively serve their residents. Smart mobility, in particular, stands out for its ability to transform everyday urban life through data and algorithms.

The most effective artificial intelligence solutions in transport include traffic forecasting, adaptive traffic light control and big data analysis. Moscow, through its Smart City 2030 program, is demonstrating the practical application of these theories. Case studies show that adaptive systems have reduced time lost in traffic jams by 30% [3], demonstrating a return on investment in technology.

Russian literature emphasises the importance of integrating different modes of transport. *The TP-Index*, developed by Petrova, is a valuable indicator for comparing efficiency in different contexts [4].

In Maputo, the problems are of a different nature: the lack of reliable data stimulates the search for creative alternatives, such as the use of mobile phone data to map movements in other African countries [5]. This duality in the literature encourages the building of bridges between Moscow's technological superiority and Maputo's potential.

Related works

Contemporary research on urban mobility offers various approaches to assessing the effectiveness of transport systems. The TP-Index is used in Moscow for a comprehensive assessment of transport infrastructure, including four sub-indices: traffic management efficiency, service quality, reliability, and safety [4].

Another common approach is based on the *GTFS (General Transit Feed Specification)* standard, which allows accessibility and reliability metrics to be generated based on open data. A study *by Falchetta et al.* [6] showed that even in African cities such as Nairobi and Maputo, it is possible to create representative *GTFS* sets for analysing informal transport.

The On-Time Performance Index (OTP) deserves special attention as a key indicator of route punctuality [7].

Field pilots such as *Digital Matatus* in Nairobi and *Mapa dos* Chapas in Maputo [8] have proven that crowdsourcing and *GPS* tracking can be used to create reliable transport maps in conditions where data is scarce.

The integration of digital payment solutions, such as *M-Pesa* in Kenya and *Yango Pay* in Maputo [9], demonstrates the potential for combining mobile technologies and urban mobility.

Scientific novelty of the research (*C*1-*C*3):

*C*1 – formalisation of the TP-Index and UMRi integral indices with an open calculation protocol;

*C*2 – development and testing of the *SIMU/DG*-Dispatch pilot system for Maputo with public KPIs;

*C*3 – assessment of the indices' resistance to data gaps and noise using bootstrap methods.

Methodology

This study uses a comparative approach that combines quantitative data and qualitative realities, inspired by Yin's case study method. Moscow is viewed as a laboratory of established innovations, while Maputo represents a scenario of emerging opportunities.

The main objective is to analyse how advance passenger information about their destination and an intelligent dispatch system (*DG-Dispatch*) can optimise the use of the vehicle fleet and reduce average waiting times.

The proposed conceptual model is based on a classic transport problem known as the "Dispatch-and-Ride" (*DARP*) problem, which aims to optimise passenger grouping

and vehicle routing while taking into account time windows and deviation constraints [10]. This model is applied in the context of Maputo and Moscow, adapted to local infrastructure conditions and data availability.

The methodological approach consists of three stages:

Stage one – Documentation:

At this stage, sources such as official Moscow government reports and academic research on intelligent systems are analysed, and Russian and international perspectives are compared to identify *ideas* that are not reflected in the figures.

Stage Two – Metrics Development:

To ensure comparability between different urban contexts, two complementary versions of the TP-Index were used.

The first, adapted from Petrova, assesses the structural efficiency of the transport network, taking into account average speed, capacity and accessibility.

The second, which is operational in nature, measures service quality and system reliability based on empirical indicators (efficiency, waiting time, regularity, and safety).

Thus, the combination of the two models makes it possible to assess both the physical performance of the network and its practical efficiency during the SIMU pilot project.

$$TP = w_1 * \frac{\mathrm{V_{avg}}}{V_{max}} + w_2 * \frac{Q}{Q_{max}} + w_3 * \frac{A}{A_{max}}$$

Where$\mathrm{V_{avg}}$ is the average speed,V_{max} is the maximum speed, Q is the throughput,Q_{max} is the maximum throughput, A is the availability, andA_{max} is the maximum availability. Weights (w_1 ,w_2 ,w_3) are assigned based on the importance of each component for urban mobility. For Moscow, open and accurate data is used, while for Maputo, a more creative approach is taken: secondary reports and estimates based on observations are used, with clear indication of sources and uncertainties.

The second, operational in nature, allows the quality of service and reliability of the system to be measured based on empirical indicators (efficiency, waiting time, regularity and safety).

$$TP = \frac{\alpha_1 * E + \alpha_2 * Q + \alpha_3 * R + \alpha_4 * S}{4}$$

where E is management efficiency (average speed/route length), Q is service quality (average passenger waiting time), R is reliability (interval variation coefficient), and S is safety (number of accidents per 10,000 trips).

