

# TOWARDS A LIVABILITY INDEX BY PUBLIC TRANSPORT (LIPT): CONCEPTUAL FRAMEWORK AND TOOL PROTOTYPING

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**Abstract:** This paper proposes the Livability Index by Public Transport (LIPT), a novel accessibility indicator designed to assess quantitatively the feasibility of completing trip chains using public transport. Alongside, we present LIPT-sim, a tool enabling users to compute several accessibility indicators using GTFS public transport data. A case study in the Nagoya region reveals that traditional coverage-based methods may overestimate accessibility in some rural regions, highlighting the need for trip chain-oriented assessments. Through these proposal and prototyping, this paper propose our direction to improve public transport assessment and designing to enable it surely support people's daily activities.

**Keywords:** Accessibility index, public transport, data spaces, trip chain, GTFS

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## 1. INTRODUCTION

When designing public transport services, it is crucial to consider how such services provide accessibility to various activity opportunities. From this perspective, numerous accessibility indicators have been proposed and compared in prior research (Miller, 2018).

In urban areas where service levels are relatively high, accessibility can often be evaluated by assessing the spatial distribution of mobility hubs such as stations and bus stops, as well as the frequency of service. For instance, Transport for London developed the Public Transport Accessibility Levels (PTAL) index, which incorporates service frequency and walking time to transport nodes to calculate expected waiting time. This indicator has also been adapted and applied in other cities—such as the Greater Manchester Accessibility Levels—through minor modifications suited to local contexts (The International Transport

Forum, 2018).

In contrast, for regions outside major metropolitan areas where service density is lower, frequency alone may be insufficient to evaluate service quality. In such contexts, it is necessary to consider whether individuals can access activity destinations, engage in their intended activities, and return—highlighting the importance of a trip chain-based perspective. In response to this need, the authors propose the development of a new quantitative indicator: the Livability Index by Public Transport (LIPT).

As indicators become more sophisticated and complex, their practical use may be hindered. This is evident in many public transport planning practices in Japan, where service areas are often assessed using simple concentric buffer zones on GIS due to ease of implementation. Accordingly, alongside the development of robust accessibility indicators, there is also a pressing need to establish systems that enable such indicators to be calculated easily.

In light of the above, this paper presents: (1) the concept and prototype implementation of a tool that enables users to easily assess accessibility indicators (Section 2), and (2) the conceptual framework and underlying analysis for the proposed Livability Index by Public Transport (LIPT) (Section 3).

## **2. TOOL PROTOTYPING OF LIPT-SIM**

This section presents the development of a tool designed to enable users to easily compute public transport accessibility indicators, including the aforementioned LIPT. The suite of concepts and tools introduced here is collectively referred to as LIPT-sim.

One of the most labor-intensive stages in computing accessibility indicators is the input and processing of public transport service data, such as operational frequencies and service routes. Traditionally, this task has been technically challenging. However, in recent years, the standardization of transit data formats—exemplified by the General Transit Feed Specification (GTFS)—has significantly improved accessibility to such data. These unified data formats offer considerable advantages, not only in enhancing passenger information services, but also in supporting accessibility evaluations (Stępnik et al., 2019).

LIPT-sim aims to leverage GTFS-compliant data to allow anyone to compute a variety of accessibility indicators with minimal effort. As a first step, in December 2024, we released a tool capable of calculating the same indicator definition used in the aforementioned Greater Manchester Accessibility Levels (GMAL). To make LIPT-sim publicly accessible, we implemented it on the Japan Mobility Data Space (JMDS)—a smart mobility data space developed through collaboration among government, academia, and industry in Japan. By accessing JMDS, users can operate LIPT-sim directly via a web browser (Figure 1). In its initial release in December 2024, the tool allowed users to select a Japanese municipality of interest, retrieve the corresponding GTFS data from the AIGIT GTFS repository, and compute accessibility indicators accordingly. In the second release in March 2025, the tool was extended to accept user-uploaded GTFS data. This enhancement enabled analyses beyond Japan, accommodating datasets from any region. It also made it possible to evaluate hypothetical or future service scenarios, rather than being limited to current levels of service (LOS). Future updates will continue to expand LIPT-sim's capabilities, including support for the proposed Livability Index by Public Transport (LIPT), as introduced in the following section.

