Journal of Transport Geography 98 (2022) 103268

Contents lists available at ScienceDirect

Journal of Transport Geography

journal homepage: www.elsevier.com/locate/jtrangeo

Factors causing low demand for a suburban passenger train in Sekondi-Takoradi

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ARTICLE INFO

Keywords:
Railway passenger demand
Land-use mix
Diseconomy of agglomeration
Railway redevelopment policy
Sekondi-Takoradi
Africa

ABSTRACT

In recent years, there has been a renaissance in urban railway transit supply in Ghana with a railway masterplan seeking to increase the rail network from 947 to 4007.6 km. However, some passenger trains are beginning to face demand downturns, which require empirical investigation. Research on railway operation and passenger demand in Africa is scarce. This paper fills this gap by investigating the causes of declining ridership for the 25 km rehabilitated Sekondi-Takoradi sub-urban train service in Ghana, West Africa. The authors employed a cross-sectional survey of 600 residents in 14 communities within Sekondi-Takoradi and fitted an ordered logit regression model. From the results, the causes of declining ridership are the train's route location, easy access to alternative modes, the pricing system, and the limited supply of only two OD trips per day (operating $\leq$ 50% of capacity). We recommend a dynamic pricing mechanism, shuttle service, and passenger incentives for increased ridership.

1. Introduction

Passenger railway services have been very instrumental in reducing traffic congestion on the roadway, especially for urbanized cities (Albalate and Fageda, 2016; Zhao et al., 2015). Primarily, passenger trains satisfy mobility and economic needs in cities by connecting commuters from various suburbs to the Central Business District (CBD) (APTA, 2005). The passenger flow and demand dynamics, therefore, play a significant role in their sustainability (Frétigny and Lin, 2021; Zhang et al., 2019). However, passenger trains face stiff competition from road-based transport such as taxis, minibuses, buses, and mini-buses. This is profound for sub-urban trains because they travel a short distance, which road-based transport can travel with little travel time variations. Besides, passenger trains have a fixed route, whereas road-based transport may have several routes. These sometimes account for declining ridership.

The railway passenger demand is derived from several factors including the price, accessibility, route choice, spatial developments, the built environment, and the population density. Cao and Fan (2012) found that residents of high-density neighborhoods travel, on average, 3.31 fewer miles per person per day than those who live in low-density neighborhoods. The land-use mix in a city affects passenger travel choices (Cao, 2016). Some studies found that land-use policies, enhanced transportation services, or travel costs and accessibility contribute positively to travel behavior in cities (Cao et al., 2007; Chatman and Noland, 2011; Graham, 2007; Safirova, 2002; Venables, 2007).

Generally, there is scarce research on passenger railway service in sub-Saharan Africa (SSA) although it presents different market features from other parts of the world (Bouraima and Qiu, 2020; Zuidgeest, 2019). The existing knowledge is mainly found in working papers and reports, which give generalized discussions on the railway supply in

; CBD, Central Business District; DMU, Diesel Multiple Unit; EMU, Electric Multiple Unit; SSA, sub-Saharan Africa; GRDA, Ghana Railway Development Authority; GRC, Ghana Railway Company.

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https://doi.org/10.1016/j.jtrangeo.2021.103268
Received 1 June 2021; Received in revised form 2 December 2021; Accepted 15 December 2021

Africa. Existing studies on the railway service in Africa focus greatly on engineering, concessions, and freight transportation other than passenger transit services. This is because the railway network largely supports freight-based transportation (Bouraima and Qiu, 2020; Olievschi, 2013). The latest working paper by the World Bank Group (Bullock, 2009) indicates that apart from South Africa, Egypt, Morocco, Algeria, and Tunisia, the passenger demand and operation of commuter transit in SSA is below global standards. A recent report on railway development in eight African countries (Africa Development Bank Group, 2015), pointed out that low traffic densities present a huge constraint for the development of passenger railways in SSA. Bullock (2009) reported that Egypt and Southern Africa supply over 85% of passenger-km, making them dominant in the rail passenger market of the then 51 active railways operating in 36 countries in Africa. Currently, railway networks in SSA operate only 1.7% of the total volume of passengers carried in Africa (Olievschi, 2013). Comparable to many European rail systems, the traffic density of the Maghreb systems connecting Morocco, Algeria, and Tunisia spans from 2 to 4 million traffic units per rail-route-km. However, just three SSA railways generate traffic densities greater than a million in 2010 with several of the traffic density averaging less than 300,000 (refer to Fig. A1). The low traffic volumes render most railways in SSA non-competitive as the above figures are respectively fourfold and sixfold lesser than the average in Africa and the amount realized by South African railways. Nonetheless, the railway service in Africa and SSA, in particular, is experiencing a renaissance (Africa Development Bank Group, 2015) despite the latter representing merely 2% of railway lines operated globally with a total railway network length of around 56,000 km. Therefore, studies investigating passenger demand, passenger experiences, and level of service are required for effective transportation planning. This lack of insight has created a mix of population, empirical, and knowledge gaps in the SSA context.

This paper fills this gap by investigating the causes of declining ridership for the 25 km rehabilitated Sekondi-Takoradi sub-urban train service in Ghana. The demand has progressively declined since it was opened to commuters in the year 2015 and further worsened since 2018 (Ghana Agent, 2018). Several factors have been speculated as possible causes. However, there is no empirical evidence to show the cause and effect. The questions underlining this study are as follows: (1) what are the real factors causing low demand? (2) What is the demand for the train among different groups of people? (3) What is the connection between the land-use mix and the fixed supply of the train? (4) Can the provision of a subsidized shuttle service increase the demand from residents in the inland settlements? (5) What are the policy implications of the findings?