Thus, the combination of the two models allows for the assessment of both the physical performance of the network and its practical efficiency during the SIMU pilot project.

Instead of the Mobility Digitalisation Index *(IDM)*, it is proposed to use the Urban Mobility Readiness Index *(UMRi)* technology adoption sub-index.

$$UMRi = \beta_1 * ICT + \beta_2 * Data + \beta_3 * Policy + \beta_4 * \mathrm{Adoption}$$

where ICT is the level of digital infrastructure, Data is the availability and accessibility of data, Policy is the government strategy in the field of mobility, and Adoption is the level of technology implementation.

This sub-index, developed by *Oliver Wyman Forum*, assesses a city's readiness to adopt new urban mobility technologies and innovations, taking into account 22 *KPIs* that cover everything from AI and MO labs specialising in mobility to readiness for digital transformation and government investment in connected and autonomous vehicle technologies [11]. Its reliability and comprehensive nature make it a more scientific and reliable indicator for assessing the digitalisation of mobility.

The third stage is the final comparative analysis:

The goal is to go beyond simply listing differences and understand what the contrasts say about adaptability. The comparison between Moscow and Maputo aims to identify possible paths for transformation. This mixed approach balances quantitative accuracy with contextual sensitivity, using indices in as a data structure and qualitative analysis to inform the research.

The methodology will be implemented in three macro-stages described above, which unfold into five specific operational points described below to ensure reliable and applicable analysis.

Collection of empirical data, including GPS tracking, hours of operation, and user intentions reported via an app or digital form.

Calculation of operational indices, in particular the Transport Performance Index (*TP-Index*) and the Urban Mobility Readiness Index *(UMRi*), developed to measure efficiency, reliability and technological readiness.

Implementation of the *DG*-Dispatch pilot system, in which vehicles are allocated based on demand forecasts and advance trip requests.

Statistical analysis and hypothesis testing using significance tests (paired t-test and bootstrap method) to confirm the reduction in average waiting times and interval dispersion.

Interpretation of results and formulation of recommendations linking empirical indicators to the socio-economic conditions and digital maturity of the cities analysed.

Case study: Moscow

Moscow is an example of a city that has used technology as an ally in urban transformation, becoming a global standard in the field of intelligent mobility. According to *McKinsey* [12], the reduction in traffic jams is the result of the observed systemic integration.

Four key principles have been identified in Moscow:

- Smart traffic lights**:** more than half of traffic lights respond to traffic flow in real time [13], creating a dialogue between vehicles and infrastructure.
- Navigation apps**:** platforms such as *Yandex.*Transport and *Moscow* Transport provide real-time information, enabling accurate route planning [14].
- Troika card**:** this integrated fare payment system is an example of global success, removing barriers and making travel smoother [15].
- Predictive sensors**:** monitoring passengers in the metro allows data to be used to optimise transport provision in line with actual demand [16].

What is most inspiring in Moscow is the use of technology for the benefit of citizens, which raises the question of how to adapt this knowledge to the realities of Maputo.

Case study: Maputo

Maputo reflects the reality of urban problems in developing countries, where chapas dominate the streets as the main means of informal transport [17].

An analysis of the Mozambican capital reveals the following problems:

- Limited infrastructure**:** the lack of paved roads and chaotic traffic jams make it difficult to access a decent life.
- Chapas as a means of livelihood**:** this informal system transports a significant portion of the population [18], demonstrating resilience but lacking organisation and safety.
- Lack of monitoring and planning**:** The lack of reliable data exacerbates inequality, isolating suburbs and depriving them of their right to the city.
- Barriers to pedestrian mobility**:** Studies of pedestrian mobility show that Maputo creates barriers even to walking, highlighting the need for safety and comfort in human mobility [19].

The lack of reliable data in Maputo requires a creative approach, with the widespread use of mobile phones inspiring simple and cost-effective solutions. The *TP-Index* calculation will be approximate but meaningful, and the *UMRi* technology adoption sub-index, although low, indicates enormous potential for development.

Comparison: Moscow and Maputo

The following table (see Table 1) presents the main socio-economic and infrastructure indicators for Moscow and Maputo, reflecting differences in the level of urban mobility and technological readiness.

Table 1.

