UNDERSTANDING THE OPERATIONAL CHARACTERISTICS OF PARATRANSIT SERVICES IN ACCRA, GHANA: A CASE STUDY

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ABSTRACT

This paper studies the operational characteristics of paratransit services in Accra, Ghana. These semi-formal minibus operations provide the bulk of transportation services in Ghana, but little is known about them. In this paper, modern data collection methods leveraging smartphones are used to survey six paratransit routes. Data is collected both during trips and at the station. Analysis reveals that paratransit vehicles typically operate with high load factors, but do a limited number of rotations per day. It also shows that outbound and inbound trips have very different profiles, because different rules apply to passenger boarding in each direction. A key finding is that vehicles spend more time queuing at the station than driving with passengers onboard. This considerably reduces their profitability and constitutes a major source of inefficiency. Implications of this finding are discussed and the potential for reform is explored.

INTRODUCTION

A growing number of voices are calling for a reform of the paratransit industry in Africa. Whether advocating institutional overhauls, promoting hybrid transport systems, or encouraging participatory processes, scholars and practitioners alike are asking for action. Aside from a few notable exceptions, little is known about (and little is done for) the paratransit sector, and its merits have only recently begun to be documented. However, these merits are becoming increasingly apparent, as it become clear that it is impossible to replace paratransit with BRT systems. This paper contributes to filling this gap through the case study of a minibus terminal operating six trotro routes in south-western Accra. Its objectives are threefold: first, it illustrates the kind of insights that can be gained from a data collection exercise carried out with limited means; second, it presents key characteristics and performance indicators for sample paratransit routes in Accra; third, it draws on these observations to consider perspectives for reform of the trotro industry.

In Accra, the BRT project, launched in 2008, has fallen far short of its promises. A large share of citizens continue to rely on minibus services (locally known as "trotros") for their transportation needs in the coming years. While the trotro industry is often criticized for being unable to provide quality transport services, it does provide these services in quantity and at an affordable cost. Reforming the paratransit sector has the potential to improve the lives of millions of urban dwellers, stimulate the economy through job creation and improved mobility, and benefit the environment by controlling vehicle emissions. However, assessing the feasibility and relevance of such a reform will only be possible if the inner workings of the sector are clearly apprehended.

To date, very little data is available on paratransit operations in Ghana. In the wake of the BRT project, Departments of Transport (DoTs) were created in several municipalities of the Greater Accra, with a mandate to regulate trotro operations on their territory. This resulted in increased levels of formalization for trotro operators, who now have to register their routes and vehicles with municipal authorities. Nonetheless, information collected by DoTs through that process is limited and not consolidated at the metropolitan level. In Accra, the DoT also carried out several studies to better understand the network falling under its jurisdiction. Even so, an important gap remains to be filled in the knowledge of the operational characteristics of paratransit services in Ghana.

METHODOLOGY

Scope of study

This case study focuses on six trotro routes operated by the Kaneshie branch n°2 of the Ghana Private Road Transport Union (GPRTU). GPRTU is the largest trotro operators' association in the country, gathering approximately 70% of the drivers. Since the trotro industry is mostly self-regulated in Ghana, operators' associations play an important role in the organization of the sector. Their structure is organized at different levels: national, regional, and local. At the local level, "branches" or "locals" bring together between 50 and 100 members. Most association members are drivers, renting their vehicle from an owner against a daily fee. Some of the members (in particular executives of the association) are owner-drivers. Members of a branch typically operate a fixed set of routes out of a dedicated terminal or "station". A branch may operate from more than one location, but usually has a main station where its offices are located.

Kaneshie branch n° 2 of GPRTU has 101 members, operating 70 vehicles. According to the first trustee of the branch, these 70 vehicles belong to 20 different owners. Their station is located in the Kaneshie market area, one of the busiest commercial and transport hubs of Accra. Passengers board vehicles from a yard, which is accessed from a side street. Figure 1 represents the six different routes operated from this station and the most commonly requested stops on those routes. Most stops are not formally designated and vehicles tend to stop upon request from passengers.