The remaining parts of this paper are arranged as follows. Section 2 provides the historical development of passenger railway service in Ghana and expounds on the current problems with the Sekondi-Takoradi passenger train service. Section 3 presents the research methodology, which comprises the geographical setting, data collection, analysis, and model formulation. Section 4 has the results. Section 5 has the discussion and Section 6 contains the conclusion, policy implications, limitations, and future research areas.

2. History of passenger railway transit in Ghana and problem statement

The Construction of Ghana's railway network started in 1898 under the Great British Colony. The then Gold Coast (Ghana) had an initial railway stretch of 66 km, which began operation in 1901. The rail network then expanded to the southern part of the country with a route of 947 km. The existing network consists of three lines. These are the Western line (373.8 km), the Central line (239 km), and the Eastern line (334 km). Within the past 2 decades, there was a decline in the passenger railway service. The tracks and rolling stock deteriorated, due to lack of maintenance and non-usage. Before 2009, there were only 13% of the approximately 947 km railway network operating across the initial network (Burchardt, 2014). In a bid to revive the railway industry and promote the involvement of private investors or foreign investors, the Ghana Railway Development Authority (GRDA) was created in 2009 to enhance infrastructure. The Ghana Railway Company (GRC) also had a reformation. The ongoing progress has led to the rehabilitation of some old railway lines for passenger use and the construction of new lines. The Ghana railway master plan envisages a total rail network of 4007.6 km (GRDA, 2021).

The trains in Ghana are different from elsewhere. The passenger trains used in Ghana are Diesel Multiple Unit (DMU) trains. Unlike other passenger trains used in other countries (e.g., electric traction), DMU trains use diesel. Its disadvantages, however, are higher fuel costs, noise, pollution, and high maintenance costs. The DMU trains in Ghana travel at an average speed of 60 km/h. Currently, many countries are using more sustainable trains such as Electric Multiple Unit (EMU) trains with overhead electric lines/electrified track, faster acceleration, and less pollution ($< 1\%$ of total CO_2 emissions globally). For low and middle-income countries, DMU is perhaps more cost-effective due to the erratic power supply and high cost of electricity production. Generally, technological investments have improved in the railway sector although low. For instance, the ticketing system is yet to become electronic.

Given these developments, passenger transit trains require proper planning and continuous research to evaluate passenger demand and experiences. The present study investigates the growing decline in demand for the Sekondi-Takoradi sub-urban train service, which is replete with several challenges. The sub-urban railway line is one of the rehabilitated railway lines in Ghana's Western line that was opened in 2015 after eight years of shutdown. Currently, there are two fully air-conditioned DMU trains, which operate a monthly shift system. The train sets off at 5 a.m. from Sekondi Harbor to Takoradi and returns at 5 p.m. (average speed of 60 km/h). Each train has a capacity of around 600 passengers and 6 coaches.

First, recent residential settlements are moving towards the inland areas away from the trains' route, which lies along the coastal stretch of the city. This diseconomy of agglomeration apparently affects the demand from the inland areas. The rehabilitation project did not provide multiple lines to serve all suburbs but rather changed the dilapidated rails and provided newly furnished trains, perhaps due to capital constraints. However, the demand has declined over the past 2 years (Ghana Agent, 2018). As of 2018, the 600-seater train moved either half-full or lesser (Ghana Agent, 2018). Fig. 1(a) and (b) shows several empty seats in the moving train. Fig. 1(a) was adapted from Ghana Agent (2018) whiles Fig. 1(b) was taken in October 2020 during our field inspection. These pictures emphasize the low demand, which was investigated.

Besides, the price for a one-way journey is GH¢2.00 (US$0.34) for all stops. A passenger traveling to the CBD usually spends an extra GH¢1.50 (US$0.28) to board a shared taxi or Uber to the CBD. This increases the transportation spending of a passenger since it costs about GH¢4.00 (US $0.68) to travel from Takoradi to Sekondi by taxi and even cheaper by a minibus (Trotro).[1] According to Ghana Agent (2018), a passenger said: "*If we have to travel by train, it is faster, though, we have to first take a taxi to the terminal at the harbor at an additional cost of GH¢1.50. So instead of spending GH¢4.00 for a two-way trip, we end up spending about GH¢7.00 on daily two-way transportation*." Furthermore, there is a fixed price irrespective of the travel distance. The probability of passengers choosing alternative transport modes when traveling short distances is high. Are these the real causes of declining ridership? Hence, this study seeks to investigate and suggest plausible solutions.

[1] Note: Ghana cedi to US dollar conversion, November 23, 2020 (US$1.00 to GH¢5.84).

(a) (b)

Fig. 1. (a) An inner view of the train in 2018 (Source: Ghana Agent, 2018), (b) An inner view of the train in 2020 (Source: Authors' field photo).

3. Methodology

3.1. Geographical setting, data, and analysis

Sekondi-Takoradi covers a land size of 191.7 sq. km with a population of 946,000 people (World Population Review, 2021). Sekondi-Takoradi serves as one of Ghana's important cities bordering the Gulf of Guinea. Designating the geographical setting of this study as shown in Fig. 2, Sekondi-Takoradi is the capital city of Ghana's Western Region and hosts one of the nation's major ports and fishing harbors.

This study began with a pilot survey of 50 residents with dichotomous (Yes/No) questions. The respondents could not give an overwhelming rating of whether they preferred the train or alternative modes. Consequently, a five-point Likert scale rating was designed: strongly disagree (1) to strongly agree (5). The questionnaire was premised on the purported causes of the low demand and opinions gathered from the pilot survey. Subsequently, a cross-sectional survey was done in October 2020 using paper-based questionnaires. The survey was administered by five surveyors using a random sampling of previous users of the train. Previous users in this context are residents who have at least used the train once since it was rehabilitated.

