What is the relationship between the distribution of parking facilities and the local traffic in Kwun Tong, Hong Kong?

Personal code: [redacted]

1 Table of Contents

2 Introduction

2.1 Abstract

Since the industrialisation of Hong Kong (HK), the territory has observed a steady increase in car ownership, while the growth rate of the total amount of parking spaces has decreased ("Transport Department", 2021), resulting in a shortage in parking supply. With HK being one of the busiest freight and container hub ("HKTDC Research", 2021) and being one of the most densely populated areas ("Census and Statistics Department", 2021), the development of an efficient transportation system is paramount to the long-term sustainability of the logistics industry. With the vehicular speed in urban areas declining ("Legislative Council Secretariat", 2014), traffic congestion decreases the throughput of products and services, exacerbates air pollution, and worsens the quality of life of citizens (Arnott and Small, 1994). Therefore, this investigation aims to provide a more solid understanding of the relationship between the spatial distribution of parking spaces and the local traffic in urban areas of HK, so to build a more resilient and sustainable transport system.

2.2 Literature Review

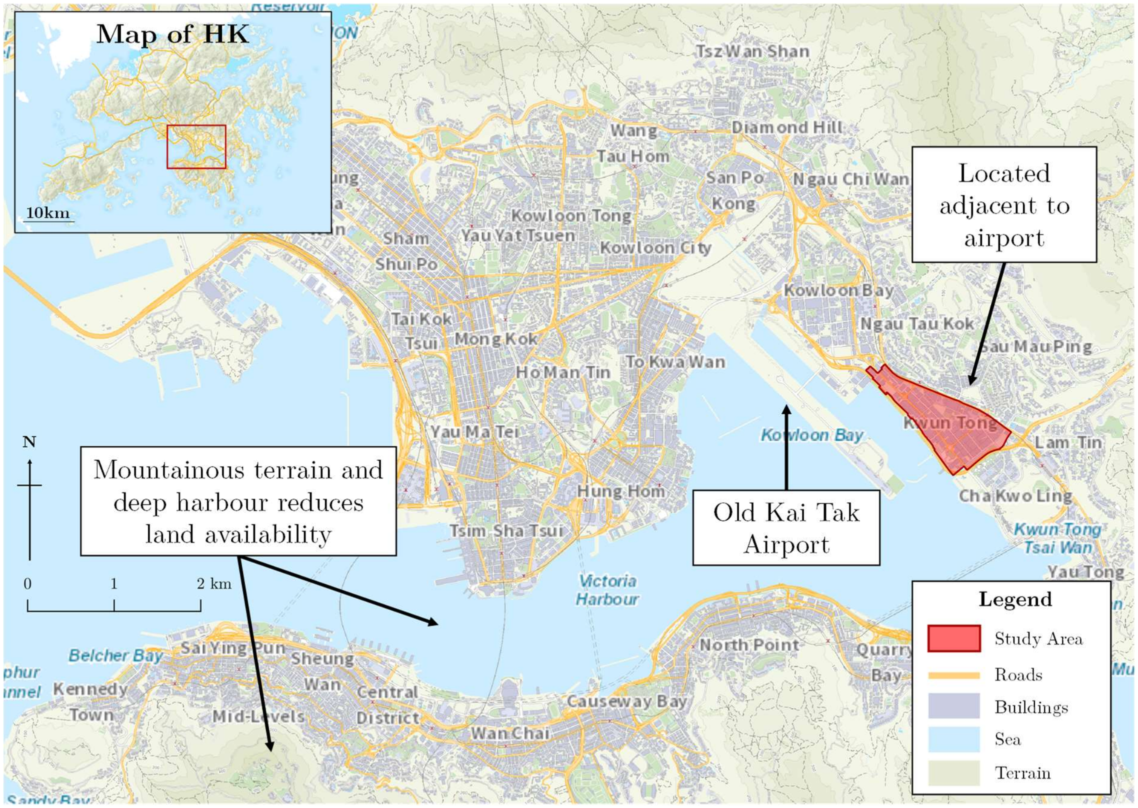
According to the Transport Advisory Committee, traffic congestion is one of the most important urban issue in HK. Many researchers have compared traffic congestion to fluid dynamics, outlining the three fundamental components, including flow, the number of vehicles passing through a point per unit time; speed, the distance covered per unit time; and density, the number of vehicles occupying a road segment per unit distance (Salter, 1976; Gaddam and Rao, 2018). Although multiple attempts have been made to relate speed and density (Greenshields, 1935; Drake et al., 1967; Wang et al., 2010), it has been widely accepted that traffic congestion is characterised with high density and low speeds (Bovy and Saloman, 2002).

It has historically been trivial to quantify traffic congestion (Aftabuzzaman, 2007). One of the methods developed is the Roadway Congestion Index (RCI), which the ratio between the mean time delayed and the theoretical free-flow travel time (Schrank et al., 1994). Although the measure is widely implemented in the U.S., researchers have argued that the measure is inapplicable to public transport heavy cities (Levinson and Lomax, 1996), which is the case for HK as 90% of the population uses public transport ("Legislative Council Secretariat", 2016). Another measure adopted by the U.K. and Japan is the volume-to-capacity (V/C) ratio, which is calculated by the quotient of the measured traffic volume and the maximum design volume and are often classified into different traffic behaviour categories (Lindley, 1987). Despite the measure offering great scalability, since fundamental parameters are not accounted for, some researchers have criticised using V/C as a measure of traffic congestion (Gordon et al., 1997; Hamad and Kikuchi, 2002). With a variety of different measures developed, researchers have argued that the direct measurement of traffic speed is arguably the simplest, least biased, and most representative method of quantifying traffic congestion (Wardrop, 1952; Ye et al, 2006; Cvetek, 2021). Speed can be measured directly with cameras or estimated from time-occupancy, the percentage of time occupied by a vehicle, from inductive loop detectors or manually (Ulberg and McCormack, 1988; Arasan and Dhivya, 2009).

The distribution of services is often expressed by the extent of which geographical features are clustered or evenly spread out. Because drivers have the incentive to park at locations closest to their destination (Parmar et al., 2020), insufficient off-street parking spaces often cause drivers to resort to curb-side illegal parking, reducing the road capacity and increasing road accident risks (Tong et al., 2004). On the other hand, an overabundance of parking space can also cause drivers to cruise around the area in search for lower costs, resulting in a lower vehicular speed and the occupation of road space (Shoup, 2006). Therefore, multiple parking strategies and models have been developed in order to ensure an evenly distributed level of service, such as the Second Parking Demand Study in HK (Wong et al., 2000; Lau et al., 2005).

The distribution of facilities can be measured using the Nearest Neighbour Index (NNI), which is the ratio between the observed and expected mean Euclidean distance (Pinder and Witherick, 1972). Although the index provides an excellent general outlook on the inequity of services, the assumptions that facilities are fully interconnected with no friction of distance is highly unreasonable (Wang and Lou; 2005). With the need of pinpointing regions with inadequate supply of facilities on a microscopic level increasing, researchers have developed the two-step floating catchment area method (2SFCA), which involves summing up distance-decayed supply-to-demand ratios (SDR) surrounding the survey point (Wang and Luo, 2004). Since 2SFCA incorporates the both the aspatial utilisation of the service and the spatial demographic patterns, 2SFCA can effectively represent the real-life preferences of users and therefore has gained widespread interests in applications such as the measurement of accessibility in healthcare services (McGrail, 2012; Chen and Jia, 2019).