The station of the Kaneshie branch n°2 of GPRTU was selected for study as previous data collection showed that it had the highest number of weekly departures of 12 stations surveyed. The high frequency of departures made it possible to collect a significant number of observations within a limited time frame. The fact that all vehicles depart from the narrow space and through a single gate also made it easier for surveyors to register departures on different routes. Finally, this branch operates a clearly delimited and fairly consistent set of routes, making observations more reliable.

FIGURE 1 Paratransit routes operated by the Kaneshie branch n° 2 of GPRTU

Organization of data collection

First, embarked data collectors recorded trips onboard vehicles. Second, static surveyors recorded every departure from the station during a full week. All data collection was exclusively done with smartphones. Embarked collectors used two different apps to record data: DataMobile (https://www.itinerum.ca/) to record GPS traces and Tap Log (a free personal event logger) to record information on stops and passengers boarding and alighting. They were equipped with entry-level smartphones paired with power banks to be able to last for a full day on the field. At the end of each day, collectors sent their data electronically through Wi-Fi or 3G internet connection.

Embarked collectors started their journey at the Kaneshie station and made round trips on their assigned routes. A total of 254 trip legs, distributed on six routes, were recorded in this way (after removing incomplete data). This corresponds to approximately 127 round trips, although not every outbound trip can be matched with an inbound trip. Collectors sat near the receiver onboard, and generally experienced their cooperation.

Static collectors used Tap Log to record the license plate number, route number, and seating capacity of departing vehicles. They worked in shifts to log complete days of operations, from 5 AM to 9 PM, Monday to Sunday. Preliminary meetings were held with the branch executive to explain the purpose of the data collection campaign. After exhibiting some level of resistance, trotro operators allowed collectors to work unencumbered. Altogether, 3 526 departures from the station were recorded.

The two types of data collection were carried out at different times. Embarked collectors were dispatched in May 2016 as part a larger survey covering 60 routes in Accra. Data from static collectors was collected in June 2017 (May and June are broadly comparable in terms of activity level in Accra).

Data analysis

The datasets were used to perform three types of analyses. First, data from embarked collectors was used to determine the attributes of a typical trip on each of the six routes (distinguishing between outbound and inbound trips). Average trip lengths and duration were defined in this manner. Since collectors were keeping count of passengers boarding and alighting along the way, it was also possible to calculate vehicle load factors between stops of a trip. To do this, stops were defined for each route by spatially regrouping points where boardings and alightings were recorded. All boardings and alightings were associated with the nearest stop on the route using a GIS program. Observations recorded half-way between two stops are therefore considered to either belong to the previous or to the following stop. Although it would be more accurate to count boardings and alightings by route segment than by stop, a presentation by stop was preferred to allow for comparison with institutional bus services.

Second, data from the static collectors was used to calculate aggregated indicators by route and at the station level. Breakdowns of departures by day of the week and by route were obtained in this way. One of the specificities of paratransit is that vehicles only leave their home station when they have reached their maximum load factor (the "load and go" system). Because of that, it can be assumed that the number of passengers departing in each vehicle equals its capacity. Here, the majority of vehicles had a capacity of 13 passengers. This makes it simple to compute the total number of passengers transported per route and day of the week (or during peak hours, for instance). As the fare by passenger (for a full trip) is also known, it is possible to estimate the fare box revenue generated by each departure. It was not difficult to project revenue by route, vehicle, day of the week, etc. Based on the frequency of departures per hour, we determined the average headway between vehicles.

Third, data from both static and embarked collectors was combined to estimate the general characteristics of each route. Although the second step of analysis described in the previous paragraph gives a general idea of passenger volumes and fare box revenue, it does so assuming that each departing vehicle returns to the origin station with the same number of passengers onboard – which rarely is the case in reality. It also does not account for passengers boarding or alighting the vehicle during the trip, after the vehicle has left the station. To define these indicators more accurately, it was thus necessary to first quantify the characteristic of a typical trip on a route, before expanding these values by the number of trips occurring on that route.