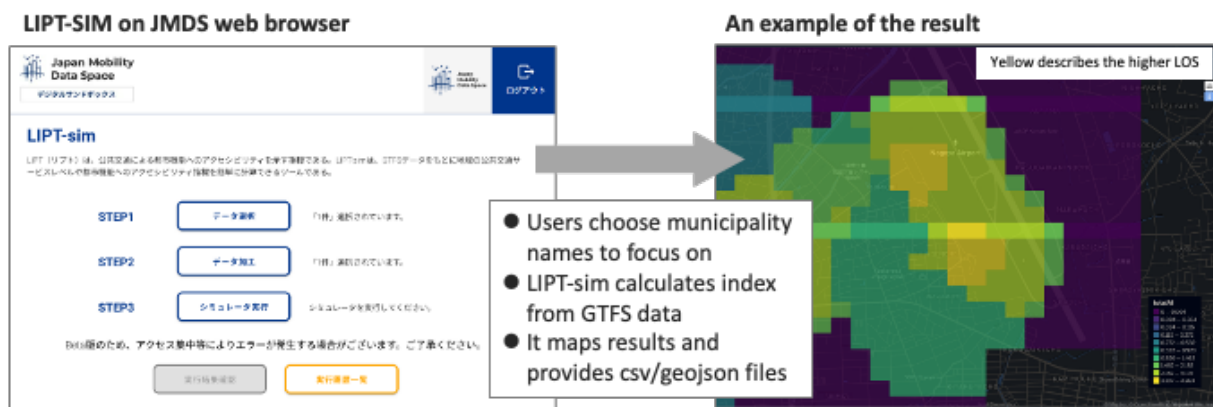


Figure 1. An example of LIPT-SIM on JMDS

### 3. LIPT: LIVABILITY INDEX BY PUBLIC TRANSPORT

#### 3.1. A concept of LIPT

As noted earlier, in urban areas where public transport service levels are relatively high, indicators that reflect service density can effectively function as proxies for accessibility. In contrast, in non-urban or rural regions, it is necessary to consider not only service frequency but also whether individuals can access activity opportunities by public transport, spend a reasonable amount of time at their destination, and return within a feasible timeframe—i.e., the feasibility of completing a trip chain.

In this context, the Accessibility Table has been proposed as an indicator (Fukumoto, 2024). However, its application has so far been limited, and the indicator itself is binary in nature, representing only whether a given trip chain is feasible or not. The Livability Index by Public Transport (LIPT) builds upon and extends the concept of the Accessibility Table by incorporating quantitative considerations of service levels, such as total travel time and times of transfer. This approach allows for a more nuanced and practical evaluation of public transport accessibility in low-service areas.