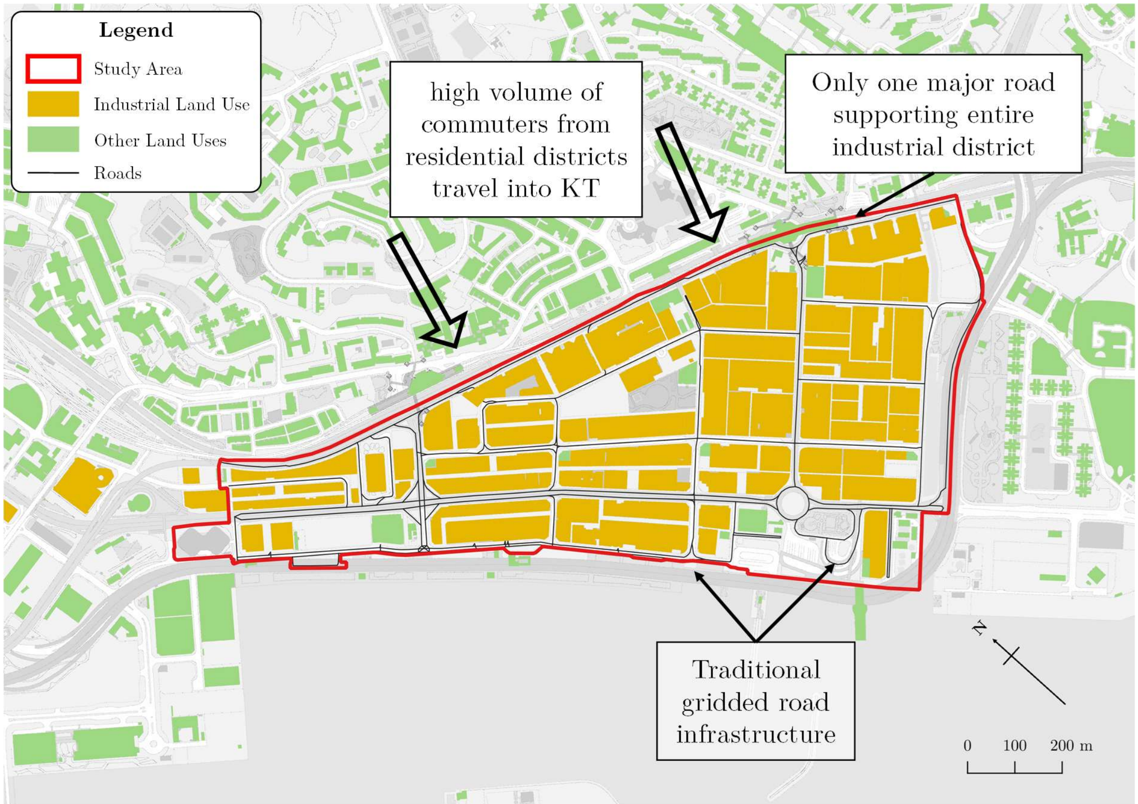
3 Geographical Context



Map 1. The location of the study area with reference to HK. (Hong Kong Geodata Store, 2021)

Due to the unique mountainous geography of HK, with land availability being highly contested and limited, land developers often construct tall buildings in order to maximise their profit. As a result, due to the densely populated nature of HK, the demand for transport services is exceptionally high, causing severe traffic congestion.

In the early 1950s, HK is a major manufacturing hub for the Greater Asia. To fulfil the growing industrial needs, Kwun Tong (KT) has been designated as the first industrial zone of HK (Kwun Tong District Council, 2015). As KT is within close proximity to the then-airport (see Map 1), it allowed raw materials to be rapidly imported and products to be efficiently exported, generating large volumes of traffic (Lai and Dwyer, 1965).



Map 2. The road infrastructure and land use of the study area. (Hong Kong Geodata Store, 2021)

In order to boost economic productivity, KT has been designated as a satellite city (Scott, 1982), where industrial zones and residential areas are clearly segregated from each other, as shown above. Although distinct functional zones can increase the quality of life in residential neighbourhoods and allow industrial activities to be centralised, high volumes of cross-commuting occur during peak hours, resulting in heavy traffic stresses (Merrilees et al., 2013). Furthermore, due to the traditional gridded road layout, the high amount of traffic junctions and intersections causes traffic flow to be frequently interrupted. Coupled with the fact that the area has the highest population density across all districts of HK ("Census and Statistics Department", 2016), KT is renowned for its heavily congested traffic, with bus journey speeds as low as 1.32km/h during peak hours (Tse and Wong, 2021).

4 Hypothesis

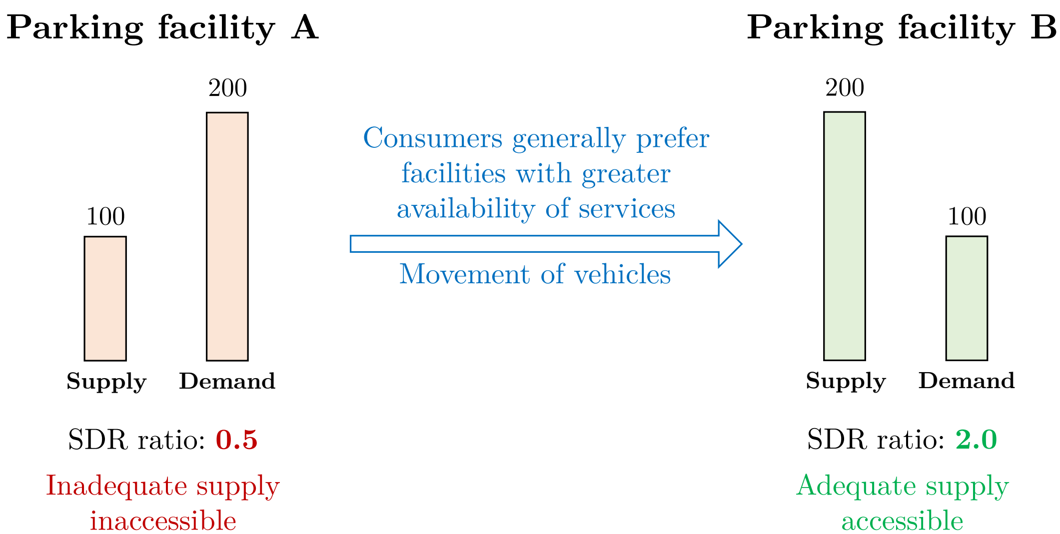


Figure 1. Demonstration of the movement of vehicles to areas with greater parking accessibility.

As shown above, where there is an imbalance in SDR, drivers tend to move towards areas with greater supply in parking spaces. While it is commonly believed that areas with adequate supply in parking facilities can alleviate traffic congestion, several researchers have pointed out the excess of parking supply can instead worsen traffic congestion. The reason for this phenomenon goes by that with a wide spectrum of parking spaces available, drivers are willing to constantly circle around the area in search of better parking prices (Millard-Ball et al., 2020). Since cruising behaviour often involves frequent lane-changing and abrupt changes in vehicle acceleration, it essentially forms a mobile stream of slow-moving traffic queue, thereby worsening traffic congestion (Zhu et al., 2020). Conversely, in areas with inadequate parking supply, drivers are less likely to bid for lower parking cost at the expense of losing the opportunity to park, therefore reducing cruising and lead to smoother traffic (Shoup, 2006).

Therefore, the following set of hypotheses will be tested in this investigation:

Null hypothesis (H_0): There is no correlation between the relative magnitude of traffic congestion and the accessibility to parking spaces.

Alternative Hypothesis (H_1): There is a negative correlation between the relative magnitude of traffic congestion and accessibility to parking spaces.

5 Methodology

To assess the correlation between the independent and dependent variables, the accessibility will be first computed by processing the locations of all roads, buildings, and parking facilities through a modified version of Ga2SFCA method with QGIS[1] and Python[2], which is detailed in Section 5.1. An on-site survey will then be performed to measure the traffic congestion, detailed in Section 5.2. Finally, both variables will be compared to validate the alternative hypothesis using the Spearman Rank Correlation Coefficient (SPCC), detailed in Section 5.3.

[1] An open-source geographic information system (GIS) software, available at: https://www.qgis.org
[2] A general-purpose programming language, available at: https://www.python.org

5.1 Accessibility

5.1.1 The Gaussian-based two-step floating catchment method (Ga2SFCA)

As explored in the hypothesis, since the utilisation of parking services is heavily influenced by the SDR of the location, the accessibility at location i can be expressed by the sum of SDRs of every facility j:

$$A_i = \sum\nolimits_j \frac{S_j}{D_j} \tag{5.1.1.1}$$

where:

- A_i Accessibility to parking facilities at location i
- S_j Supply of parking facility j
- D_j Demand of parking facility j

However, the equation above infers that each parking facility has an equal probability of being selected by the driver, which is inherently untrue. In fact, because transport incurs some form of cost such as time, drivers often have to overcome the friction of distance using additional resources, consequently, the attractiveness of a facility is attenuated at increasing distances (Huff and Jenks, 1968).