RESULTS

Operational characteristics of routes

The main characteristics of the 6 routes studied are presented in Table 1. Looking at the first part of the table, these routes have fairly similar profiles. One of their main characteristics is that they are short – between 4.5 and 6 km one way. Routes 2, 3, 4, and 6 are similar in terms of length, average travel time, and average commercial speed (15 to 17 km/h). This is not surprising since these routes share most of their itinerary and only branch out towards the end of their journey. Route 1 and 5 use different roads that are less congested or have higher capacity (for route 1) and are therefore faster. These two routes also take fewer passengers along the way, thus reducing their stopping time. Ratios of passengers transported over travel time on each route indicate that the Korle Bu route has the highest theoretical profitability of all routes. However, this ratio is only indicative because it does not account for waiting time at the terminal, which is the main determinant of the profitability.

TABLE 1 Characteristics of routes

Displayed results are rounded	1. Mortuary Rd	2. Korle Bu	3. Chorkor	4. Shallom	5. Soko	6. Alhaji
	Means for round trips (n = 254)					
Route length	12 km	9 km	11 km	10 km	9 km	10 km
Travel time	34 min	33 min	42 min	36 min	29 min	40 min
Commercial speed	21 km/h	16 km/h	16 km/h	17 km/h	19 km/h	15 km/h
Passengers boarding	26.6	30.0	31.6	27.9	25.8	26.5
Passengers / travel time	48	55	45	47	53	40
	Means for week days (n = 3,526)					
Number of departures	105	76	138	67	61	24
Vehicle.km travelled	1,265 km	680 km	1,516 km	668 km	547 km	244 km
Passengers (both directions)	2'810	2'270	4'350	1'860	1'570	650
Morning peak hour headway	5 min	8 min	12 min	11 min	43 min	*n/a*
Evening peak hour headway	11 min	14 min	3 min	8 min	7 min	13 min
Number of vehicles operating	31	38	61	36	35	15

One therefore also has to look at the number of departures per day and the average headway during peak hour to assess the performance of a route. Here, route 6 is clearly not very attractive from the operator's point of view: it has a slow commercial speed, the second lowest number of passengers per rotation, and a small number of departures per day. In contrast, routes 1 and 3 have intermediate ratios of passengers by travel time, but a high number of departures per day. Taken together these two routes represent approximately 55% of the vehicle.km and passenger trips generated by the station.

Demand on route 1 and 2 is boosted by the Korle Bu teaching hospital located at the end of these routes. This can be seen from the fact that headway is much shorter during the morning peak than during the evening peak. Because activities linked to the hospital mostly take place in the morning, demand on those routes is concentrated in the first half of the day. Since demand determines the frequency of departures on a route (through the load and go system), it results in shorter headways in the morning.

Routes 3, 4, 5, and 6 have opposite peak hour patterns. They do not face much demand in the morning because they are going towards residential areas. It is likely that demand on these routes would be higher in the return direction (towards Kaneshie) in the morning, when residents converge on commercial areas to start their daily activities. However, since the branch does not have any stations in Chorkor (route 3), Shallom (route 4), Soko (route 5), and Alhaji (route 6), vehicles cannot wait to load passengers from these locations. It is therefore not clear how residents of these areas travel towards Kaneshie in the morning. It is possible that some of the vehicles finishing a morning trip at Korle Bu or Mortuary Road drive to these neighborhoods to pick up passengers before returning to Kaneshie. Another possibility is that these residents use the services of another group of operators, which does have a station in their area.

Characteristics derived from sample trips

Sample trips on each route were analyzed, separating outbound and inbound trips. The main outcome of this analysis is the calculation of load factors over the course of a typical trip for the six routes. The most distinctive feature is that load factors are on average very high on all routes – in particular for outbound trips. This is primarily explained by the "load and go" system, which sets the load factor of departing vehicles at 100%. In practice, a few vehicles departed with less than a full complement of passengers, but the average load factor at the start of outbound trips was still above 95%. This means that outbound vehicles do not have unused capacity to pick-up additional passengers during the first part of their trip.