To verify this, the surveyors asked respondents if they had ever traveled by train since 2015. The rationale behind this approach was to avoid biased responses from residents who never used the train. Moreover, most residents have had travel experiences with the refurbished train because of the euphoria created and rush for its services when the new trains began operation. Therefore, the respondents had experienced the train and can compare their experiences with alternative modes. As shown earlier in Fig. 1, the decline in demand started before the first COVID-19 cases emerged in Ghana. The residents were already used to the train service and all the variables tested were before 2020 so the pandemic did not affect the patronage of service but could have influenced the number of responses and consequently the results.

In all, the surveyors administered 600 valid responses, which incidentally is a full train capacity. The respondents are residents of 14 selected communities inland to the rail line. Fig. 3 shows a section of the map of Sekondi-Takoradi, the sampled suburbs, and the route of the train. Although Kwesimintsim is the farthest from the train's route, it was included because most of the residents work in the communities along corridors of the train's route.

The data were processed and an ordered logit regression model was formulated to measure the preference of the respondents to travel by train. This is a suitable model since the questions were in Likert scale format. The regression results are either positive or negative. A positive result suggests that an increase in the independent variable has a likelihood of increasing demand for the suburban train. Negative results, on the other hand, indicate that an increase in the independent variable has a likelihood of reducing demand for the suburban train, whiles increasing demand for road transport. Stata/SE 14.0 was employed for the analysis.

3.2. Conceptualized model

The conceptualized model assumes that passenger demand to travel by the suburban train is dependent on nine independent variables as shown in Fig. 4. In the model, shuttle service is a subsidized/low-cost bus/minibus transit service that can serve commuters moving from the inland areas to the train terminals thereby reducing their travel costs. Shuttle services have been identified as useful in tourism, transportation services, and increasing interest in public transport (Lawson et al., 2011; Shiftan et al., 2006). Ng and Acker (2018) studied gender disparities in travel choices in eight cities across three continents and found that women tend to travel shorter distances and prefer public transport than men. The latter are veered towards private transport. Besides, Olivieri and Fageda (2021) found that women are less mobile than men. It was also found that women are more sensitive to safety and security than men regarding transport modal choice decisions (Ouali et al., 2020; Rišová and Sládeková Madajová, 2020). Whelan (2007) identified a positive correlation between private car ownership and household income. Commuters who own private cars would rationally not travel by the transit train except on rare occasions where random events such as vehicle breakdown occur. In addition, the extant literature suggests that both travel time and travel costs significantly affect travel demand (Paulley et al., 2006; van Loon et al., 2011; Walther et al., 2020). It is expected that commuters will prefer the train service if they perceive it has a comparatively lower travel time and costs than other modes. De Gruyter et al. (2020) found that among all modes of transport, passenger train had the strongest association with the built environment and land-use mix in Melbourne. The location of commuters' residential accommodation and their work influences their choice of transport mode. In transportation planning, the route choice problem is a critical consideration in passenger demand choice models (Jansson and Ridderstolpe, 1992; Narayan et al., 2020), hence it is considered in this study. It refers to the location of the train routes along the coastal areas of the city which affects ridership from the inland areas. This is important since the train has only one route. It is closely related to the number of OD trips. In this study, the case study train has only 2 OD trips. It sets off from the train terminals in the morning to its destination and returns later in the evening. This means commuters have access to it once in the morning and once in the evening. This is different from the