The distance decay effect is often accounted mathematically by multiplying the attractiveness by some monotonically decreasing distance decay function. The most commonly used function is Gaussian-based (Dai, 2010; Luo and Whippo, 2012; Tao et al., 2020), defined by:

$$f(d, d_0) = \begin{cases} \dfrac{e^{-\frac{1}{2}\left(\frac{d}{d_0}\right)^2} - e^{-\frac{1}{2}}}{1 - e^{-\frac{1}{2}}} & \{d \leq d_0\} \\ 0 & \{d > d_0\} \end{cases} \tag{5.1.1.2}$$

where:

- d Distance between location and facility
- d_0 Maximum catchment distance

Since the demand of a parking facility follows distance decay effects:

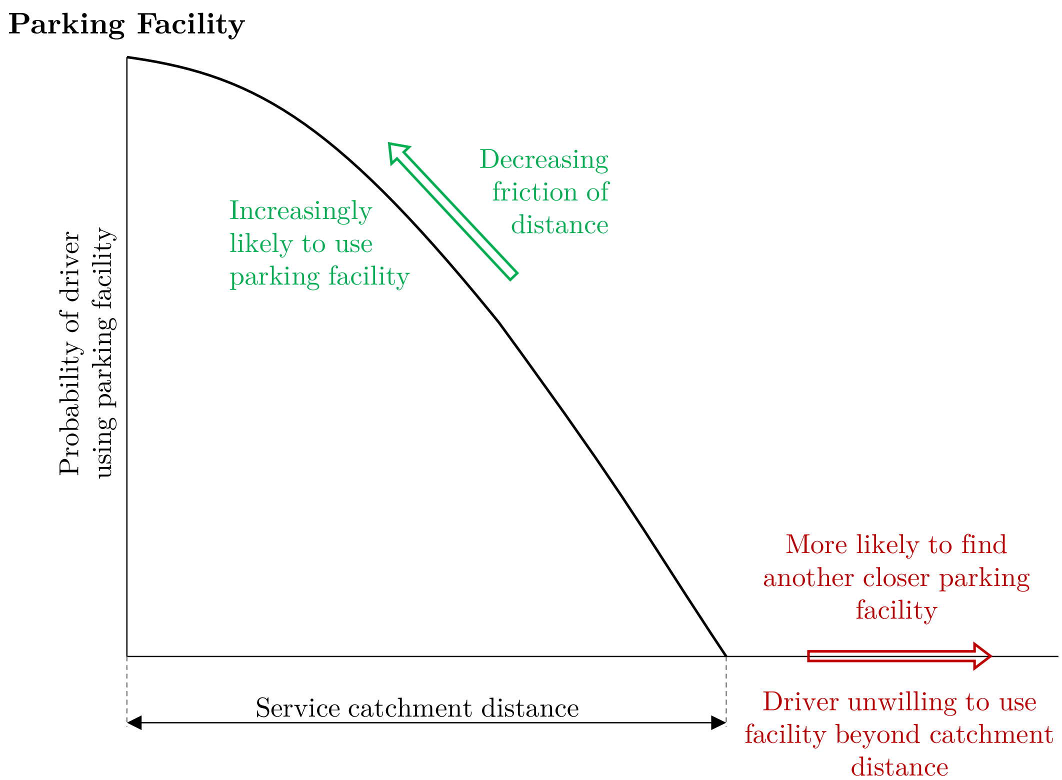


Figure 2. Demonstration of the distance decay effects on the supply of parking facilities.

The effective supply is often adjusted with the distance decay function (Wang et al., 2021), hence Equation 5.1.1.1 can be better represented as:

$$A_i = \sum_j \frac{S_j f(d_{ij}, d_i)}{D_j} \tag{5.1.1.3}$$

where:

A_i	Accessibility to parking facilities at location i
S_j	Supply of parking facility j
f	Distance decay function, as defined in Equation 5.1.1.2
d_{ij}	Distance between location i and parking facility j
d_i	Service catchment distance of location i, by driving
D_j	Demand of parking facility j

Since the distance decay effect also applies for the demand:

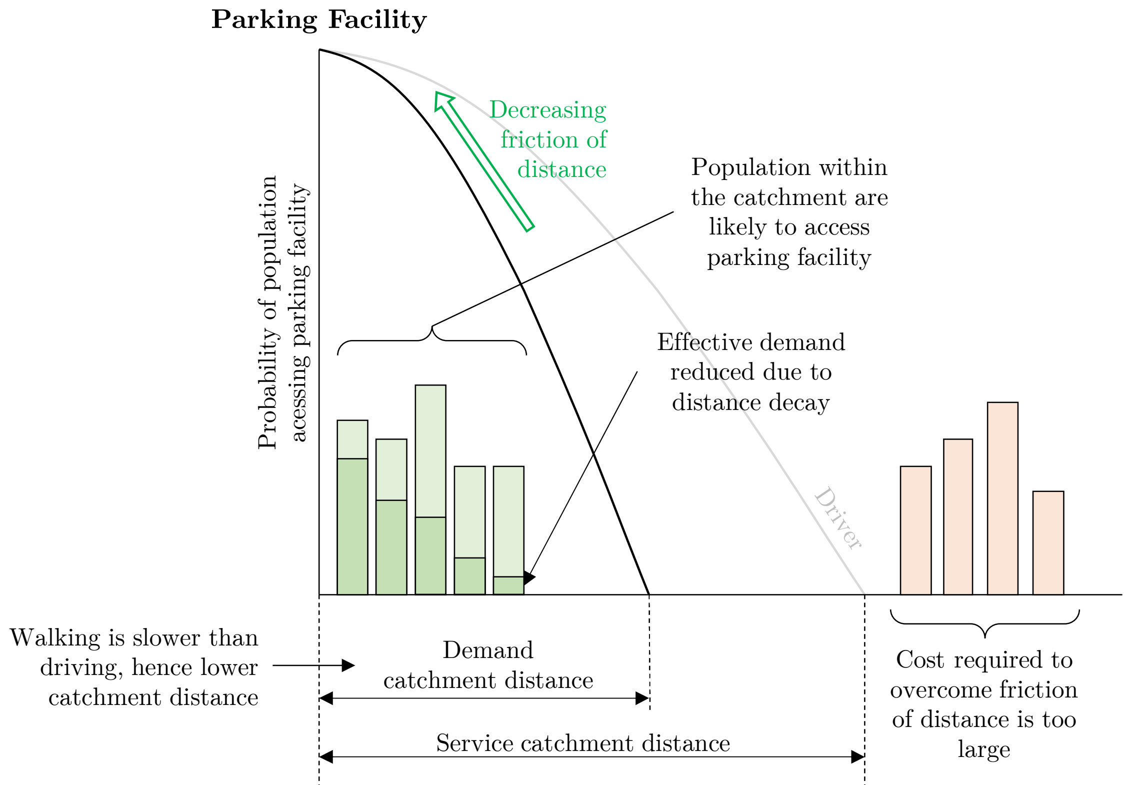


Figure 3. Demonstration of the distance decay effects on the demand of demand nodes.

The demand of a facility can be represented by the sum of distance-decayed effective demands at every demand node k surrounding the facility j. This yields the final equation of Ga2SFCA, which accounts for both the aspatial utilisation and spatial effects (Wang et al., 2021):

$$A_i = \sum_j \frac{S_j f(d_{ij}, d_i)}{\sum_k D_k f(d_{jk}, d_j)} \tag{5.1.1.4}$$

where:

A_i	Accessibility to parking facilities at location i
S_j	Supply of parking facility j
f	Distance decay function, as defined in Equation 5.1.1.2
d_{ij}	Distance between location i and parking facility j
d_i	Service catchment distance of location i, by driving
D_k	Demand at demand node k
d_{jk}	Distance between parking facility j and demand node k
d_j	Demand catchment distance of parking facility j, by walking