#### 3.2. Fundamental analysis in Nagoya region, Japan

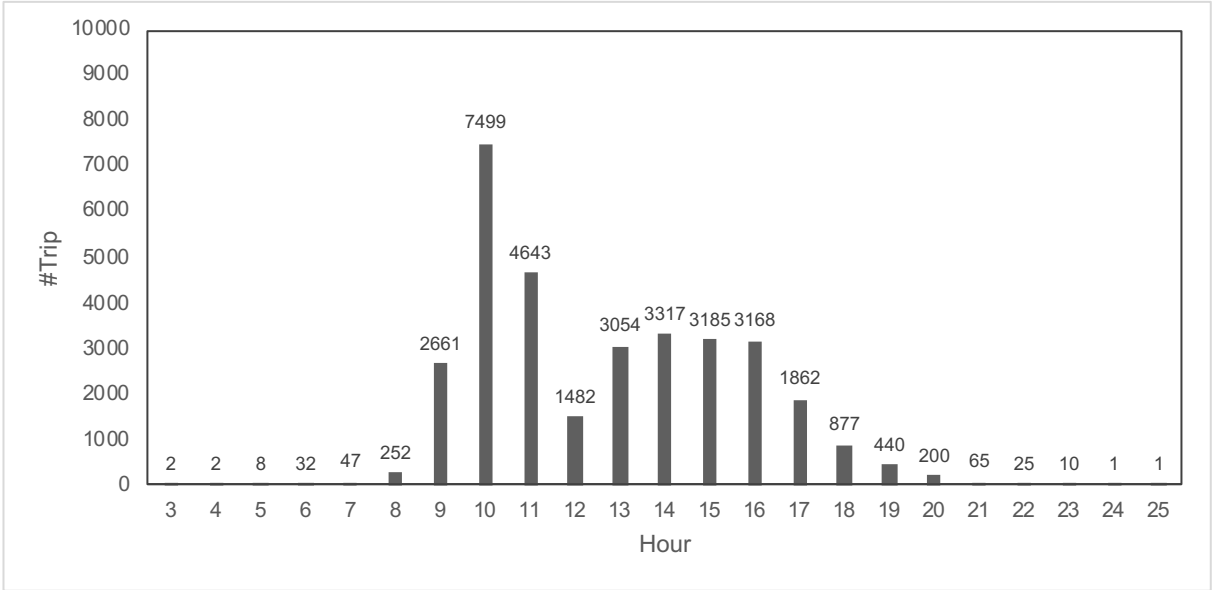
##### 3.2.1. Current trip chain for daily shopping by cars and walking

As a fundamental analysis toward the development of the LIPT, this section evaluates the extent to which typical home-based shopping trips can be feasibly realized as trip chains using current public transport services. The study focuses on the Chukyo metropolitan region, centered around the Nagoya urban area, Japan.

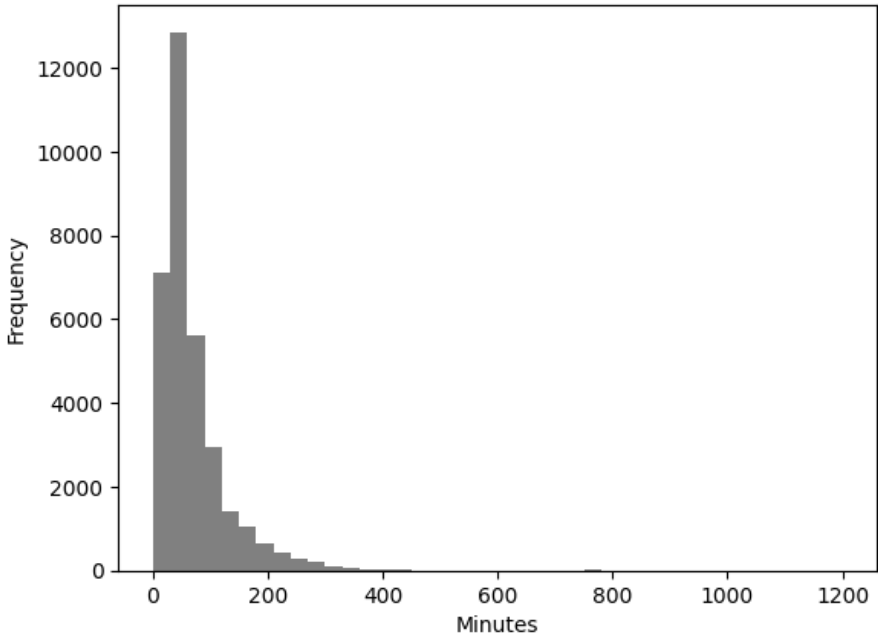
In contrast to public transport, trips made by private car or on foot are generally less constrained in terms of arrival times and allowable staying duration at destinations. Based on this, we analyze existing home-based shopping trips—currently made by private car or on foot—within the study area to determine their temporal characteristics and assess whether equivalent trip chains would be feasible using public transport under current service conditions.