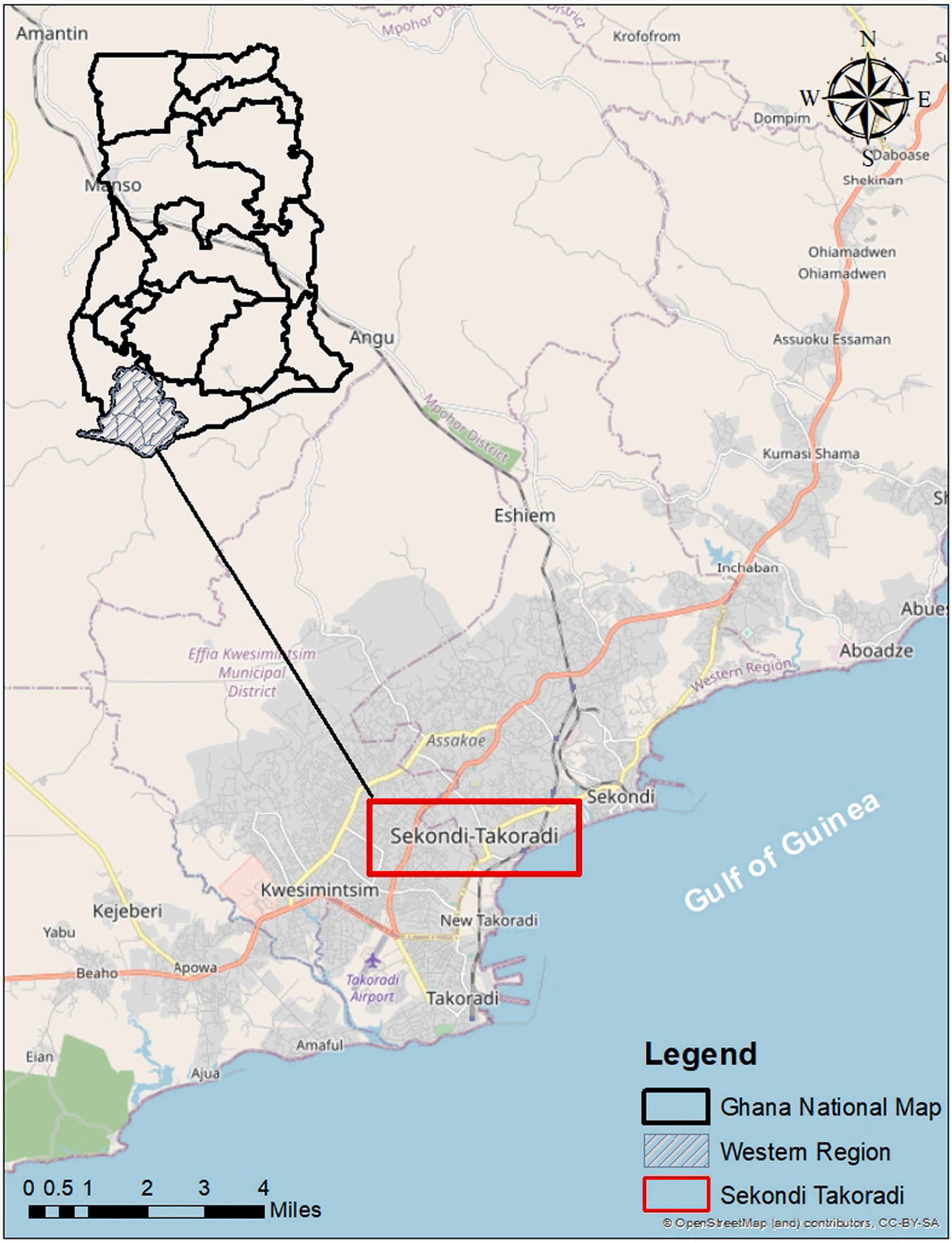

Fig. 2. The geographical setting of the study area.

advanced transit operations in South Africa and the global north. It has an association with passengers' mobility. Because some passengers leave home in the morning and return in the evening, so are likely to prefer this schedule. Contrarily, businessmen and other highly mobile commuters will prefer alternative modes of transport to the train. Train scheduling and passenger demand optimization has also received attention in transportation research (Wang et al., 2017, 2018) hence its inclusion in the conceptual model. Thus, the variable 2 OD trips measure the effects this passenger attribute has on passenger decisions to travel by train.

The demand for transport modes is a utility function. For this study, the assumption is that a passenger chooses between two or more transport modes based on the satisfaction obtained from previous consumption, plus random utility (De Vos et al., 2016; Horowitz, 1980). The present model, therefore, gives allowance for both marginal utility and random utility. Usually, transit choice is made based on past and present satisfaction. The marginal utility is the difference between the current (final) total utility and the previous (initial) total utility divided by the differences in the units consumed such as the number of trips. From the marginal utility theory, given that an *i*th passenger prefers transport mode Y, the marginal utility is:

$$MU_Y = \left(TU_f - TU_O\right) / \left(Q_f - Q_O\right) \quad (1)$$

where:

Fig. 3. A section of the Sekondi-Takoradi map showing the sampled suburbs and the route of the train.

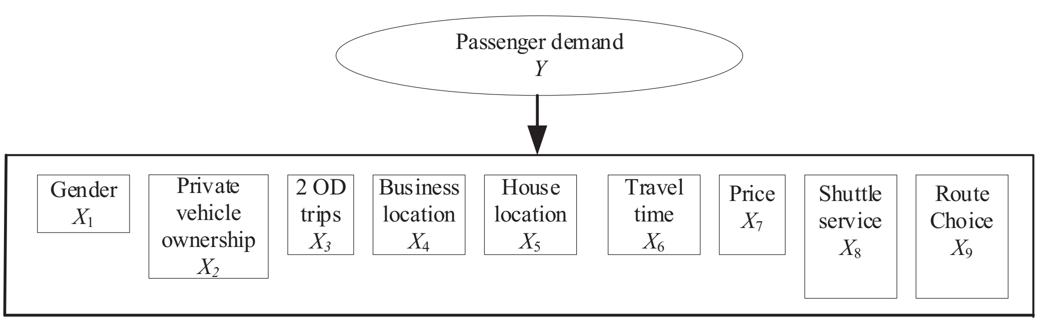

Fig. 4. The conceptualized model.

MU_Y is the marginal utility for consuming mode Y,
TU_f is the satisfaction derived from an additional consumption of mode Y,
TU_O is the satisfaction derived from a previous consumption of mode Y,
Q_f is the additional units of mode Y consumed by the passenger (e.g., number of trips).
Q_O is the previous units of mode Y consumed by the passenger.

For this study, there is one dependent variable Y_1 (the suburban train). We assume the alternative mode Y_2 (other modes) and so the functions derived for both choices are:

$$MU_{Y_1} = \left(TU_{fY_1} - TU_{OY_1}\right) / \left(Q_{fY_1} - Q_{OY_1}\right) \tag{2}$$

$$MU_{Y_2} = \left(TU_{fY_2} - TU_{OY_2}\right) / \left(Q_{fY_2} - Q_{OY_2}\right) \tag{3}$$

Gossen's Second Law (Walker et al., 1985) posits that with a limited income, a consumer achieves maximum satisfaction when resources are allocated in such a way that the marginal utilities of the different products are equal. This suggests that to achieve maximum satisfaction, the marginal utility of Y_1 should be equal to the marginal utility of Y_2. However, this only applies to a situation where consumers spend simultaneously on different products. For this study, this assumption cannot be fulfilled because passengers make only one modal choice at a given time. A rational traveler chooses the mode with the highest utility (Chen and Li, 2017; Sekhar, 2014). Thus, to choose the train, the marginal utility of riding the train cannot be the same as the marginal utility of competing modes (ceteris paribus).

This is expressed as:

$$MU_{Y_1} \neq MU_{Y_2} \quad (4)$$

$$\frac{(TU_{fY_1} - TU_{OY_1})}{(Q_{fY_1} - Q_{OY_1})} \neq \frac{(TU_{fY_2} - TU_{OY_2})}{(Q_{fY_2} - Q_{OY_2})} \quad (5)$$

In this case, the probability of choosing Y among several options z is expressed as:

$$Pr(Y_i = 1|z_i) = Pr(MU_{Y_i} - MU_{Z_i} > 0|z_i, Y_i \neq k) \quad (6)$$

where k is all alternative modes of transport.