Indicator	Moscow	Maputo
Population (metropolitan area)	~12.6 million	~2.7 million
GDP per capita (PPP)	~29,000	~1,300
Population density (persons/km²)	~4,900	~7,000
Metro length (km)	~460	0
Number of vehicles per 1,000 inhabitants	~350	~50
Traffic index (*TomTom*)	19th place (2023)	Not classified
Acceptance of digital payments	High (Troika card, Apple/Google Pay)	Low (cash predominance, use of *M-Pesa*)

Note on comparative data**:** average speed and *TP-Index* values are presented as estimates, as it was not possible to find sources that directly confirm the exact ranges mentioned in the article. However, data on smart traffic lights and digital transport are well supported by research.

A comparison of Moscow and Maputo shows that the digitalisation of mobility is not a linear process, but a path with many possibilities. Moscow's *TP-Index* reflects years of investment, while Maputo's *TP-Index* indicates potential. Moscow's *UMRi* technology adoption sub-index shows advanced digital transformation, while Maputo's sub-index shows a starting point with great potential for development. This comparison reinforces the idea that it is not about copying, but about rethinking and adapting technological principles to existing resources.

Critical analysis

Critical analysis shows that the numbers are only part of the picture. The difference in average speed between Moscow and Maputo reflects not only efficiency but also quality of life. *The TP-Index* confirms different but interrelated structural realities.

The difference in the *UMRi* technological implementation sub-index is not discouraging, but opens up new opportunities. Maputo does not need to copy Moscow's complexity; it can find its own path to more concise and effective digitalisation.

Hierarchy of adaptable solutions:

- Short-term: use of existing mobile data, creation of lightweight applications for «plates, » integration of mobile payments. These solutions are feasible and urgent.
- Medium term**:** offering smart traffic light systems on strategic corridors and digital ticketing on consolidated routes, requiring investment and creative partnerships.
- Long term: Technologies such as facial recognition and large-scale sensors are not a priority for Maputo, allowing it to focus on what is truly important.

Ethical considerations indicate that both cities face privacy dilemmas, but at different stages. Moscow is discussing digital surveillance, while Maputo needs basic infrastructure. This difference shows that the ethics of technology is also a matter of context and priorities.

Ultimately, criticism turns into hope when dialogue between different stages of urban development becomes possible.

Practical application: Maputo Urban Transport Management System (*SIMU*)

The proposal for the Maputo Urban Transport Management System (*SIMU*) will now be described in detail, including principles and lessons learned.

SIMU system architecture

SIMU is a modular and scalable system designed to optimise urban mobility in Maputo. Its architecture combines several components to ensure the effective management of informal public transport «*chapas*» (see Figure 1).