For this purpose, we utilize a travel data from the Fifth Chukyo Metropolitan Area Person Trip Survey, conducted in 2011, which serves as the household travel survey for the region. A total of 32,833 trip

samples matching the criteria were extracted. Among these, the most common arrival time window was between 10:00 and 11:00 AM (22.8%), followed by 11:00 to 12:00 AM (14.1%) (Figure 2). The median dwell time was 50.0 minutes, and the average dwell time was 65.4 minutes (Figure 3).



**Figure 2. Arrival time distribution for daily shopping by private cars or on foot**



**Figure 3. A distribution of staying minutes at daily shopping facility**

**3.2.2. Availability assessment of public transport enabling shopping trip chain**

Given the previous result, we define a representative trip scenario to evaluate the feasibility of completing a trip chain by public transport. Specifically, we consider a round trip in which a traveler departs from an evaluation point (assumed to be their residence), arrives at a shopping facility between 10:15 and 10:45 AM, secures a dwell time of 50 minutes (with an additional 15-minute buffer before and after), and then returns to the origin by public transport.

Departure points were selected from the area covered by the Chukyo Metropolitan Area Person Trip Survey using Japan's standard third-level grid system (approximately one kilometer square), with samples taken at roughly 2 km intervals. The centroid of each mesh cell was treated as the representative evaluation point.

Potential destinations were identified using the Yahoo! Open Local Platform (YOLP) Local Search API by retrieving up to three supermarkets within a 20 km radius from each evaluation point, sorted by straight-line distance. If a point of interest (POI) was located within 300 meters of the evaluation point, it was assumed to be accessible on foot and thus excluded from the analysis. As a result, a total of 2,403 evaluation points (origin–destination pairs) were obtained.

For each origin–destination pair, we assessed whether the round trip could be completed using public transport, utilizing the commercially available Navitime API for route planning. Each OD pair was classified into one of three categories: (1) round trip feasible (round trip), (2) outbound trip feasible but return trip infeasible (outbound only), and (3) outbound trip infeasible (unavailable).

The results showed that 2,139 evaluation points (89.0%) allowed for a feasible round trip. In contrast, 112 points (4.7%) permitted only the outbound trip, and 152 points (6.3%) were infeasible even for the outbound. The latter two categories—constituting 11.0% of all evaluated points—represent cases in which the assumed trip chain cannot be completed. It should be noted, however, that the evaluation points include areas in mountainous or sparsely inhabited regions, where actual residential activity is minimal.

### **3.2.3. A comparison between conventional assessment with spatial service coverage**

We compared the trip chain feasibility assessment with a conventional method widely used in public transport planning practice in Japan. This traditional approach defines service coverage areas based on proximity to railway stations or bus stops, classifying locations as either inside or outside these coverage areas. For this comparison, we defined service coverage as a 300-meter radius around each bus stop, using publicly available bus stop location data from the Digital National Land Information published by Japanese government. Among the 2,403 grid-based evaluation points used in the earlier analysis, we identified those located within these defined coverage areas—i.e., those that would traditionally be considered accessible by bus services.

This process yielded 1,292 evaluation points within coverage zones. Among these, 29 points were identified as feasible for the outbound trip but infeasible for the return trip, and 44 points were infeasible for the outbound trip altogether. Thus, a total of 73 points—representing 5.7% of the evaluation points within the conventional coverage zones—were determined to be infeasible for completing a full trip chain (Table 1). Figure 4 shows the spatial distribution of the assessment results. In the figure, blue grids represent areas where round-trip travel is feasible (round trip), green indicates outbound-only feasibility (outbound only), and red indicates full infeasibility (unavailable).