Next, is the random utility theory. Given that an ith passenger prefers the jth transport mode, the random utility comprises the factors that influenced the decision plus the unobserved factors such as weather, diminishing returns, vehicle breakdown, etc. The random utility function of Zambang et al. (2020) was used as follows:

$$U_{ij} = \delta_j z_i + \varepsilon_{ij} \quad (7)$$

where:

U_{ij} is the random utility.
z_i is the vector of passenger characteristics, e.g., income, gender, and vehicle ownership.
δ_j is the vector of parameters with such characteristics.
ε_{ij} is the vector of the unobserved characteristics.

The probability that a passenger i will prefer the jth mode (Y) as a better utility to the other modes to maximize utility is given as:

$$Pr(Y_i = j) = Pr(U_{ij} > U_{im}|z_i) \quad (8)$$

$$Pr(Y_i = j) = Pr(\delta_j z_i + \varepsilon_{ij} - \delta_m z_i + \varepsilon_{im} > 0|z_i, j \neq k) \quad (9)$$

Given that the error term ε_{ij} is identically and independently Gumbel distributed, the probability that a passenger i chooses the jth vehicle on condition that the utility of choosing a vehicle is higher than that of other vehicles is specified by the multinomial logit model (McFadden, 1978) defined as:

$$Pr(Y_i = j) = \frac{exp(\delta_j z_i)}{\sum_{i=1}^{n} exp(\delta_k z_i)}, j = 1, 2, 3, \dots, n \quad (10)$$

However, this has only one vehicle choice based on passenger characteristics so an ordinal logistic regression is required. Using Y_1 as our dependent variable, the proportional odds model for the ordinal logistics regression model $\Pr(Y_i \le j)$, as opposed to the multinomial logit model, $\Pr(Y_i = j)$ is expressed based on Liu (2009) as:

$$\text{logit}[\pi(Y_1 \le j|x_1, x_2, \dots x_p)] = ln\left(\frac{\pi(Y_1 \le j|x_1, x_2, \dots x_p)}{\pi(Y_1 > j|x_1, x_2, \dots x_p)}\right) \quad (11)$$

$$= \alpha_j + (-\beta_1 X_1 - \beta_2 X_2 -, \dots - \beta_p X_p) \quad (12)$$

where α_j is the threshold, j 's are the ordinal categories, β 's are the logit coefficients, and x 's or X 's are the independent variables.

As mentioned earlier, this study assumes that a passenger's choice of transport mode is premised on the satisfaction (marginal utility) plus random utility. Thus, passengers' choice to travel by train or not, is not only premised on the satisfaction of increased consumption but also premised on random (unknown) factors that may influence their choice. Extending ideas in the literature (Cascetta, 2009; De Vos et al., 2016), it is assumed that the choice probability (C), is the sum of probabilities of the marginal utility and the random utility. This way, the model incorporates variables related to the service offered by the transport system (price, service frequency, travel time, route), the land-use characteristics of the study area (housing location, business location), passengers' characteristics (income, gender, vehicle ownership and use), and the random factors which are independent to passengers. This is expressed as follows:

$$C = Pr(MU_{ij}) + Pr(U_{ij}) \quad (13)$$

4. Results

4.1. Socio-demographic characteristics of respondents

The average age of the respondents is 36 years (Table 1). The distribution of men to women is almost the same (51% and 49% respectively). Fifty-eight percent of the respondents are unmarried. The occupation of respondents is good for this study. Further, about 40% of respondents are property owners (Landlords) whilst the rest are tenants. Generally, income levels are low in these areas. The upper-class income earners (earn more than US$342.00 a month) only contribute 16% of our respondents while the middle class, 68% earning between US$85.00 and US$171.00 a month. Households of three people formed the majority. Another significant feature is that 41% of respondents own either a private car or a motorcycle.

4.2. Price, income, and daily spending distribution

Considering the low incomes of the respondents, the results suggest that the daily transportation spending is generally high. Assuming that each respondent travels only two OD trips a day, Table 2 shows that the lower class income earners could spend about 62% of their income on daily travels. The middle class spends between 45% and 62%, whiles the upper class spends 45% of income on daily travels. The situation is worse for the household, especially where the dependency ratio is high. For household transportation spending, the lower class spends 125% of their income on daily travels, whereas the upper class spends 60%. Using the current price of the suburban train as a benchmark, a lower-class passenger tentatively spends 25% of daily income on the two-way trip by train, whilst the upper class spends 6% of daily income.

4.3. Respondents' preference for the suburban train

The results in Table 3 show notable characteristics and the mean

Table 1
Socio-demographic features of respondents.

Measures	Variables	Frequency (%)
Age	Average age	36 (*SD* = 3.46)
Gender	Male	307 (51)
	Female	293 (49)
Marital status	Married	254 (42)
	Unmarried	346 (58)
Occupation	Office job	184 (31)
	Artisan	165 (28)
	Security services	100 (17)
	Trader	88 (15)
	Other	63 (11)
Residential accommodation	Self-owned	241 (40)
	Rented	359 (60)
Monthly income (US$)	< 85.00	97 (16)
	85.00–171.00	207 (35)
	172.00–342.00	199 (33)
	>342.00	97 (16)
Household size	1 person	62 (10)
	2 people	94 (16)
	3 people	234 (39)
	4–5 people	133 (22)
	≥6 people	77 (13)
Vehicle ownership	Own car/motorbike	244 (41)
	none	356 (59)

Note: *SD* denotes standard deviation.

Table 2
Price, daily income, and daily transportation spending comparisons.