Passengers wanting to board a vehicle between stops 2 and 5 are generally unable to do so for lack of available seats onboard. Instead, they have to walk to the Kaneshie station to board a vehicle that will take them to their desired destination (driving through their original location!). This is clearly a major inconvenience for trotro users, yet it is a rule enacted by the operators themselves. In theory, trotros are not allowed to pick up passengers in the vicinity of a station, although this rule is rarely enforced in practice. The reason is to better control transport operations (for the authorities) and guarantee their profitability (for the operator), by concentrating all departures in identified stations.

Another rule observed by trotro operators is that they are not allowed to wait to load passengers outside of a station. As a result, they have to go back to their origin station soon after completing an outbound trip. In general, they are only allowed to wait until the next vehicle on the route reaches the destination station – at which point they must go back to the origin station. This translates into lower load factors at the start of inbound trips (typically between 50% and 70%) than at the start of outbound trips.

An interesting pattern observed on all routes for outbound trips is that load factors remain high for the first 50% to 75% of the trip and drop abruptly after that. This indicates that passengers' destinations are typically located in the second half of the routes. Figure 2 also shows that a large share of passengers alight the vehicle before the last stop. For instance, for outbound trips on route 4, 60% of the passengers alight between stops 12 and 18. As a result, trotro typically reach the last stop on the route with only 30% of their capacity used. This indicates that there is potential for route optimization – at least from the point of view of the operator. On inbound trips, several routes show a dip in load factor for the two last stops. This is because the area near the Kaneshie station is usually congested; many passengers therefore choose to get off at the penultimate stop.

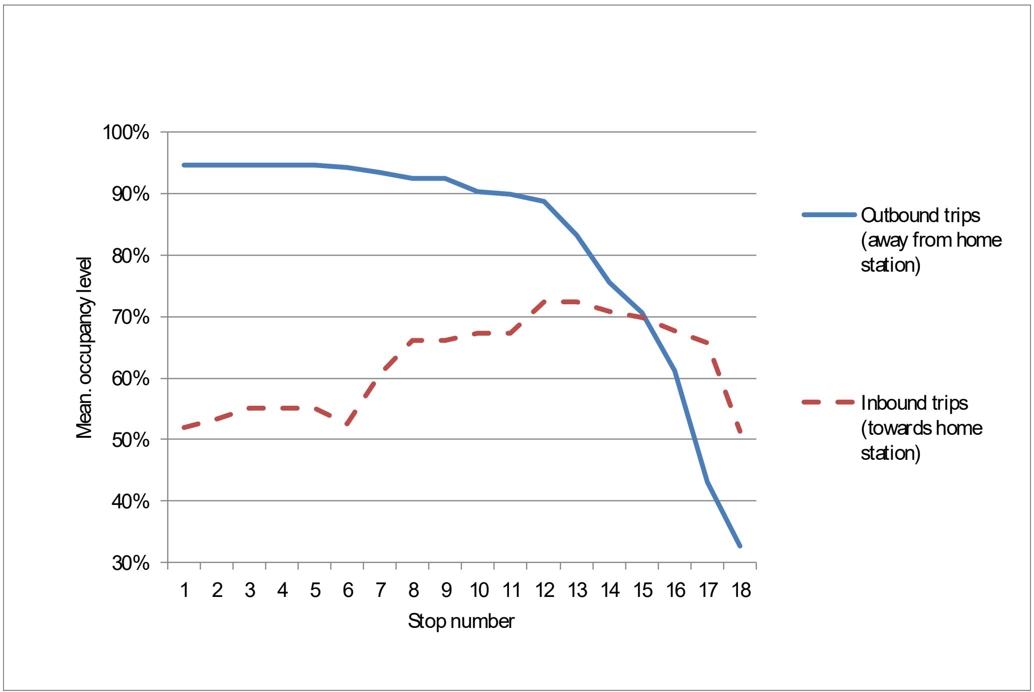

FIGURE 2 Average load factors

Operators' performance

Paratransit is a self-regulated sector in Ghana, thus the organization of operations is largely determined by the operators' search for profitability. In turn, because this sector is atomistic, profitability has to be considered at the individual level – that of the driver. Because each driver is associated with a vehicle (whether he rents or owns it), trotro operations should also be analyzed at the vehicle level to understand the characteristics of services.