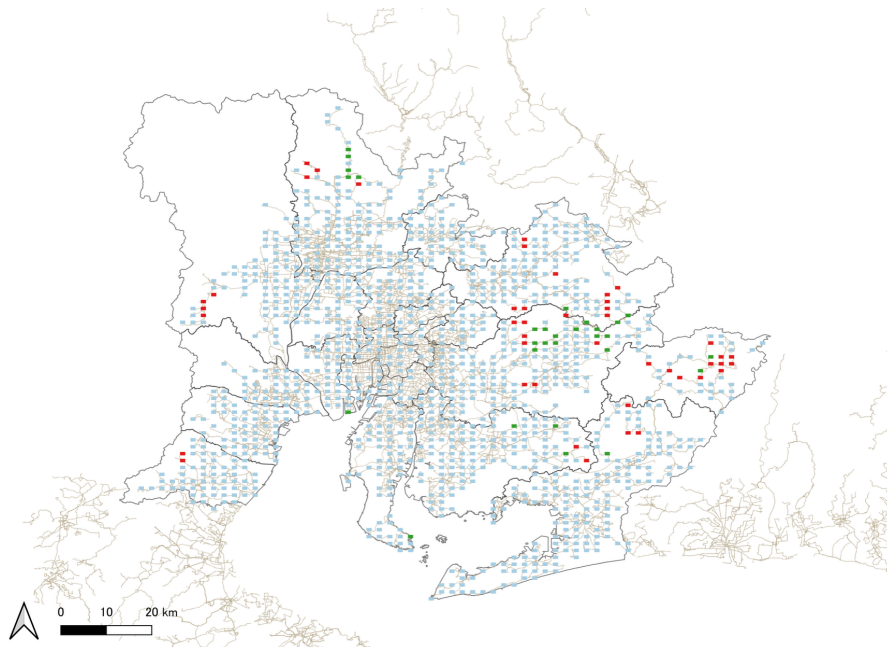
Compared to the results from all evaluation points, the proportion of locations where trip chains could not be completed was reduced under the conventional coverage-based method. However, such infeasible areas were still clearly observed. Whether the 5.7% share of infeasible locations should be considered significant is open to discussion.

It is also important to note that even among OD pairs deemed feasible under the current analysis, various

service-level concerns likely persist—such as long or steep walking distances to bus stops, lengthy total travel times, or multiple transfers. Building on the findings of this study, the proposed LIPT should be further developed to incorporate these qualitative service attributes into a comprehensive and quantifiable accessibility indicator.

**Table 1. Result of trip chain feasibility assessment to supermarket with public transport**

Category			All grids		Grids within bus coverage	
Name	Meaning		Count	Ratio	Count	Ratio
	Outbound trip	Inbound trip				
Round trip	OK	OK	2139	89.0%	1219	94.3%
Outbound only	OK	NG	112	4.7%	29	2.2%
Unavailable	NG	-	152	6.3%	44	3.4%



**Figure 4. Spatial distribution of trip chain feasibility with public transport**

## 4. CONCLUSION

As discussed throughout this paper, the authors are engaged in two complementary efforts aimed at enhancing public transport planning practices: (1) the proposal of a new accessibility indicator—the Livability Index by Public Transport (LIPT)—which explicitly considers the feasibility of completing a trip chain; and (2) the development of a practical tool, LIPT-sim, designed to allow users to easily compute LIPT and other accessibility indicators.

With respect to LIPT-sim, the first version of the tool has been successfully released. This version enables users to compute existing indicators, such as those derived from the UK context, directly through a web interface. The tool is hosted on the Japan Mobility Data Space (JMDS), a national smart mobility data space.

In parallel, this paper presented a fundamental analysis of LIPT using empirical data from the Nagoya

metropolitan area in Japan. The analysis focused on evaluating whether home-based, shopping-purpose trip chains—common in daily life—can realistically be completed using public transport. Results revealed that, in some areas, existing accessibility evaluations based solely on spatial proximity (e.g., to bus stops) may falsely suggest sufficient service availability. In fact, such areas may not support viable round-trip travel chains, indicating the limitations of conventional metrics.

Future research should aim to further refine LIPT, moving beyond binary feasibility assessments to incorporate service-level factors such as total travel time, number of transfers, and walking burden. Such enhancements will support the development of more comprehensive and practically applicable accessibility metrics for diverse transport contexts.

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