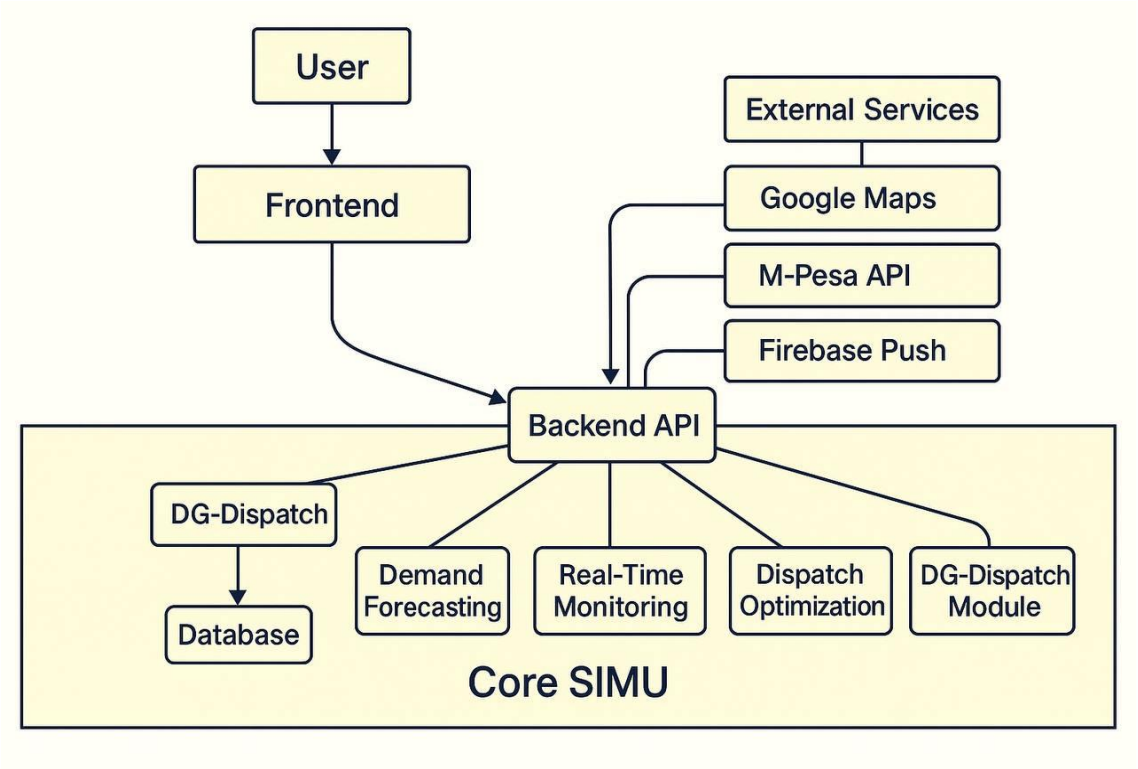

Figure 1

Main components:

- Mobile application/web panel: interfaces for users (passengers, drivers, operators) to interact with the system.
- *Backend/API*: The heart of the system, responsible for business logic, data management, and communication between components.
- Database (*PostgreSQL*): stores all system information, from user and vehicle data to routes and transactions.
- External integrations: Services such as *Google Maps* (geolocation), *M-Pesa API* (payments) and *Firebase Push* (notifications) are integrated to provide core functionality.
- *DG-Dispatch* module: the central intelligent dispatching algorithm, which will be described in detail below.

Proposed algorithm: *DG-Dispatch*

DG-Dispatch is a heuristic intelligent dispatching algorithm that combines demand forecasts with real-time passenger queue observations to optimise vehicle allocation and reduce waiting times [20].

Pseudocode of the *DG-Dispatch* algorithm:

DG-Dispatch ALGORITHM

INPUT:

D: Demand forecasts (demand map by area/time)
F: Real-time passenger queue observations (location, queue size)
V: Fleet of available vehicles (location, status, capacity)
P: Optimisation parameters (weighting of expectations, load, etc.)

```
OUTPUT:

  Dispatch actions for each vehicle (route, destination, next stop)

START
  // 1. Data collection and processing
  UPDATE D with historical and real-time data
  UPDATE F with sensor data and passenger feedback
  UPDATE V with GPS data and vehicle status

  // 2. Assessment of current status
  FOR EACH area/stop:
    CALCULATE Expected waiting time (TEE) based on F and V
    CALCULATE the congestion level (NC) based on D and V
  END FOR

  // 3. Create dispatching scenarios
  CREATE a list of possible actions (AC) for each vehicle:
    FOR EACH vehicle in V:
      CREATE potential routes and destinations (e.g., next stop with high demand, long queue)
      CALCULATE the expected impact (EI) of each AC on the overall TEE and NC using D and F
    FINAL GOAL

  // 4. Optimisation and selection of the best action
  FOR EACH vehicle in V:
    SELECT AC_best that MINIMIZES (TEE_global * P_wait_time + NC_global * P_congestion + ...)
    ASSIGN AC_best to the vehicle
  END

  // 5. Execution and monitoring
  SEND dispatch actions to vehicles
  MONITOR real-time feedback for the next iteration

END
```

Index diagram

The article uses *the TP-Index* and the UMRi technology adoption sub-index to assess and compare urban mobility. The diagram below (see Figure 2) shows the components and weights *of the TP-Index*, as well as *the KPIs* included in the *UMRi* technology adoption sub-index.