This analysis is made possible by data collected at the station level, where each departure was recorded and tied to a licence plate number for a complete week. However, after correcting for typos, the resulting dataset contained 143 unique licence plates. This is twice as many as the number of vehicles operated by branch members, which means that drivers who do not belong to the branch occasionally operate out of Kaneshie station.

Because our interest is in understanding the daily level of activity of vehicles working at the station, this part of the analysis excludes occasional vehicles likely to work from other stations as well. It was assumed that the 70 most active vehicles were those of the branch members, and that these vehicles operated from the Kaneshie station only. This may lead to a slight underestimation of trips made and revenue collected if these vehicles operate on other routes from time to time. However, this is balanced by the fact that all passengers are assumed to pay the fare for a full trip, when in reality some pay less for a shorter trip. Overall, consolidated daily rotations and revenue per vehicle are coherent with values typically reported by operators. Member vehicles accounted for 80% of all recorded departures and most of them (75%) worked 7 days a week.

TABLE 2 Rotations and revenue per day of the week and vehicle

Only taking into account 70 union vehicles Displayed results are rounded	**WEEK**	Mon.	Tue.	Wed.	Thu.	Fri.	Sat.	Sun.
				Rotations analysis				
Mean rotations by vehicle	**38**	5.6	5.5	5.5	5.7	5.1	6.2	4.6
Max. rotations by vehicle	**87**	12	15	12	13	11	14	14
Estimated driving time / veh.	**23h**	3h30	3h25	3h25	3h25	3h	3h55	3h05
Total number of rotations	**2'667**	389	385	384	397	355	436	321
Number of vehicles operating	**70**	67	68	68	70	70	67	63
				Revenue analysis (in Ghana cedis)				
Total collected revenue	**129'700**	19'000	18'800	18'800	19'300	17'200	21'200	15'400
Max. revenue by vehicle	**GHS 3'740**	GHS 610	GHS 680	GHS 560	GHS 620	GHS 560	GHS 680	GHS 660
Mean revenue by vehicle	**GHS 1'860**	GHS 280	GHS 280	GHS 280	GHS 280	GHS 250	GHS 320	GHS 250
Median revenue by vehicle	**GHS 1'780**	GHS 290	GHS 270	GHS 270	GHS 260	GHS 250	GHS 320	GHS 270
Standard deviation in revenue	**GHS 490**	GHS 110	GHS 110	GHS 100	GHS 100	GHS 90	GHS 100	GHS 110

Results presented in Table 2 show that operations are fairly stable across weekdays, with a slightly lower level of activity on Fridays. This is consistent with the fact business is generally slower on Friday afternoons, as many people leave the city early. Saturdays are busier than average weekdays because of trips generated by the market. A notable characteristic of this station is that there are almost as many trips recorded on Sundays as on weekdays. These trips are most likely connected to social functions. This differs from most trotro stations, which do not operate on Sundays.

Among branch members, important differences exist in daily number of rotations and collected revenue. While vehicles on average make 5.5 rotations and collect 280 Ghana cedis (64 USD) per day, the highest earners make more than twice these amounts. This uneven income distribution is confirmed by the high standard deviation in weekly revenue – representing 25% of the median income. Variations in the number of rotations are often explained by privileges given to union executives. Their vehicles can be exempted from queuing at the station before loading passengers, or move up faster in the queue.

The most striking result of this analysis is the low ratio of driving time per vehicle and per day. On a typical weekday, and using the average route characteristics presented in Table 1, trotros only spend 3.5 hours actually driving. Assuming that drivers work at least 8 hours a day (a conservative estimate), this means that they spend more than half of their worktime queuing at the station! Because of the load and go system and since the number of vehicles in operation is too high, long queues of vehicles form at the station, waiting for their turn to load passengers and go on a trip. While this situation clearly points to an over-supply of vehicles at the station, it does not explain why the branch would collaborate with external vehicles.