Categories	Description	Price/value (US$)	Daily travel spending as % of income	Daily train spending as % of income
Mode of transport	Train	0.68	–	–
	Taxi and train	1.20	–	–
	Minibus	0.92	–	–
	Taxi	1.37	–	–
Daily income	Lower class	<2.74	–	–
	Middle class	2.74–11.47	–	–
	Upper class	>11.47	–	–
Daily passenger transportation spending	Lower class	<1.71	62	25
	Middle class	1.71–5.14	45–62	
	Upper class	>5.14	45	6
Daily passengers' household transportation spending	Lower class	<3.42	125	–
	Middle class	3.42–6.85	125–60	–
	Upper class	>6.85	60	–

ranking of the responses. Respondents did not show an overwhelming agreement or disagreement. For example, 30% of the respondents remained neutral regarding the dependent variable. There was a non-preference for the train with a mean of 2.98. These responses confirm partly, the declining demand.

4.4. Regression results

The model in Table 4 shows an acceptable goodness-of-fit as indicated by a significant chi-square (0.0004), a McFadden pseudo R^2 (0.0165), and a log-likelihood of −891 (see Liu, 2009).

Though Macfadden R^2 appears relatively low, suggesting somewhat a weak relationship between the independent variables and the dependent variable but does not make the model unfit. This argument is reinforced by the statistical significance of the chi-square goodness-of-fit value which compares the discrepancy between the distribution of observed values with expected values under our model.

Further, results in Table 5 indicate the marginal effects (dy/dx) that a unit change in an independent variable could have on passenger demand holding other independent variables constant. Thus, a unit change reduces or increases the odds of passenger demand.

The sum of the marginal effects of each independent variable is equal to zero (Buis, 2010). These are split among the ordered categories. For example, a unit change in females has a 3.1% chance of increasing demand for the train among females who 'strongly agree' to use the train. Similarly, it has a 5.9% chance of increasing passenger demand among females who 'agree' to use the train. A unit change in car ownership has a chance of reducing the train's ridership by 2.5% among those who 'strongly agree' to use the train, and 4.6% among those who 'agree' to use the train. As the negative perceptions about the limit of the train to 2 OD trips increases, the demand has a 1.2% likelihood of reducing among those who 'strongly agree' and 2.3% among those who 'agree'. These negative odds apply to an increasing distance between housing location, business location, and the location of train terminals. Additionally, as the price of the train increases, the odds of reduced ridership are predicted among those who 'agree' and those who 'strongly agree' to the high pricing scheme.

5. Discussion

The model results show that the travel time of the train negatively affects its ridership although this is statistically insignificant. Respondents who are satisfied with the train's speed (outcome 2) and those who think it is too slow (outcome 1) have respectively 0.8% and 0.6% likelihood of using it. Presumably, the respondents do not agree that the train provides faster services compared to other modes. Demand elasticities are usually higher for very short and very long trips and lower for medium-length ones (Paulley et al., 2006). For very short distances, passengers may prefer to walk which could reduce the demand for the train. Similarly, for extremely long distances, other modes may be preferred because the train has a restricted OD distance of 25 km. This affirms the findings of previous studies (van Loon et al., 2011; Walther et al., 2020).

The choice of residential location has a connection with travel choices. The findings show a negative effect of the respondents' residential location and their preference for the train although statistically insignificant. Besides, the findings show a negative effect of the location of the workplace on the train's ridership, although marginally significant ($p = 0.985$). This has a relation with the effects of route choice of the train. These results confirmed the assumption that the route choice of the train and the land-use mix accounts for its low demand. This is consistent with findings of De Gruyter et al. (2020).

The model further shows a significant negative effect of the actual price of the train on ridership. Ourfindings are in line with Iseki et al. (2018), who found that transit fares per mile have a significant effect on demand. For those who are content with the current price, the odds of riding the train are 4.6% (outcomes 1 and 2). On the contrary, a unit increase in the perception that the train is expensive decreases the likelihood of ridership by 4.4% (outcomes 4 and 5). Although the face value is cheaper, the cost of accessibility (boarding a taxi) makes it more expensive for some passengers. Also, the adoption of a common price for all distances covered by passengers makes the train more expensive than alternatives. Passengers should pay according to the travel distance. In advanced railway markets, passengers pay according to the distance they travel. This would require modern technologies currently not operationalized in Ghana. Moreover, the respondents indicated that the provision of a discount-shuttle service to the train terminals would increase their demand for the train although statistically insignificant. Furthermore, the limit of the train to only two trips a day accounts shows a significant negative effect of −0.156 on ridership.

The provision of a shuttle for the train terminals has around 0.42% odds of increasing demand for the train. Regarding the route of the train, the respondents who have no problem with the explanatory variable

Table 3
Descriptive statistic of Likert scale responses.

Measures	Percentage (%)					Mean	SD
	Strongly disagree	Disagree	Neutral	Agree	Strongly agree		
2 OD trips makes others more accessible	6	27	31	30	6	3.11	1.109
Alternatives modes suit business location	6	26	31	25	12	3.15	1.043
House Location favorable for alternatives	5	24	33	28	10	3.03	1.036
Train is faster than road transport	9	22	34	27	8	3.04	1.073
The train's price needs reduction	6	22	31	26	16	3.24	1.134
Provide a discount shuttle service	8	24	31	28	9	3.06	1.103
Route choice for the train is good	7	30	33	23	8	2.95	1.049
I like to travel by the train[a]	11	25	30	26	9	2.98	1.137

[a] Denotes dependent variable.

Table 4
Ordered logit regression estimates for the suburban train's passenger demand.