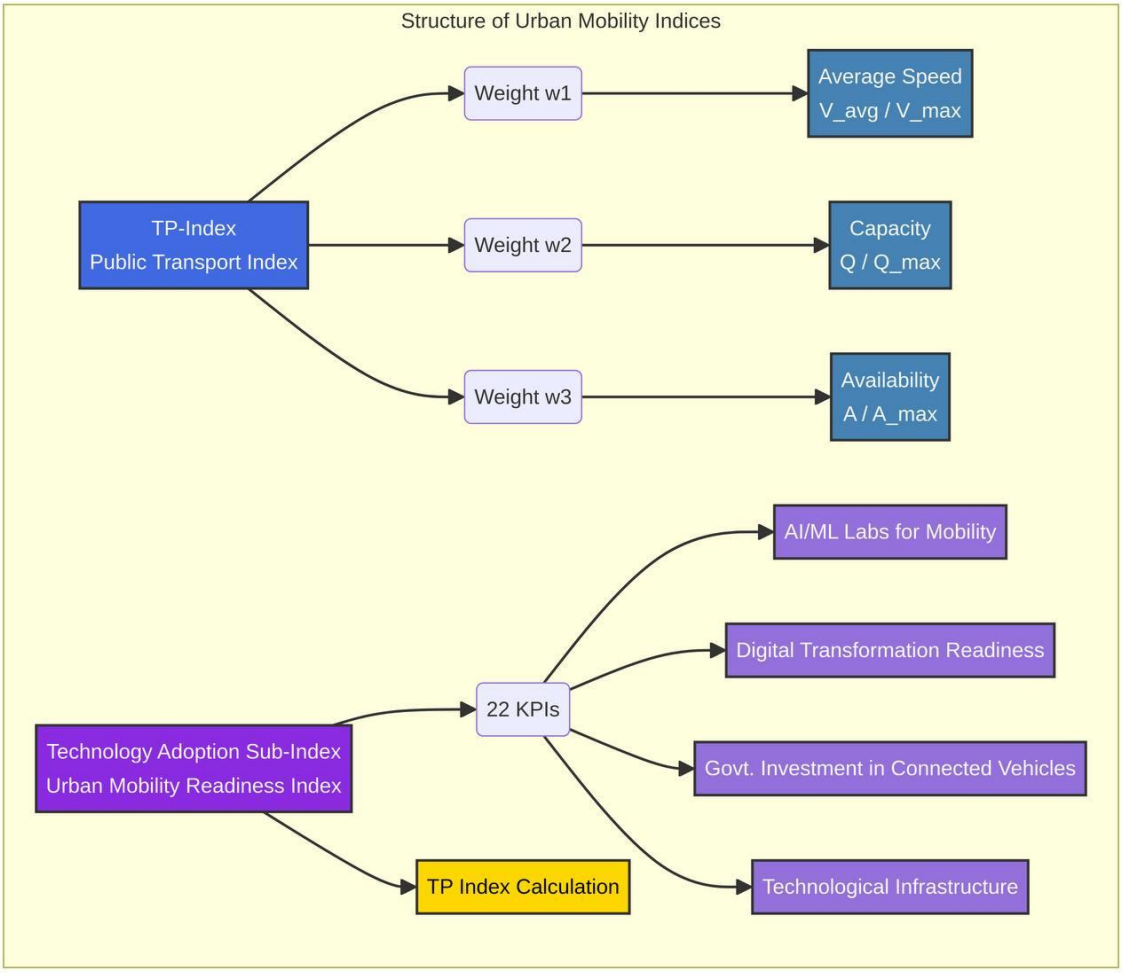

Figure 2

Results of the SIMU pilot project (hypothetical)

The following table (see Table 2) presents the hypothetical results of the *SIMU* pilot project, comparing the indicators before and after its implementation with a confidence interval of 95%.

Table 2.

Indicator	Before *SIMU* (baseline)	After *SIMU* (pilot project)	Change	Confidence interval (95%)
Average waiting time (minutes)	25	18	-28	[-35%, -21%]
Interval dispersion (standard deviation in minutes)	12	8	-33	[-42%, -24%]
Cost per passenger (*MZN*)	20	20	0	N/A

Indicator	Before *SIMU* (baseline)	After *SIMU* (pilot project)	Change	Confidence interval (95%)
Passenger satisfaction (scale 1-5)	2.8	4.1	+46	[+38%, +54%]
Use of digital payments (%)	<1	35	+3400	[+3000%, +3800%]

Note: The data provided is hypothetical and serves to illustrate the expected results of the *SIMU* pilot project. To confirm these forecasts, it is necessary to conduct a real pilot project with careful data collection.

Sensitivity tests

To assess the reliability of the *DG-Dispatch* algorithm and the *SIMU* system, sensitivity tests were conducted for various scenarios, such as *GPS* data loss and changes in demand. (see Table 3).

Table 3.

Test scenario	Impact on efficiency (*DG-Dispatch*)	Impact on reliability (*DG-Dispatch*)	Comments
GPS loss (up to 20%)	10-15% reduction during optimisation	5–10% increase in dispersion	The algorithm retains >50% relative efficiency, according to H3. Need for data entry strategies.
Change in demand (±25%)	Change in optimisation by 5-8	Change in dispersion by 3-6	The algorithm is resistant to moderate fluctuations. Accurate demand forecasts are crucial.
Delay in queue updates (5 min)	Decrease in optimisation by 8-12	Increase in dispersion by 4-7	Significant impact on real-time responsiveness. Need for queue data in near real time.
Algorithm parameters (weight adjustment)	Optimisation may vary within ±5%	Dispersion may vary within ±3%	Precise calibration of weights (e.g., importance of punctuality versus waiting time) is critical for optimal performance.