DISCUSSION

Results illustrate a fundamental paradox in the organization of paratransit operations in Accra. On the one hand, vehicles exhibit high load factors, which could demonstrate high efficiency through optimal use of their seating capacity. On the other, the system appears extremely inefficient when the use of this capacity is analyzed over time. Most trotro seats are occupied when they are driving; but driving only occupies a fraction of their time.

Their main activity consists in waiting in line at the station. This phenomenon is made obvious by the number of vehicles queuing outside of transport terminals in Accra. Because the yard from which vehicles depart is quite small, trotros use surrounding streets as waiting spaces. At the study station, they formed a queue of 300 m on two lanes, and completely prevents passage by other vehicles.

Since the queuing process plays an important role in operations and takes up so much time, queuing orders are reflected on a blackboard at the station. Drivers returning to the station write their licence plate under the name of the route that they want to run next. They do so after carefully studying the length of the queue and estimating demand for each route. Few vehicles are in line for Alhaji (route 6) because it is a slow and not very profitable route. On the contrary, many vehicles have chosen to join the queue for Chorkor (route 3), because demand for this route is high and departures are frequent. The blackboard allows the branch to dynamically distribute its vehicles on the six routes and flattens waiting times across routes and vehicles.

While this system reflects the efforts of the association to organize and regulate operations, it also reveals deep-seated inefficiencies. An obvious way to fight these efficiencies is to increase the number of rotations per vehicle, by decreasing the size of the fleet working at the station. If passenger throughput remains constant, each vehicle will capture a larger share of the demand. This could risk not having enough vehicles to satisfy peak hour demand – and replace queues of vehicles by queues of passengers. Nevertheless, this risk is mitigated by the fact that the six routes have complementary peak hour demand patterns. A simple way to confirm this would be to record the total length of vehicles queuing at the station over a week's time. The minimum observed number of vehicles in the queue could safely be removed from the fleet without affecting passenger's waiting time at the station; this could even allow for a reduction of passengers' waiting time. Keeping the same daily revenue target but doing more rotations per day, trotros could afford to operate with lower load factors. That is, they could leave the Kaneshie station without waiting to have 13 passengers onboard, and still make the same earnings – by spending more time driving and less time queueing. As a result, they would also have free seats available during the first part of their trip and could pick up passengers along the way. This could result in an increase in total passenger throughput per route, since part of the demand might currently not be met on the first half of all routes (because vehicles are full capacity on those segments). This additional ridership could also cover the increase in operational costs resulting from higher vehicle mileage (since trotros would do more trips to collect the same revenue). Admittedly, a model where operators would actually increase their revenue should be favored. Indeed, experience has shown that buy-in for reform programs would be easier to obtain if these programs benefit both passengers (through improved services) and operators (through increased revenues).

Removing some of the vehicles in circulation raises the question of where these vehicles would go and what would happen of their crew. The paratransit sector provides employment opportunities for many unqualified workers (especially youth having recently migrated to urban areas), and reducing the number of jobs available to them would come at a high social cost. Paratransit reform schemes need to transform jobs rather than destroy them.

CONCLUSION

Through simple data collection methods leveraging modern technologies, it was possible to carry out a detailed survey of six paratransit routes operated by a local branch of the main road transport union in Ghana. This data revealed that paratransit vehicles typically operate with a high load factor, but do a limited number of rotations per day. It also shows that outbound and inbound trips have very different profiles because vehicles cannot wait for passengers at the destination point. It was also found that trotros spend most of their working time queuing at the origin station. This considerably reduces their profitability and constitutes a major source of inefficiency. The potential for reforming the paratransit industry is thus high, and the needs are pressing. One of the levers to initiate this transformation is to control the oversupply of vehicles currently observed. Decreasing the number of vehicles in operation could be the first link in a chain of change.

However, one has to acknowledge the strengths and hear the aspirations of the paratransit industry, before proposing to transform it. Trotro operators provide inexpensive and abundant transport services to the urban population, and do so without using public funds. In the absence of external regulation, they have developed sophisticated rules and procedures to guarantee the smooth running of their business.

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