Findings

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TRANSPORT FINDINGS

Coverage versus Frequency: Exploring Service Variability among Informal Public Transport Operators in South Africa

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Findings

Informal public transport operators often make routing and dispatch decisions on the fly, as demand and traffic conditions change. This may cause highly variable and unpredictable services for passengers. This paper examines variability in spatial coverage, route alignment, and service frequency over time and space using GPS data in a medium-sized city. We propose using a GINI coefficient to measure the spatial concentration of services. While considerable variation exists, consistent high-frequency routes exist where many services are concentrated throughout the day. In lower demand areas service availability and routes vary much more, causing significant variations in service provision by direction.

1. Questions

Coverage versus frequency is a fundamental trade-off in public transport planning (Walker 2024). In many global South cities, informal transport (paratransit or shared taxi) lacks central coordination, meaning individual drivers continuously make this trade-off through their route and departure time decisions. The result may be demand responsive but highly variable service offerings.

Recent research on paratransit has examined speeds and travel times (Ukam et al. 2023; Nyaki, Bwire, and Mushule 2020), service types (Du Preez, Zuidgeest, and Behrens 2019), passenger service quality (Ankunda and Venter 2025), and efficiency (Ndibatya and Booysen 2020). In Sub-Saharan African cities, findings indicate that while services provide widespread coverage (Falchetta, Noussan, and Hammad 2021), they can be highly variable and inefficient (King et al. 2019; Saddier and Johnson 2018; Dumedah et al. 2023).

Understanding the characteristics, causes, and implications of service variability requires a more in-depth look at individual cases. This paper examines how spatial coverage, route alignment, and vehicle frequency vary over time and space, and how it affects the concentration of services offered to passengers in a medium-sized city in South Africa.

2. Methods

Data comes from GPS-tracked minibus taxis, 16-seater vehicles providing the bulk of public transport in the city of Rustenburg (population 600,000). The city has a small Central Business District (CBD) surrounded by lower density neighbourhoods. While implementing a new bus system, the city tracks 47 minibuses operating in the northwestern quadrant (Maseko 2024). The taxis hold area-based licenses and drivers can choose service patterns at will (Chetty et al. 2024).

We obtained 10-second GPS data for 30 minibuses tracked over seven days in December 2023, covering 1069 trips (524 inbound, 545 outbound). Most trips (80%) start or end at a central taxi rank (terminal) in the CBD (c in Figure 1). We used the furthest point on each round trip as the cut-off between the outbound and inbound segments. One-way route lengths range from 4.7 to 8.2 kilometers.

We firstly plot taxi frequencies using bandwidth plots to visualize service areas and volumes. To identify important routes more clearly, we develop simplified route plots categorizing frequent routes into medium (8-16 vehicles/hour), high (16-24), and very high frequency (24-32) bands.

Next, we develop three indicators of service distribution:

- Total service area: The area covered by taxi services within a 400 meter (Kittleson & Associates Inc. 2013; Van Soest, Tight, and Rogers 2020) walking distance from taxi routes. Since taxis do not stop at designated stops, stop spacing is irrelevant. The focus is on overall territorial coverage.
- Average frequency: The average frequency (weighted by route length), in vehicles per hour, relates both to capacity and passengers waiting times.
- Service concentration: We plot a Lorentz curve reflecting the cumulative percentage of street segments receiving less than a given percentage of services (by frequency). We then calculate a GINI coefficient, normally used to measure income inequality (Dorfman 1979), to express how equally services are distributed across space. The coefficient varies between 0 (when taxi services are uniformly distributed across all roads in the service area), and 1.0 (for perfect inequality, where all services are concentrated on a single road segment while no other roads receive any service).