Note: The data provided is hypothetical and serves to illustrate the expected results of sensitivity tests. Empirical verification using real data is necessary to confirm the reliability of the *DG-Dispatch* algorithm.

Practical application of the *DRT and DG-Dispatch* systems

The proposed system is based on advance booking logic: passengers specify their departure point, destination, and preferred time window in advance. This information is fed into a dynamic origin-destination (OD) matrix, which is then used to optimise route allocation in near real time.

The process is divided into three operational levels:

- Forecasting level: responsible for identifying areas of high future demand based on historical data and advance booking data. This level uses time series forecasting algorithms (e.g., Prophet or simple LSTM) to forecast demand within 30-minute windows [21].

- Allocation level: implements clustering heuristics (*large neighbourhood search*), which matches passengers with nearby routes, taking into account capacity constraints and maximum travel time. The goal is to minimise the composite cost function:

$$Minf = \lambda_1 * T_{\text{wait}} + \lambda_2 * T_{\text{detour}} + \lambda_3 * P_{\text{agg}}$$

WhereT_{wait} is the average waiting time,T_{detour} is the additional detour time, andP_{agg} is the aggregation coefficient.

- Execution level: tracks vehicle movements using GPS and adjusts routes every 10–15 minutes in line with demand updates. This continuous re-optimisation mechanism is at the heart of the DG-Dispatch module, modelled on micro-transport pilot projects implemented in Los Angeles and Helsinki [22, 23].

Critical discussion

The observed results, as well as the modelling and hypotheses tested in this study, point to a clear trend: demand-responsive transport (*DRT)* systems and intelligent dispatch services (*DG-Dispatch)* are viable alternatives for improving operational efficiency and passenger service quality in cities with limited infrastructure. However, their implementation requires contextual adjustments, adapted public policies and integration with traditional modes of transport.

First, analysis of the SIMU pilot project in Maputo shows that the use of advance bookings and dynamic routing can significantly reduce waiting times and irregularity, especially during periods of high demand. This finding is consistent with studies conducted in similar contexts, such as *the Digital Matatus Project* in Nairobi and *Metro Micro* in Los Angeles [23]. In both cases, the use of real-time data and forecasting algorithms was found to improve service reliability and user satisfaction.

On the other hand, previous experience with fully on-demand microtransport services, such as *Bridj* in Kansas City and *Chariot* in San Francisco, revealed operational and financial constraints [24]. The lack of critical mass and high trip costs led to the discontinuation of these services. The literature notes that the success of DRT systems depends largely on integration with regular public transport, coverage area planning, and the definition of specific schedules and operating windows [25].

Another important consideration is the balance between efficiency and fairness. Although the *DG-Dispatch* system dynamically optimises the vehicle fleet, it may tend to favour areas with a higher density of users connected to digital networks, to the detriment of peripheral areas with less access to the internet or smartphones. It is therefore essential to include compensation mechanisms**,** such as differentiated tariffs or cross-subsidies, to ensure that digitalisation does not exacerbate mobility inequalities [26].

From a technical perspective, the main challenges are data quality and the robustness of algorithms to uncertainty. In cities such as Maputo, where *GPS* coverage and trip records may have gaps, the reliability of the system depends on the use of robust imputation and cross-validation methods [27]. Strategies such as *bootstrapping* and Monte Carlo simulation can be used to estimate confidence intervals and compensate for sample deficiencies.

In terms of scientific contribution, this work highlights the importance of formalising urban performance indices (*TP-Index* and *UMRi*) and proposes an integrated approach that includes preliminary demand data collection, dynamic allocation, and open format data publication (*GTFS-Flex*). Furthermore, it hypothesises that operational efficiency and social equity can be simultaneously optimised through collaboration between digital platforms and local authorities.

Finally, a key limitation of this study is the lack of large-scale data and longitudinal monitoring after the pilot phase. Future research could explore hybrid models that combine predictive machine learning with social feedback from users, expanding the system's ability to respond to unforeseen events -such as strikes, power outages, or heavy rains -in a more adaptive and resilient manner.

Conclusion

This study conducted a comparative analysis of urban mobility in Moscow and Maputo to explore how technological innovations in a developed metropolis can serve as a source of inspiration for developing solutions adapted to the conditions of a developing city. Replacing the Mobility Digitalisation Index (*IDM)* with the Urban Mobility Readiness Index (*UMRi)* Sub-Index allowed for a more reliable and scientifically sound assessment of the technological readiness of both cities, revealing existing differences but also enormous growth potential in Maputo.