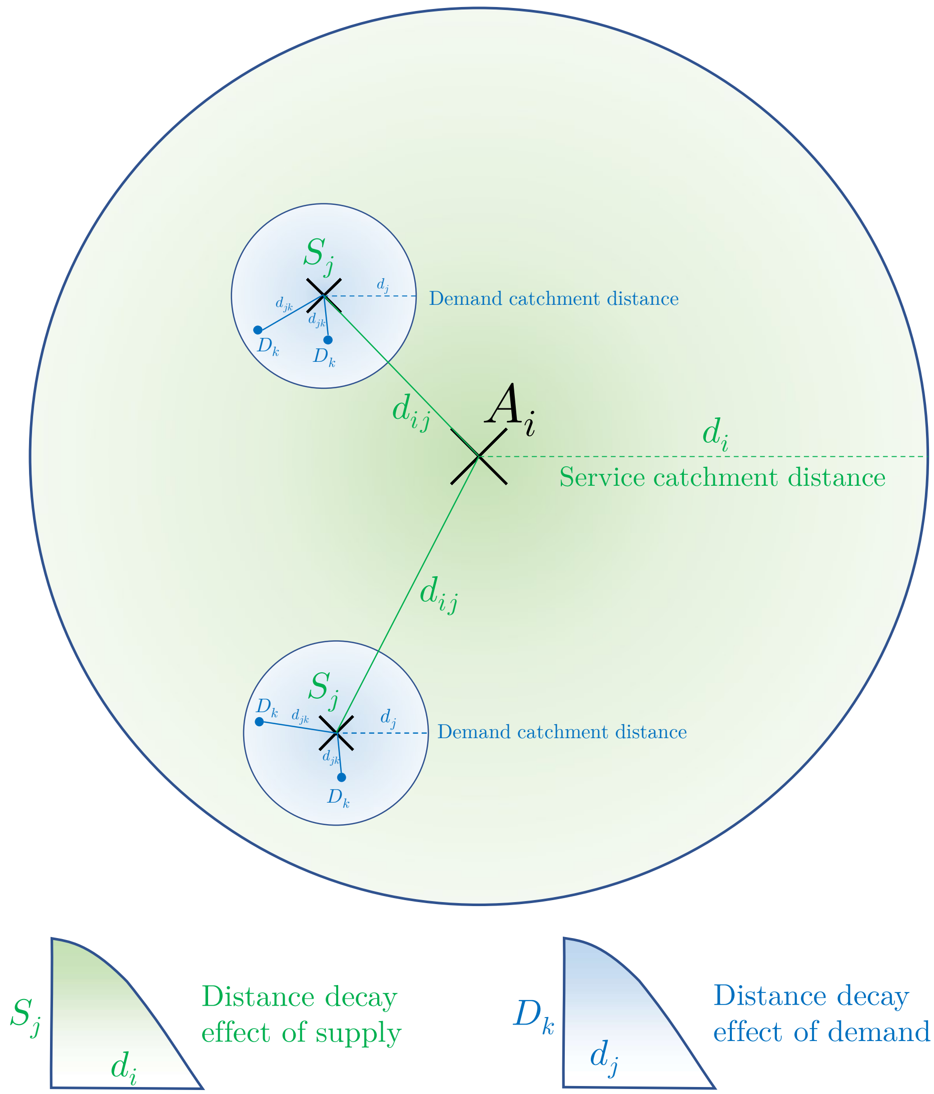
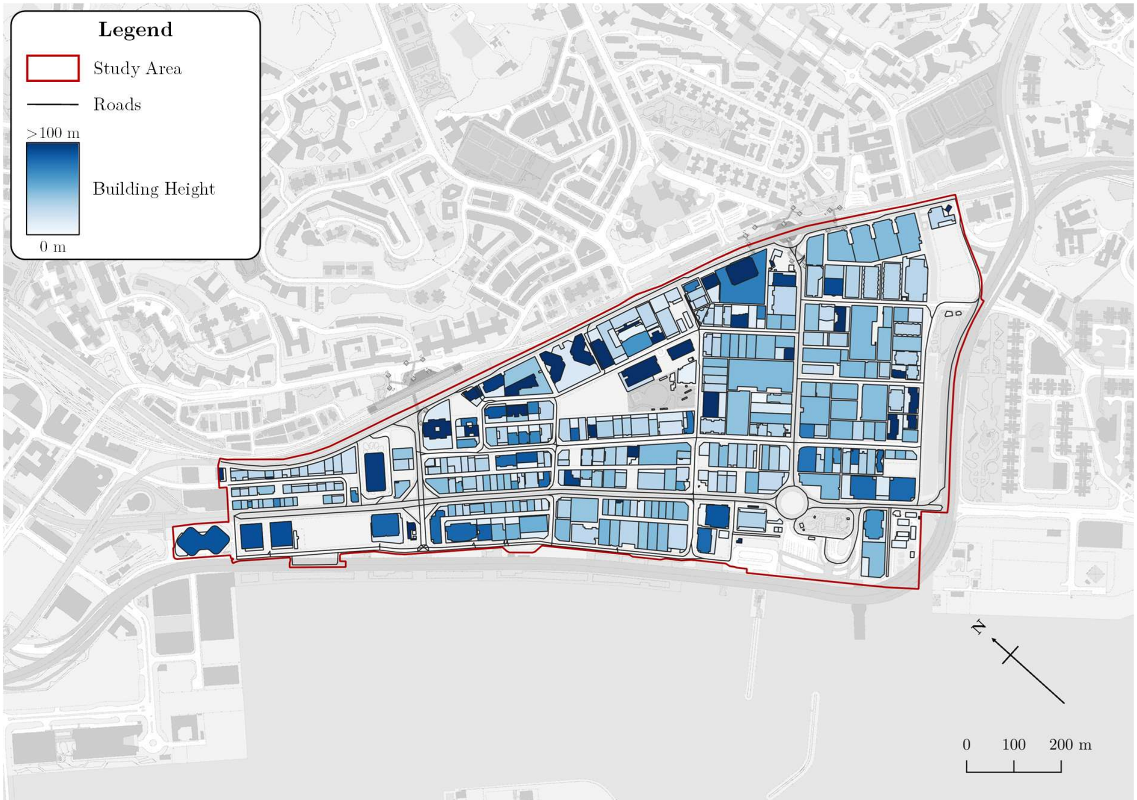


Figure 4. Visual representation of the Ga2SFCA method.

5.1.2 Quantification of demand

$$A_i = \sum\nolimits_j \frac{S_j f(d_{ij}, d_i)}{\sum_k D_k f(d_{jk}, d_j)} \tag{5.1.1.4}$$

In order to obtain the demand at every demand node k required for Ga2SFCA, a digital "iB1000" map is first downloaded through the HKMS2.0 portal ("Lands Department", 2021), and all buildings are then extracted using QGIS, displayed below:



Map 3. All buildings and their heights. (Hong Kong Geodata Store, 2021; Lands Department, 2021)

Since the demand to parking facilities is closely correlated to the gross floor area (GFA) of the building, the relative demand at each demand node k is proportional to the product of the estimated number of floors and the area of each floor:

$$D_k \propto \text{GFA} = A_{floor} \left\lfloor \frac{h_{rooftop} - h_{base}}{\overline{h_{ceiling}}} \right\rfloor \tag{5.1.2.1}$$

where:

$h_{rooftop}$	Height of the roof of the building (mPD[3])
h_{base}	Height of the base of the building (mPD[3])
$\overline{h_{ceiling}}$	Average ceiling-to-ceiling height of a building, which is 3.0m (Cheung, 2019)
A_{floor}	Area of each floor (m^2)

The list of buildings and their GFAs are listed in the Appendix.