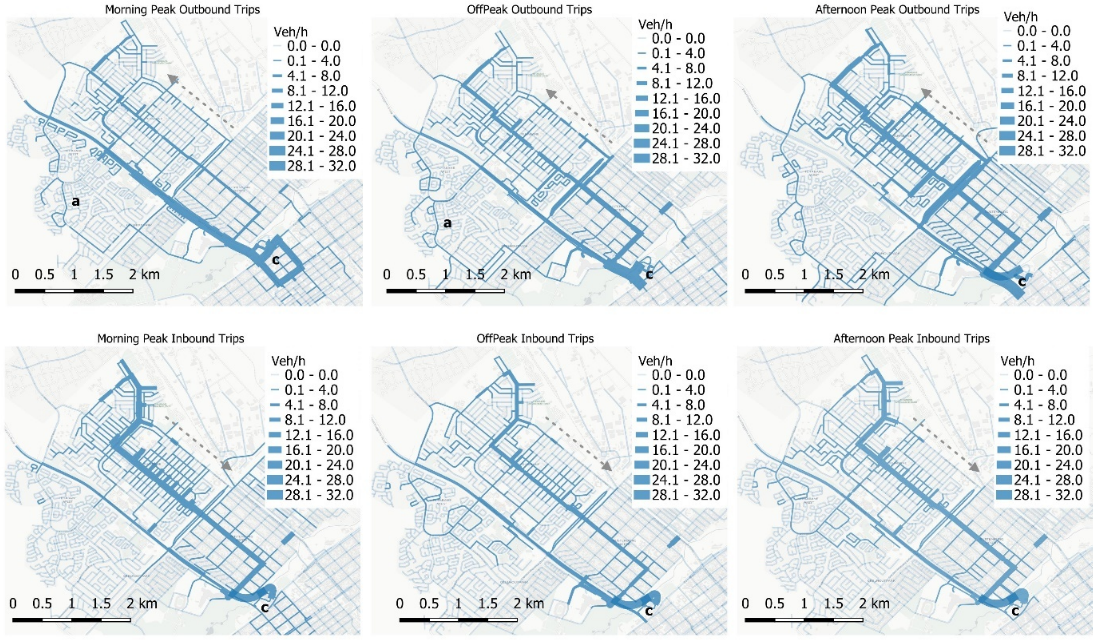

Figure 1. Routes of tracked vehicles per direction and time period. Width of plot shows observed frequency per street segment (c=CBD; a=south-west).

3. Findings

Taxi services vary considerably across space and time (Figure 1). While some high frequency routes are evident, many services are dispersed across minor roads with inconsistent patterns. This creates sometimes stark differences between inbound and outbound services within the same period of the day. For example, in the outbound direction, operators serve areas to the southwest (a in Figure 1) at low frequencies, but avoid them inbound.

Visual observations of passenger pickup patterns explain why. Inbound, passengers tend to cluster at dense pickup points at the start of routes and near major roads, taxis are fuller, and drivers follow the most direct routes to town in “express” mode. On the outbound trip, passenger destinations are more dispersed, and taxi drivers are willing to deviate onto minor roads within neighbourhoods to drop off passengers and to search for new ones.

As a result, the total service area is about 40% smaller inbound than outbound (Table 1). Some passengers receive highly unequal service depending on their direction of travel: going inbound, they face either longer walking distances or time-consuming, circuitous trips after boarding a taxi going in the “wrong” direction.

The differences between peak and off-peak periods, for the same direction, are less stark. While the service area contracts slightly off-peak as fewer routes are operated, average frequencies remain similar throughout the day (Table

Table 1. Summary indicators by time period and direction

	Total service area (km^2)	Average frequency (veh/h)	Service concentration (GINI coefficient)
AM Outbound	12.862	3.7	0.879
AM Inbound	7.206	3.3	0.713
OP Outbound	11.791	3.6	0.877
OP Inbound	7.103	3.7	0.825
PM Outbound	12.349	4.2	0.810
PM Inbound	7.345	4.1	0.814