Parameters	B	S.E.	*p*-Value	Odds ratio	95% confidence interval	
					Lower limit	Upper limit
Gender (Ref. is Male)						
Female	0.405	0.149	0.006*	1.499	0.114	0.696
Private vehicle ownership (Ref. is none)						
Yes	−0.312	0.150	0.038**	0.732	−0.606	−0.017
Ordinal variables (Ref. travel by train)						
2 trips of the train	−0.156	0.073	0.033**	0.855	−0.299	−0.013
Business location	−0.112	0.067	0.093***	0.894	−0.243	0.019
Location of respondents' house	−0.001	0.073	0.985	0.999	−0.145	0.143
Travel time (faster than others)	−0.061	0.071	0.392	0.941	−0.201	−0.079
Price of the train	−0.199	0.067	0.003*	0.819	−0.331	−0.067
Provision of discount shuttle service	0.048	0.067	0.477	1.049	−0.084	0.179
Route choice for the train	−0.138	0.075	0.064***	0.871	−0.284	0.008
Threshold parameters α						
/cut1	−4.101	0.577			−5.233	−2.968
/cut2	−2.508	0.561			−3.609	−1.406
/cut3	−1.244	0.554			−2.330	−0.158
/cut4	0.487	0.557			−0.605	1.580
Model statistic						
Number of observations	600					
Number of parameters	9					
McFadden pseudo R^2	0.0165					
Log-likelihood	−891					
Chi-square						
LR chi-square	29.97					
Prob > chi-square	0.0004					

* $p < 0.01$, ** $p < 0.05$, *** $p < 0.10$ denote statistically significant. Ref. = Reference. S.E. = Standard Error.

have 3.1% odds of riding the train. This suggests that a unit increase in the perception that the route of the train is unfavorable decreases the likelihood of ridership by 3.1%. These findings are consistent with past studies (Lawson et al., 2011; Shiftan et al., 2006). They emphasize the good prospects of implementing bus/minibus shuttle services to make the train terminals easily accessible at a cheaper cost.

Compared to men, women are more likely to travel by suburban train. A unit increase in women can lead to about a 150% likelihood to travel by suburban train. This is consistent with past studies (Ng and Acker, 2018; Olivieri and Fageda, 2021). This suggests that the current schedule of the train would favor women more than men. Perhaps this is due to perceived safety and security as expounded in extant literature (Ouali et al., 2020; Rišová and Sládeková Madajová, 2020). Our current findings indicate that private vehicle owners are less likely to travel by train. This significant effect has a likelihood of a 73% impact on reducing ridership. Private car ownership has a positive correlation with household income and transportation spending (Whelan, 2007).

Besides, the results indicate that a low standard of living and a high daily transportation spending exists in Sekondi-Takoradi, especially among lower and middle-class income earners. Transport spending is the second-highest household expenditure (Guerra et al., 2018). Berg et al. (2017) found that transport costs in SSA are relatively higher than in developed economies. Presently, there is scarce literature on daily transport costs in similar cities that would have been beneficial for the purposes of comparison. Nonetheless, this high transport spending identified in this study presents the need for future research in SSA cities to add items on housing and transportation spending. Low traffic densities or volumes generated render the railway transportation services' operation costs in Africa 3 to 10 times greater than the costs of running railways in China, Russia, or the US (Olievschi, 2013). This tends to have a dramatic effect on railway fares in SSA.

6. Conclusion and policy implications

The present study investigated the factors causing the low demand for the Sekondi-Takoradi sub-urban train in Ghana, West Africa using a cross-sectional survey of 600 residents. From the analyses, the causes of the low demand for the sub-urban train are as follows. First, the location of the train's route in the coastal enclave of the twin-city is negatively affected by the current direction of residential settlements towards the inland areas. Second, responses showed that the limited supply of the train to only 2 OD trips per day makes it less competitive in the market compared to road transport. Third, prospective travelers have easy access to stations of alternative modes, which affects the demand for the suburban train. Lastly, passengers seem to be unsatisfied with paying a fixed price irrespective of travel distance.

Regarding the second research question, females and non-private vehicle owners showed more likelihood to travel by train compared to men and private car owners. Furthermore, the findings indicate that the provision of a discount shuttle to commute from the inland areas to train

Table 5
Marginal effects.

Independent variables	Outcomes									
	1		2		3		4		5	
	dy/dx	p-Value	dy/dx	p-Value	dy/dx	p-Value	dy/dx	p-Value	dy/dx	p-Value
Female	−0.036	0.008	−0.056	0.007	0.001	0.761	0.059	0.007	0.031	0.009
Car Ownership	0.027	0.037	0.043	0.039	0.0000	0.989	−0.046	0.039	−0.025	0.047
OD trips	0.014	0.036	0.022	0.035	−0.001	0.717	−0.023	0.035	−0.012	0.036
Business location	0.010	0.096	0.016	0.096	−0.0004	0.720	−0.017	0.095	−0.009	0.097
Housing location	0.0001	0.985	0.0002	0.985	−0.0001	0.985	−0.0002	0.985	−0.0001	0.985
Travel time	0.006	0.393	0.008	0.393	−0.009	0.731	−0.009	0.394	−0.005	0.394
Price of the train	0.018	0.004	0.028	0.004	−0.0008	0.715	−0.029	0.004	−0.015	0.004
Shuttle service	−0.004	0.478	−0.007	0.478	0.0002	0.743	−0.007	0.478	0.004	0.479
Route of the train	0.012	0.067	0.019	0.067	−0.0005	0.717	−0.020	0.067	−0.011	0.068

Note: (1) Strongly disagree, (2) Disagree, (3) Neutral, (4) Agree, (5) Strongly agree.

terminals can increase the demand. However, this requires verification with larger samples or pilot studies since it was statistically not significant. Besides, the land-use mix is negatively affecting the demand for the train.