[3] mPD refers to the number of metres above the Hong Kong Principal Datum (HKPD), which is a standardised Ordanace Datum similar to "metres above sea level" (AMSL)

5.1.3 Quantification of supply

$$A_i = \sum_j \frac{S_j f(d_{ij}, d_i)}{\sum_k D_k f(d_{jk}, d_j)} \tag{5.1.1.4}$$

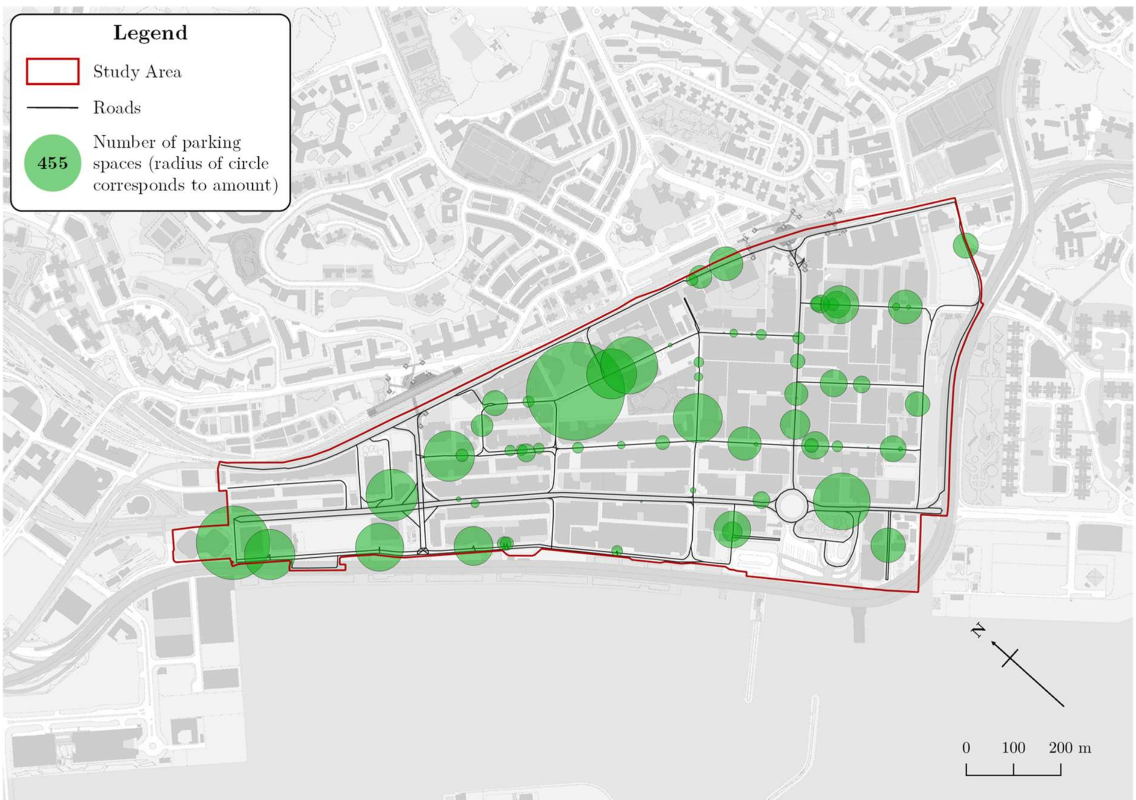
Since the exact number of parking spaces is not publicly available, the supply (S_j) is often estimated using parking standards (Wang and Liu, 2014). Since 1965, HK has maintained a set of specifications for newly constructed buildings known as the Hong Kong Planning Standards and Guidelines (HKPSG), of which, the recommended number of parking spaces N for buildings classified as business use ("OU/B") are (Planning Department, 2021):

$$S_j \approx N = \begin{cases} \left\lfloor \dfrac{\mathrm{GFA}}{675} \right\rfloor & \{n \in \mathrm{I} \cap \mathrm{O}'\} \\ \left\lfloor \dfrac{\mathrm{GFA}}{175} \right\rfloor & \{n \in \mathrm{O}, \mathrm{GFA} \leq 15000\} \\ \left\lfloor \dfrac{\mathrm{GFA}}{175} + \dfrac{\mathrm{GFA} - 15000}{250} \right\rfloor & \{n \in \mathrm{O}, \mathrm{GFA} > 15000\} \end{cases} \tag{5.1.3.1}$$

where:

GFA Gross floor area of the building (m^3), which is obtained from Section 5.1.2

n Specific land use of the buildings, type: 'I' (industrial use) and/or 'O' (office use)



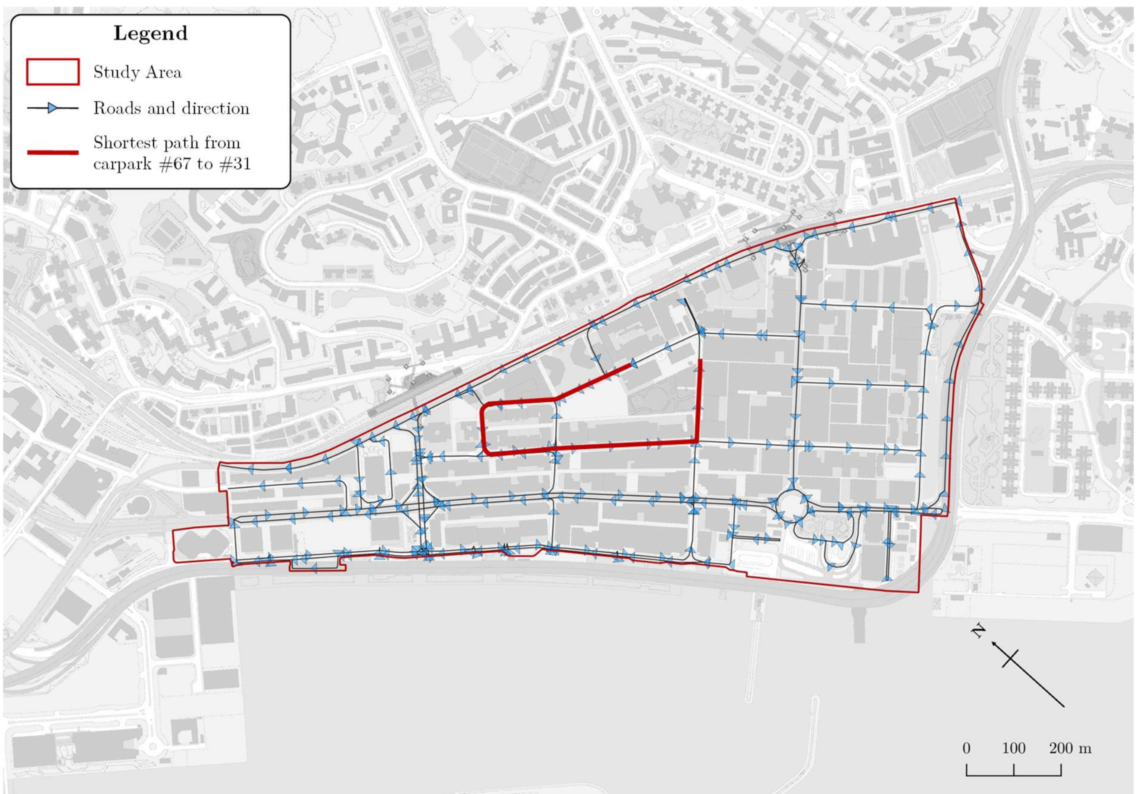
Map 4. Distribution of parking spaces and their amounts within the study area. (Hong Kong Geodata Store, 2021; Lands Department, 2021)

In order to obtain the supply at every parking facility j, a digital "Road Network (2nd generation)" map is first downloaded through the HKMS2.0 portal ("Lands Department", 2021), and combining with GFAs of the corresponding building, the list of parking facilities is extracted using QGIS and listed in the Appendix.

5.1.4 Measurement of distance between locations

$$A_i = \sum_j \frac{S_j f(d_{ij}, d_i)}{\sum_k D_k f(d_{jk}, d_j)} \tag{5.1.1.4}$$

In order to obtain an accurate distance between two points, a weighted directed graph is generated from the road network data downloaded in Section 5.1.3. By using the Dijkstra's algorithm, the shortest distance between two nodes could be found:



Map 5. A demonstration of finding the shortest distance from carpark #67 to carpark #31 using the Dijkstra's algorithm. (Hong Kong Geodata Store, 2021; Lands Department, 2021)

Using the Dijkstra's algorithm, two sets of origin-to-destination (OD) matrices of distances are generated using the QNEAT3[4] plugin of QGIS:

1. Between each survey location i and parking facility j (d_{ij})
2. Between each parking facility j and demand node k (d_{jk})

[4] An open-source QGIS plugin for network analysis, available at: https://github.com/root676/QNEAT3

5.1.5 Service catchment distance

$$A_i = \sum_j \frac{S_j f(d_{ij}, d_i)}{\sum_k D_k f(d_{jk}, d_j)} \tag{5.1.1.4}$$

Since the service catchment distance (d_i) is the maximum driving distance of a vehicle, it can be calculated by the product of the average velocity (Transport Department, 2021) and the average search distance (Lau et al., 2005) of vehicles:

$$d_i = v_i t_i$$

$$d_i = \frac{21.6 \text{ km h}^{-1}}{3.6 \text{ km h}^{-1} \text{ s m}^{-1}} \times 2.7 \text{ min} \times 60 \text{ s min}^{-1} = 972 \text{ m} \tag{5.1.5.1}$$