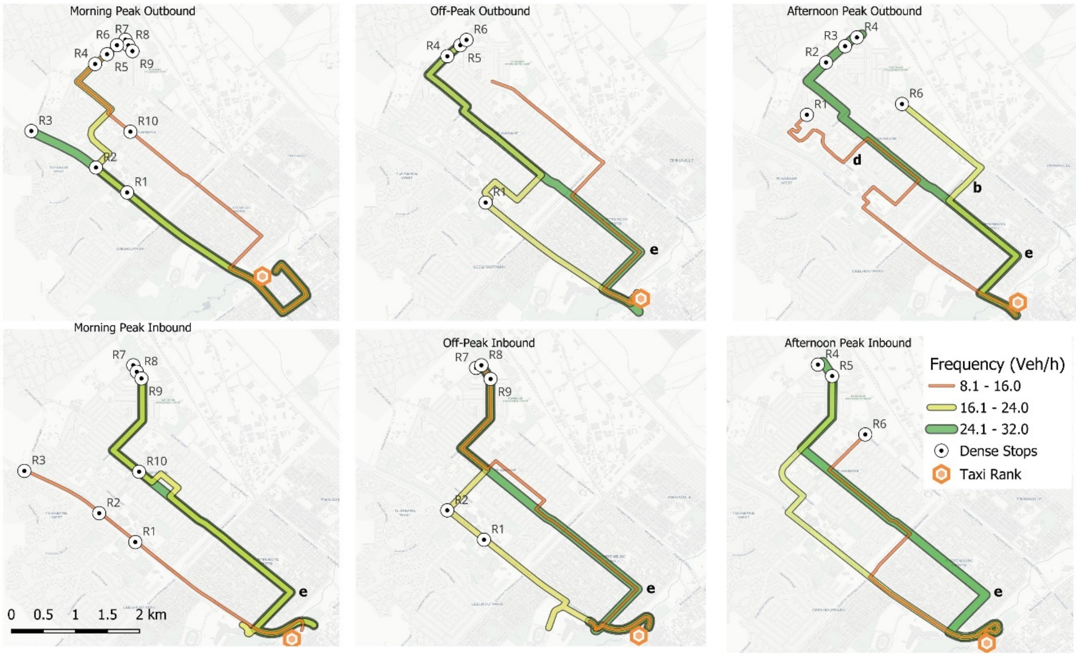

Figure 2. Simplified plots of medium and high frequency routes. (b=branching; e=main arterial; d=intermediate detour)

1). ANOVA tests confirm that frequency differences across time periods are not statistically significant (p=0.99). Thus, service variability is greater by direction than by time of day.

Figure 2 allows examination of changes in the higher frequency routes throughout the day. A consistent service at very high frequencies (up to 32 veh/hr/direction) runs along a key arterial (e) northwest of the CBD, except for the AM outbound case. But medium density routes show considerable variation in both end points and alignments, both by direction and time of day. Variations include branching (b) and intermediate detours (d). Visual observation suggests that these variations respond to changing demand patterns, as schools and work schedules differ by location. While this demand responsiveness can benefit passengers by reducing walking distances, it also results in highly variable and unpredictable frequencies and waiting times, especially on roads away from main desire lines.

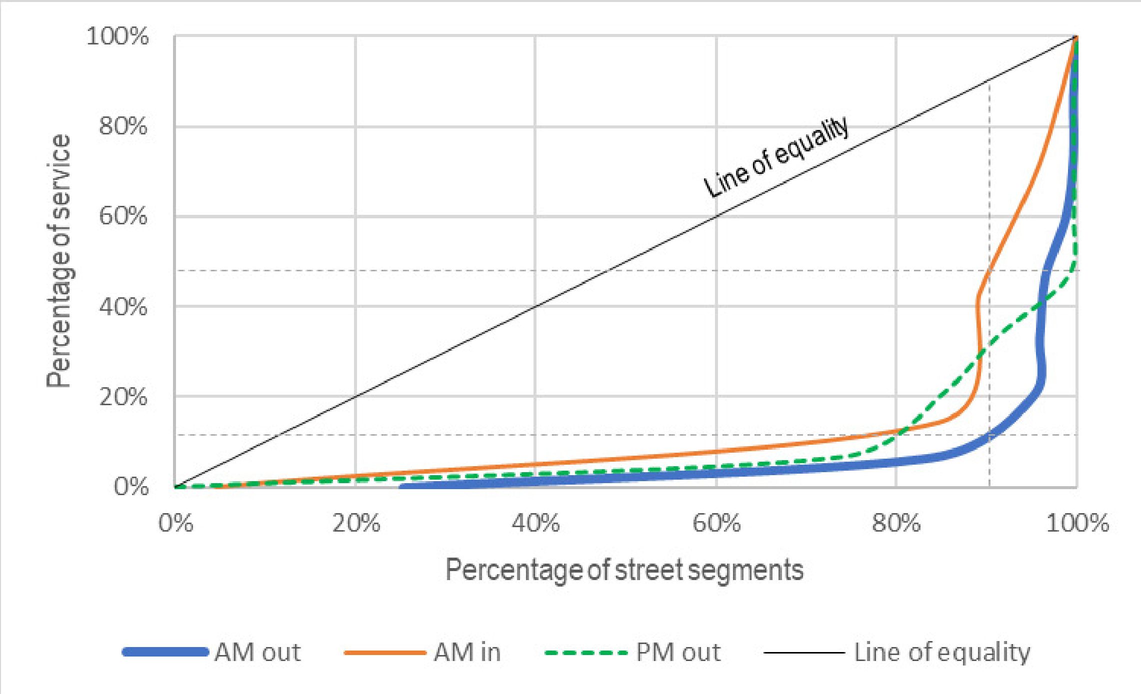

Figure 3. Lorentz curves of service concentration for selected time periods and directions

Route overlap, shrunken service areas, and variable frequencies contribute to differences in service concentration. The Lorentz curves (Figure 3) reveal high spatial concentration in taxi services, with notable variations. The dotted vertical line helps to interpret the graph. In the AM outbound direction, 10% of street segments receive 90% of service, whereas inbound, they receive only 50%. The corresponding GINI coefficients – 0.879 and 0.713 respectively – indicate greater concentration in the outbound direction. Despite the larger outbound service footprint, additional routes operate at low frequencies, while inbound services are more evenly distributed at medium frequencies.

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