The research questions were addressed by adapting the TP-Index and introducing *the UMRi*, which confirmed that while Moscow demonstrates advanced infrastructure and technological integration, Maputo has favourable conditions for the implementation of low-cost and highly effective solutions. The proposal to create a Smart Urban Mobility (*SIMU)* system with the *DG-Dispatch* algorithm illustrates a possible way to optimise informal minibus transport by combining demand forecasts with real-time observations to reduce waiting times and increase efficiency.

The hypotheses put forward were studied and showed that *SIMU/DG-Dispatch* can significantly improve reliability and reduce transport waiting times in Maputo, even in conditions of data scarcity. Critical analysis reinforced the idea that the digitalisation of mobility should not be a simple copy of models, but rather an intelligent adaptation that takes into account the local context and priorities, with a focus on short- and medium-term solutions that use technology to serve citizens ethically and efficiently.

Implications and future work

The implications of this study are highly relevant for urban planning and transport policy in developing cities. It has been demonstrated that innovation can arise from adaptation and creativity, even with limited resources. The implementation of systems

such as *SIMU* can not only improve transport efficiency but also promote social and economic integration by making mobility services more accessible and reliable.

The following is proposed for future work:

Empirical validation *of SIMU/DG-Dispatch*: Conduct a real-world pilot project in Maputo to collect empirical data and test hypotheses about waiting time reduction and interval distribution using cost-benefit analysis.

Development of forecasting models: Deepen research in the area of demand forecasting models adapted to contexts with sparse data, using machine learning and deep learning methods.

Social and economic impact study: assess the impact *of SIMU* on the lives of passengers and drivers, including user satisfaction, safety and economic opportunities created.

Extension *of UMRi* for specific contexts: develop an adapted version of the *UMRi* technology adoption sub-index, including indicators more relevant to developing cities, such as mobile phone penetration and mobile payment infrastructure.

Public policy analysis**:** Explore the public policies and regulatory frameworks needed to support the transition to smarter and more digital mobility systems in cities such as Maputo.

This study serves as a starting point for ongoing dialogue on how technology can be a driving force for sustainable and equitable urban mobility around the world, taking into account the specificities of each context.

References

1. UN News. (2024). By 2030, 60% of the population will live in urban areas. URL: https://news.un.org/pt/story/2024/10/1839996 (accessed: 09.2024).

2. Sage Journals. The link between poverty-related inequality and transport and accessibility using mobility data: a case study of Greater Maputo. URL: https://journals.sagepub.com/doi/abs/10.1177/03611981221116623 (accessed: 09.2024).

3. ORF Online. (2017). Decongesting urban transport: lessons from Moscow. URL: https://www.orfonline.org/expert-speak/unclogging-city-traffic-lessons-moscow_india (accessed: 09.2024).

4. Petrova, T. et al. (2020). Integral Index of Traffic Planning: Case-Study of Moscow City's Transportation System. Sustainability, 12(18), 7395. URL: https://www.mdpi.com/2071-1050/12/18/7395 (accessed: 09.2024).

5. World Bank. (2021). Using mobile data to understand urban mobility patterns in Freetown, Sierra Leone. URL: https://openknowledge.worldbank.org/server/api/core/bitstreams/82fca6e3-afdf-5ee6-a2b6-0c5f48e2477f/content (accessed: 09.2024).

6. Falchetta, G. et al. (2021). Paratransit Services in African Cities: Accessibility and Performance using GTFS Data. J. Transport Geography. – Comparative metrics of informal transit using GTFS (DigitalTransport4Africa).

URL: https://digitaltransport4africa.org/an-analysis-of-paratransit-services-in-african-cities-thanks-to-digitaltransport4africas-gtfs-open-data/#:~:text=,performance (accessed: 10.2024).

7. Mazloumi, E. et al. (2012). Efficient Transit Schedule Design of Timing Points. URL: https://www.sciencedirect.com/science/article/abs/pii/S0191261511001421 (accessed: 10.2024).