5.1.6 Demand catchment distance

$$A_i = \sum_j \frac{S_j f(d_{ij}, d_i)}{\sum_k D_k f(d_{jk}, d_j)} \tag{5.1.1.4}$$

Similar to Section 5.1.5, since the demand catchment distance (d_j) is the maximum walking distance, it can be calculated by the product of the average velocity of pedestrians (Master Alliance Ltd., 2021) and the average search distance (Lau et al., 2005):

$$d_j = v_j t_j$$

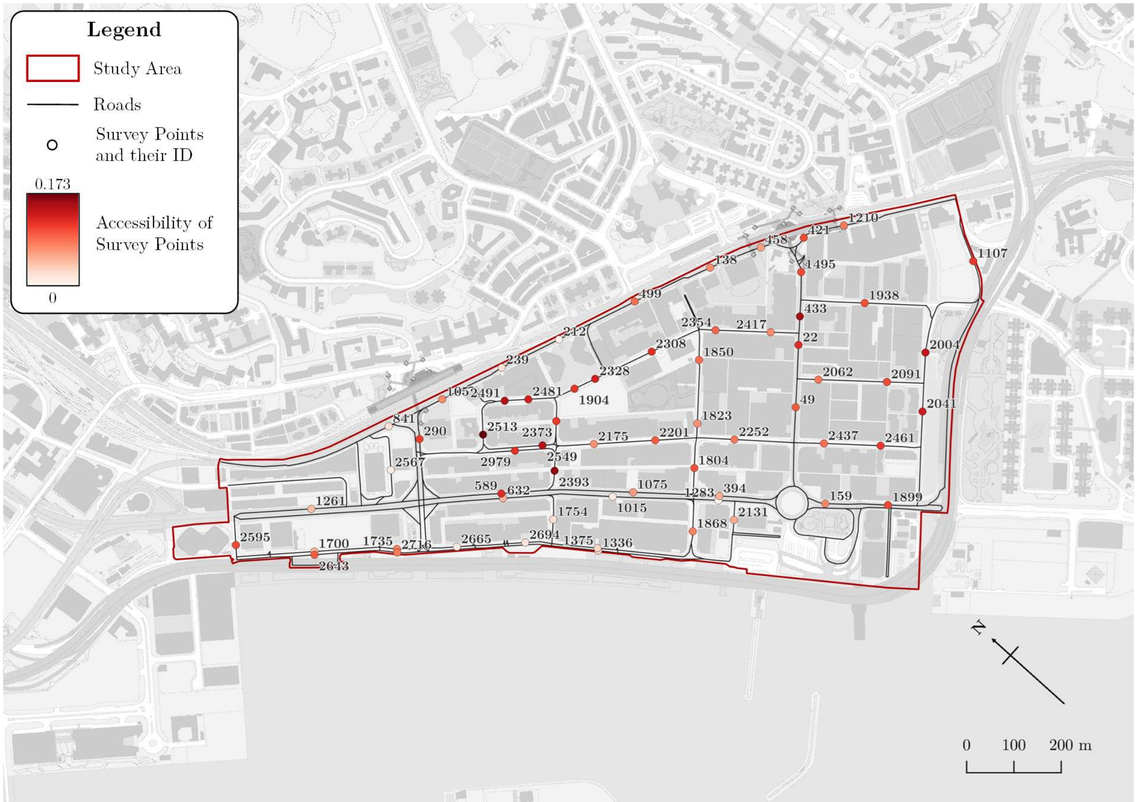
$$d_i = \frac{62.7 \text{ m min}^{-1}}{60 \text{ s min}^{-1}} \times 2.9 \text{ min} \times 60 \text{ s min}^{-1} = 181.83 \text{ m} \tag{5.1.6.1}$$

5.1.7 Sampling method

To maximise data representativeness and to reduce the time needed to collect samples, it has been decided to employ the stratified sampling technique, where each major road segment is sampled 1-2 times. In order to maximise data accuracy, the following constraints are set for survey points:

- should be as equally distributed as possible
- should not be located at/within close proximity to intersections/roundabouts, as vehicle speed is almost always lower than expected due to safety considerations

62 sample points across the study area have been selected, of which can be found in the Appendix and Map 5.



Map 5. The distribution of selected sample points and their accessibility index A_i. (Hong Kong Geodata Store, 2021; Lands Department, 2021)

5.2 Traffic congestion

As explored in Section 2, the best measure for traffic congestion is speed. The relative traffic speed at a fixed survey location can be estimated by the formula (Kidando et al., 2017):

$$v \propto \frac{O}{q} \tag{5.2.1}$$

where:

O	Time-occupancy, percentage time occupied by a vehicle (*dimensionless*)
q	Flow of traffic (vehicles per hour)

A custom web-based interface has been developed to collect both parameters.

5.2.1 Time-occupancy

Time-occupancy is defined as:

$$O = \frac{\sum_i t_i}{T} \tag{5.2.1.1}$$

which is the ratio between the sum of time measurements when the line-of-sight is occupied by the vehicle (t_i) and the total time (T).

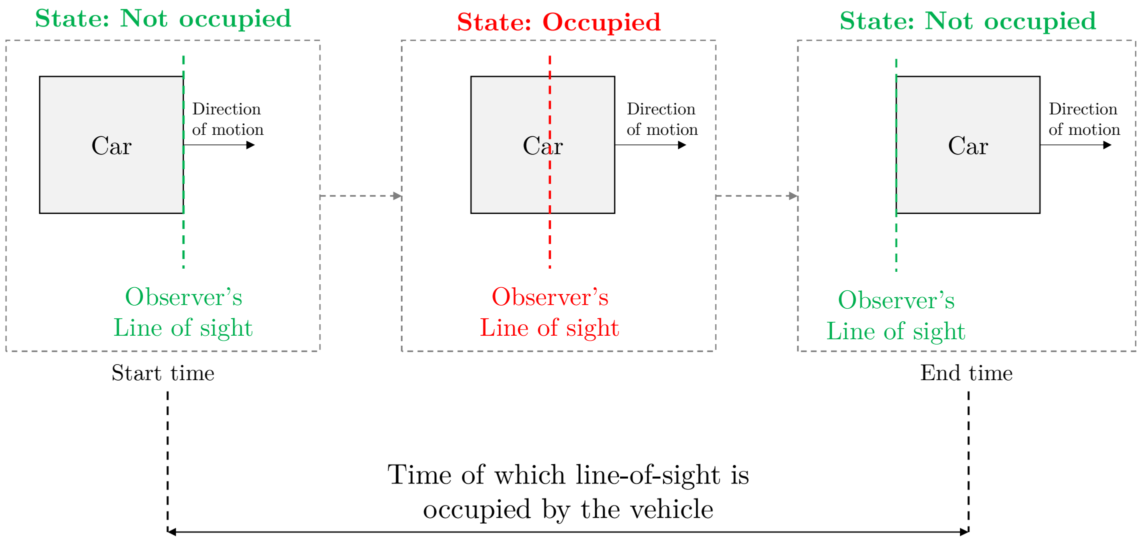


Figure 4. Visual representation of how time-occupancy is calculated.

The web interface is designed to operate on a touch-enabled smartphone[5], which will convert touch measurements into a single JSON data file[6] containing timestamps that describe the occupancy at that instant, with an instrumental uncertainty of 1ms:

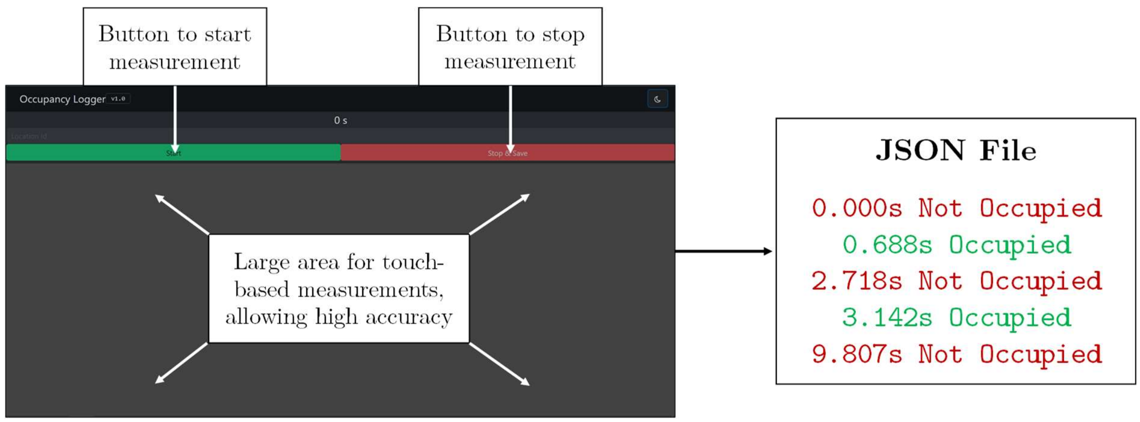


Figure 4. Visual representation of how time-occupancy is calculated.