Overall, several policy implications arise from the findings. A dynamic pricing mechanism is imperative for the emerging railway market in Ghana, which would enable travelers to pay per travel distance other than a fixed price for a full OD trip. However, this would have distributive impacts on commuters at the periphery and low-income populations. Dynamic pricing schemes should consider these groups and other social factors to make them adherent to transport justice as expounded in literature (Beyazit, 2011; Mladenović, 2017; Pereira et al., 2017). This would require investments in modern technologies and mobile phone applications that charge travel fares according to the distance traveled not merely using the number of stops. Also, the railway authorities should provide a shuttle service to link the areas developing inland to the terminals. With a discount, this would not only entice ridership but also create a gateway to provide a regular supply of the train throughout the day. Additionally, pro-poor economic policies are imperative in Sekondi-Takoradi due to the low incomes of residents in the twin-city. The GRC should consider the income distribution of the prospective demand and car ownership and use among the population to find more sustainable and enhanced services to attract patrons. The findings show that the declining ridership is manageable with improvement in service delivery. Most of the residents did not show outright disinterest in riding the train. Perhaps periodic free rides, discounts, and service bundles could entice patrons.

The railway developers should conduct more feasibility studies on the route choice of new railway lines and the dynamic market in Ghana. The railway redevelopment must consider the spatial developments when choosing the route of the trains. The land-use mix shows a diseconomy of agglomeration in Sekondi-Takoradi as people are gradually developing inland. Spatial and development planners must consider improving all forms of services that would still make the CBD attractive for businesses and transport services. This calls for more stakeholder collaborations in transportation and urban planning.

This study is beneficial to railway developers in SSA and other developing economies. Understanding the emerging railway market in Ghana and travel behavior is broadly helpful for policymaking and management of public transportation. For transportation research, this paper gives insight into the railway market in Ghana (Africa), which may apply to other developing countries having new railway development schemes. At the global level, the findings are beneficial to transportation engineers handling diverse projects globally. It also shows the technological gaps in the railway service in Ghana, which offers an opportunity to the industry.

This study has some limitations. The scope of the questionnaire did not account for important characteristics of the respondents and train services that would have provided a relatively clearer understanding of the problem, such as measures of safety, security, and comfort. This is because observations made during the pilot survey revealed that residents were less concerned about issues related to the service quality delivery as compared to general costs, route, and schedule. Future studies can include these qualitative service aspects to improve the generalization of findings. Besides, the authors wanted a larger sample but most of the respondents were apprehensive because of the COVID-19 pandemic. However, the sample size was good considering that 14 suburbs were covered. Future studies should build on the findings of this study to model an optimized price for the operation of the train, incorporating adherence to transport justice. The general pricing system for public transport also needs more research and expert attention. The authors intend to do follow-up experimentation with some modern pricing technologies.

Author contributions

Philip Kofi Alimo: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing-original draft, Editing, Final draft preparation; *Stephen Agyeman*: Conceptualization, Data curation, Formal analysis, Final draft preparation; *Sanusi Mumuni Zankawah:* Writing-original draft, Editing, Final draft preparation; *Chunhui Yu:* Funding acquisition, Supervision, Resources, Review, Validation; *Lin Cheng:* Supervision, Resources, Review, Validation; *Wanjing Ma:* Funding acquisition, Supervision, Resources, Review, Validation.

All authors approved the final manuscript.

Funding sources

This research was supported by the National Natural Science Foundation of China (61903276) and Fundamental Research Funds for the Central Universities (22120190205).

Data Statement

The dataset has been attached as supplementary material.

Declaration of Competing Interest

The authors declare no conflicts of interest.

Acknowledgment

The authors are grateful to Victus Elikplim Lumorvie for supervising the data collection.

Appendix A. Africa's rail lines and passenger volume

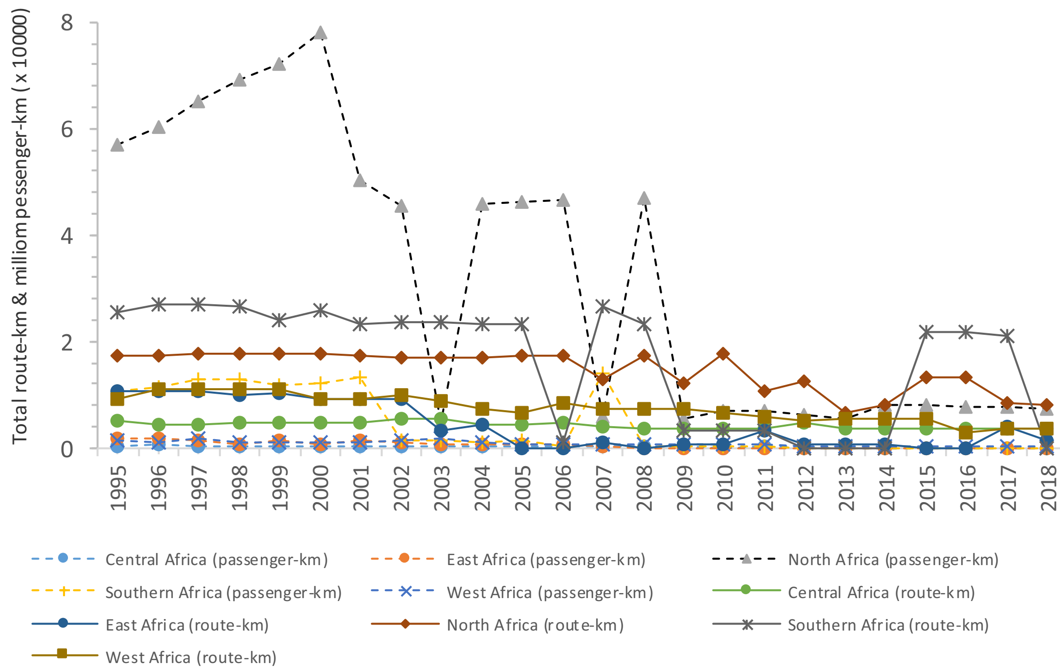

Fig. A1. Africa's rail lines (total route-km) and passengers carried (million passenger-km).
Source: AICD database (https://datacatalog.worldbank.org/dataset/africas-infrastructure-national-data).

Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jtrangeo.2021.103268.

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