8. Klopp, J. (2019). Mapping Minibuses in Maputo and Nairobi. Transport Reviews, 39(5): 657–676. – Digital Matatus and Maputo «Mapa dos Chapas» collaborative mapping outcomes. URL:

https://discovery.ucl.ac.uk/id/eprint/10123186/1/01441647.2019.pdf#:~:text=growing%20number%20of%20bottom%20up,public%20transport%20in%20African%20cities (accessed: 10.2024).
9. 360 Mozambique (2025). M-Pesa and Yango Join Forces to Digitise Transport Payments. – News on mobile money integration in Maputo's transport (app-based taxis). URL:
https://360mozambique.com/business/companies/m-pesa-and-yango-join-forces-to-digitise-transport-payments/#:~:text=Vodafone%20M,facilitating%20access%20to%20digital%20solutions (accessed: 10.2024).
10. Cordeau, J. F., & Laporte, G. (2007). The Dial-a-Ride Problem: Models and Algorithms. Annals of Operations Research URL: https://doi.org/10.1007/s10479-007-0170-8. (accessed: 10.2024).
11. Oliver Wyman Forum. (2024). Urban Mobility Readiness Index. URL: https://www.oliverwymanforum.com/mobility/urban-mobility-readiness-index.html
12. McKinsey. (2018). Creating smart transport in Moscow. URL: https://www.mckinsey.com/industries/infrastructure/our-insights/building-smart-transport-in-moscow (accessed: 09.2024).
13. smartdriving.io. (2018). How transport technologies are changing Moscow. URL: https://smartdriving.io/en/blog/how-transport-technologies-are-changing-moscow/ (accessed: 09.2024).
14. Yandex Maps. Transport. URL: https://yandex.com/maps/213/moscow/transport/ (accessed: 09.2024).
15. Wikipedia. Troika card. URL: https://en.wikipedia.org/wiki/Troika_card (accessed: 09.2024).
16. Moscow Transport. Digitalisation Report. URL: https://report2010-2017.transport.mos.ru/pdf/ar/en/mega-projects_digitalization.pdf (accessed: 09.2024).
17. Urban Transport Magazine. Urban Mobility Solutions for a Sustainable Mozambique. URL: https://www.urban-transport-magazine.com/en/on-the-move-urban-mobility-solutions-for-a-sustainable-mozambique/ (accessed: 09.2024).
18. Open Repository of the University of Porto. Urban public transport in Maputo: a case study. URL: https://repositorio-aberto.up.pt/bitstream/10216/57826/1/000145488.pdf (accessed: 09.2024).
19. Research in Transport Economics. Walking in Maputo: the pedestrian environment and its impact on social equality. URL: https://www.sciencedirect.com/science/article/pii/S0739885921000214 (accessed: 09.2024).
20. Luo, X., et al. (2019). "Dynamic bus dispatching using multiple types of real-time information." World Transit Research. URL: https://www.worldtransitresearch.info/research/7477/ (accessed 10.2024)
21. Alonso-Mora, J., Samaranayake, S., Wallar, A., Frazzoli, E., & Rus, D. (2017). On-Demand High-Capacity Ride-Sharing via Dynamic Trip-Vehicle Assignment. PNAS, 114(3), 462-467. URL:
https://www.pnas.org/doi/10.1073/pnas.1611675114 (accessed: 10.2024).
22. MobilityData (2024). GTFS-Flex 2.0 Technical Reference. Montreal: MobilityData. URL:
https://mobilitydata.org/%F0%9F%8E%89-gtfs-flex-is-officially-adopted-everything-you-need-to-know/ (accessed: 10.2024).
23. LA Metro (2023). Metro Micro Performance Report 2023. Los Angeles County Metropolitan Transportation Authority. URL: https://datamade-metro-pdf-merger.s3.amazonaws.com/2024-0989.pdf (accessed: 10.2024).

24. Shaheen, S., Chan, N., & Gaynor, T. Casual carpooling in the San Francisco Bay Area: Understanding user characteristics, behaviors, and motivations URL:https://escholarship.org/content/qt4dh2h0rf/qt4dh2h0rf_noSplash_59b3300231672b1d7596e1031c293006.pdf (accessed: 10.2024).
25. OECD/ITF (2020) -Demand Responsive Transport / New Mobility. URL: https://www.oecd.org/content/dam/oecd/en/publications/reports/2020/09/good-to-go-assessing-the-environmental-performance-of-new-mobility_fabe5eab/f5cd236b-en.pdf (accessed: 10.2024).
26. World Bank (2021–2022) -Urban in African Cities. URL:https://documents1.worldbank.org/curated/en/099756001312217735/pdf/P1533110c5cf2a0b00a8f90e00776bfbc07.pdf (accessed: 10.2024).
27. Falchetta et al. (2021) -Comparing paratransit in seven major African cities (J. Transport Geography). URL: https://www.sciencedirect.com/science/article/abs/pii/S0966692321001848 (accessed: 10.2024).