5.2.2 Flow

Since flow is defined as:

$$q = \frac{N}{T} \tag{5.2.2.1}$$

The number of vehicles (N) passing through the time period can be directly derived by counting the number of "occupied" states in the JSON file of Section 5.2.1[7].

[5] The interface is mainly written in JS. Source code: https://github.com/cathaypacific8747/occupancy-logger.

[6] A commonly used standardised machine-readable text-based format for representing data.

[7] The Python code used to derive the time-occupancy and flow from the original JSON file can be found in the Appendix.

5.3 Precautions for surveying

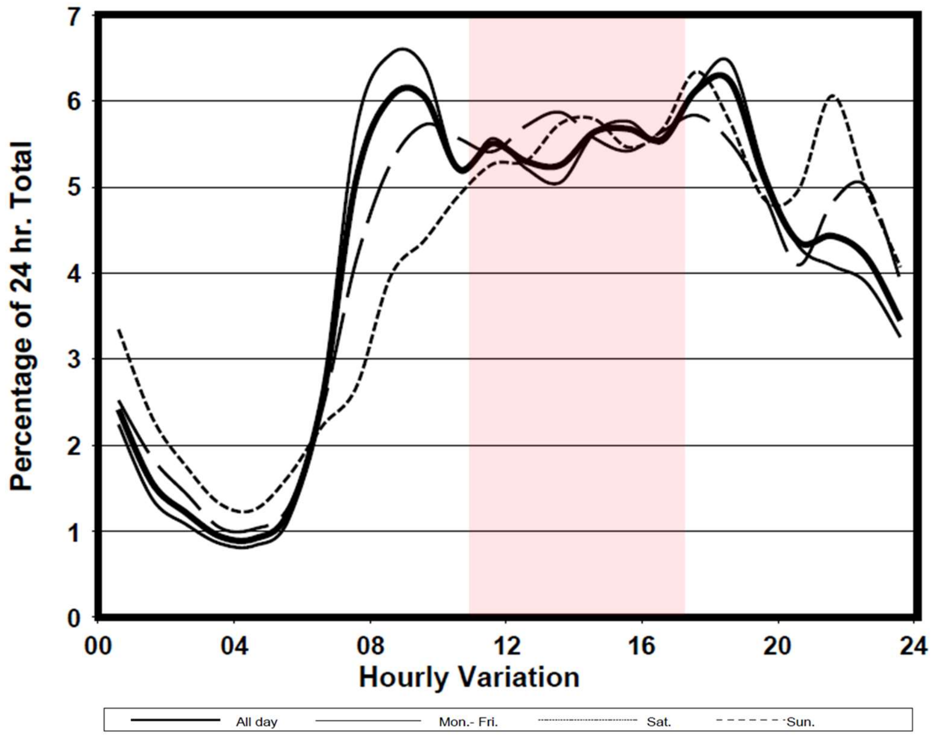


Figure 5. Graph of daily and weekly traffic changes at Station #3012 (Transport Department, 2021).

Regarding the optimum time of survey, in order to reduce data fluctuations, it has been decided to perform the surveying on weekdays between 10a.m. and 4p.m. because the traffic flow is rather stable and has a sufficiently large volume (see Figure 5), and the time interval where industrial activities are the most active (Labour Department, 2013). It has been decided to complete the entire surveying on one day to reduce the possibility of unpredictable events such as weather from affecting the rate of traffic generation.

5.4 Hypothesis Testing

5.4.1 Spearman Rank Correlation Coefficient (SRCC)

A SRCC test is used to determine the magnitude of two variables. When compared to Pearson's Product-moment Correlation Coefficient (PMCC), SRCC is insensitive to outliers and produces highly accurate measures of correlation especially for nonlinear relationships (Lovie, 1995). The SRCC is given by:

$$R = 1 - \frac{6 \sum d^2}{n^3 - n} \tag{5.3.1.1}$$

where $d = r(x) - r(y)$, as detailed below:

Rank by increasing order

If ranks are equal, take the average

Accessibility, x	**Rank of $\boldsymbol{x}$**, $r(x)$	**Relative speed**, y	**Rank of $\boldsymbol{y}$**, $r(y)$	**Difference**, d	d^2
0.001698	0	5487	5	-5	25
0.003340	1	4380	~~3,4~~ 3.5	-2.5	6.25
0.008747	2	4380	~~3,4~~ 3.5	-1.5	2.25
0.016384	3	1252	2	1	1
0.019683	4	343	1	3	9
				Sum, Σd^2	43.5

Figure 6. A table for calculating $\sum d^2$ from the accessibility (x) and relative speed (y).

$$\text{Perfect negative correlation} \quad -1 \longleftarrow R \longrightarrow 1 \quad \text{Perfect positive correlation}$$

Figure 7. A general interpretation of the correlation based on the SRCC.

5.4.2 Student's T-test

To check whether the SPCC obtained above is statistically significant enough to reject the null hypothesis, the t-value must first be found:

$$t = R\sqrt{\frac{n-2}{1-R^2}} \tag{5.3.2.1}$$

The statistical significance can then be found by obtaining the one-tailed p-value using Excel:

$$p = \int_t^{\infty} f(u)\, du \tag{5.3.2.2}$$

where f is the probability density function and t the t-value. If the calculated p-value is less than the accepted p-value of $\alpha = 0.05$, the null hypothesis can be rejected.

6 Data Analysis

In order to better highlight the correlation between both variables and to aid with the identification of outliers, a scatter graph with a linear line of best fit has been used. In addition, a bubble map is used to better visualise the geospatial patterns in traffic congestion and accessibility.

6.1 Macroscopic Trend

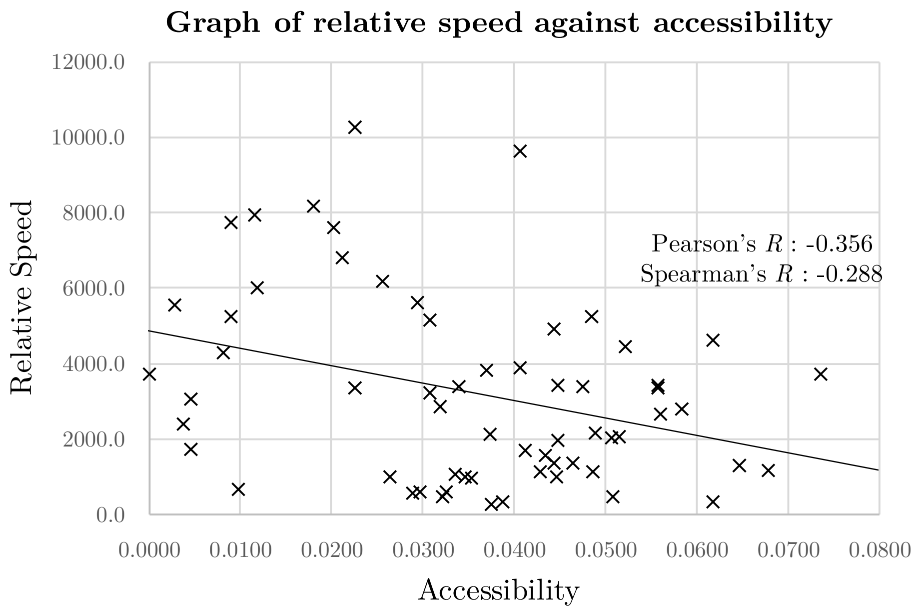


Figure 8. A scatter graph showing the relationship between relative speed against accessibility.

Parameter Name	Symbol	Value
Number of data points	n	62
Spearman's Rank Correlation Coefficient (SRCC)	R	-0.288
t-value	t	2.327
p-value	p	0.0116
Null hypothesis rejected?		Yes, as $p < 0.05$

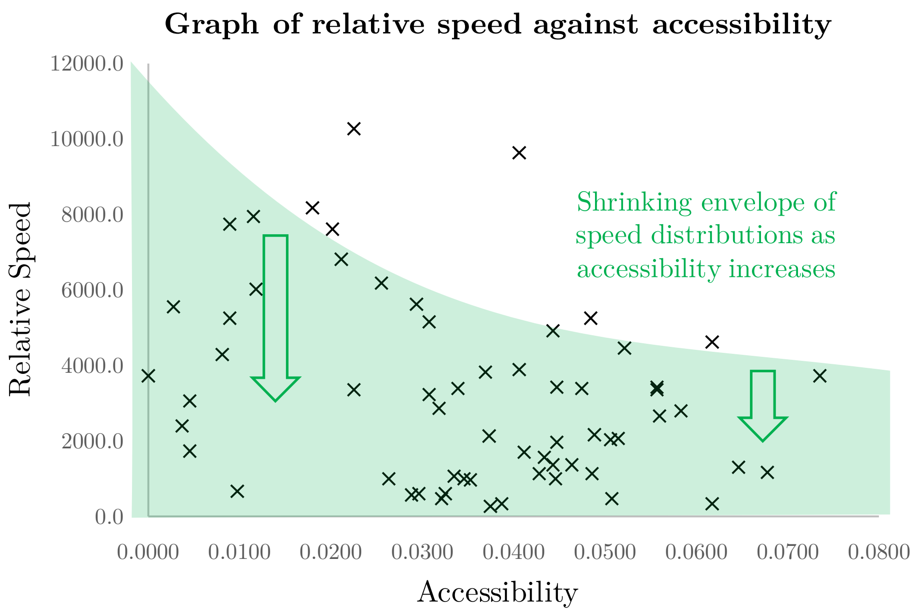
Table 1. Statistics regarding the Spearman's rank correlation testing.

As the SRCC is -0.288, there is a weak negative correlation between vehicle speed in accessibility. As discussed in the methodology, since low vehicle speeds are a common characteristic of severe traffic congestion, and that the p-value is below the accepted value, the correlation is statistically significant enough to reject H_0.

However, it should be noted that while the results statistically accepted H_1, the poor reliability of the correlation cannot be used to definitively imply that parking accessibility is the *only* causation of traffic congestion (Coleman et al., 2015). The following sections will be focused on the justification of whether the two variables are truly correlated.

6.1.1 Heteroscedasticity

In regression analyses, it is often assumed that



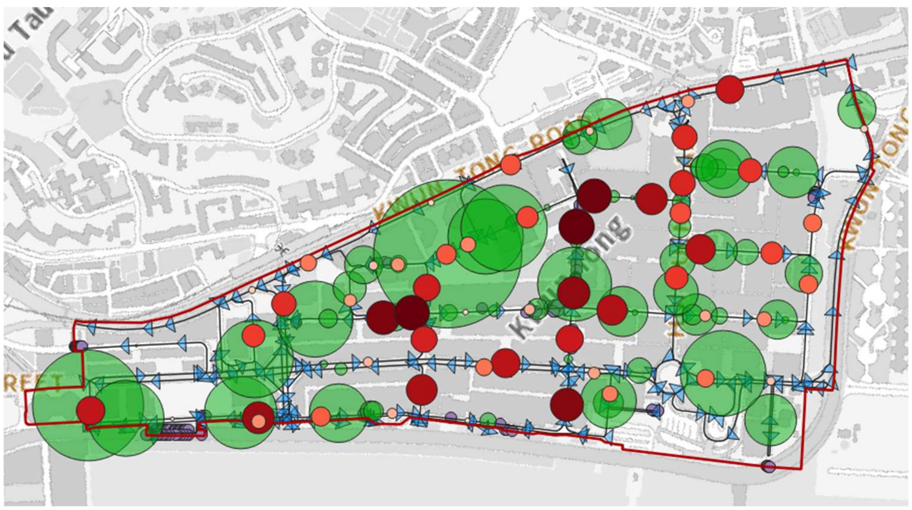
Rather than interpreting it as decreasing speed as accessibility increases, it can be better described by that the envelope of speed distributions tend to shrink in size towards zero as accessibility increases.

In order to better show areas with low speeds on a bubble map, it has been decided to calculate a relative traffic congestion severity index S_i, which propagates low speeds into large-sized bubbles:

$$S_i = 1 - \frac{v_i - \min(v)}{\max(v) - \min(v)} \tag{6.1}$$

Observations:

- MOBILE BARRICADES!!!!
- Major loop formed by Hing Yip St., King Yip Street, Shing Yip Street, Hoi Yuen Rd, allows for cruising behaviour
- Major loop formed by How Ming St., Chong Yip St., Hung To Rd., allows for cruising behaviour
    - o Single lane at both Tsun Yip St and How Ming St worsens the loop, blockading Hung To Rd.
- Illegal parking along Hing Yip St. causes trucks to have to wait to enter parking lot #22, blockading traffic on Hoi Yeun Street
- Millennium city: very supply of parking spaces, but only method of accessing is via Tsun Yip Street



- Large amounts of physical mobile barriers (such as rubbish bins) blocking access to on-street parking lots on Tsun Yip Street, forces trucks unload curbside
- Tsun Yip Street is combined by traffic from eastbound Hung To Rd and eastbound Wai Yip Street, very heavy stress
- Small arterial road at Hing Yip street blockades traffic when lorry backs out of position

Industrial areas – drivers knows the area very well → more experienced and hence will lead to longer cruising for parking (different from commercial areas where people are newcomers), tend to have longer search times

7 Evaluation

Lane-switching causing measurements is awkward

Traffic lights can be 2 minutes, and if time incorrectly it can lead to large result differences

Lane selection is inconsistent – flawed representation. Since HK is left hand drive city, drivers unload people and goods on the leftmost lane, causing interruptions of traffic flow on the left, uneven distribution especially at Kwun Tong Rd.

On-street parking services not included!!!

Only private carparks are included!!! (only 28.2% are open to the public[8])

Can be further improved by adding effective lane count to account for reduced road capacity, which was ignored completely

The incorrect lane directions are the arguably main culprit for traffic congestion

Suggestions: change lane directions so cruising is impossible, forcing drivers into their parking space / promotion

Fact that 2SFCA is used on a much larger scale (national) makes it unsuitable for measuring accessibility on such a microscopic level → V2SFCA (millennium city, as a business centre has a much larger catchment distance) should be used

Intuitively the search distance of industrial vehicles are likely to be significantly less than expected (5 minutes) because the need for delivery efficiency is very high. Heavy deliveries cannot be carried very far because KT has a poor walkability/LoS + the rugged old-style streets significantly increases the friction of distance. Coupled by the old road layout (especially How Ming Street/Tsun Yip Street intersection), encourages double parking and significantly decreasing road capacity.

Inverse distance (POW20, $d^{-1.5}$) is thought to be superior to the Guassian functions according to 10.1080/13658816.2019.1591415

“consumers are likely to patronize a facility in their immediate proximity in lieu of equalizing the visit possibility within an arbitrary distance”, so the flat peak is not really realistic

Since the unique layout/cluster of industrial buildings are very rare in urban cities

Macroscopically the parking space availability is severely lacking (90% of respondents say so), not whether there is an spatial imbalance of parking space. 54.9% believes parking prices are expensive, say they are willing to park for HKD11-20/hr

8 Conclusion

[8] https://www.td.gov.hk/en/transport_in_hong_kong/parking/carparks/index.html

9 Bibliography

https://zbib.org/e02b7bd727f64727801bae0bb2dbe0bf

preloss backup: https://zbib.org/d5f2865e0ba547eba78a8fb6d719ec83

backup 2: https://zbib.org/125fccaa2d514778948d96dd6b20c17b

backup 3: https://zbib.org/395823387e164c68a110caf69022bc73

10 Appendix