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EVALUATION OF TRAFFIC SPACE OCCUPANCY LEVELS DUE TO ILLEGAL PARKING IN URBAN COMMERCIAL AREAS

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Abstract

Illegal parking in urban commercial corridors is commonly treated as a public-order problem. From a spatial perspective, however, it also reflects a shift in roadway function, where traffic space is temporarily converted into static space. This study examines that shift using longitudinal occupation (OL), effective width reduction (EWR), and a proposed composite measurement approach termed the Space Pressure Index (SPI). The case site is an approximately 200 m urban commercial segment where vehicles routinely park in parallel on both sides despite the absence of formal parking facilities. Data were collected through a four-day parking patrol survey covering two weekdays and two weekend days, supported by roadway-width measurements under two-sided parking conditions. The results show a clear time-dependent pattern: parking builds up and intensifies during peak commercial hours. Longitudinal occupation peaked at 120.7%, meaning that the cumulative equivalent length of parked vehicles exceeded the usable segment length during the busiest period. At the same time, two-sided parking reduced the effective width by 36.7% relative to the initial geometric width. When these two dimensions are combined, the SPI reached a maximum of 44.3%, indicating substantial functional conversion of movement space during the peak interval. Overall, the findings frame illegal parking in commercial areas as a measurable form of space competition with direct operational implications for corridor mobility. Compared with partial occupancy measures, the proposed OL-EWR-SPI approach offers a clearer segment-scale description of how roadway space is reallocated over time.

Keywords: illegal parking, longitudinal occupation, effective width reduction, space pressure, urban commercial corridors.

1. INTRODUCTION

Urban commercial corridors host intense interaction between two competing functions: through-movement and short-stop access. Shops, services, and brief visits generate frequent curbside parking demand. When off-street facilities are limited or not available at all drivers often use the roadway itself as a parking substitute. As a result, part of the road is effectively reassigned from movement space to stationary space, and the remaining area for traffic flow becomes constrained. For that reason, roadside parking in commercial areas should be framed as a question of how transportation space is allocated and occupied, rather than being viewed only as an issue of compliance or user behavior.

The effects of on-street parking can be described using a space-occupancy perspective, where each parked vehicle is treated as a physical claim on road space. As these claims accumulate, the usable roadway for moving vehicles shrinks, which in turn reduces the corridor's effective operating capacity [1]. When vehicles park parallel to the roadside, the effective lane width is reduced and the roadway's ability to accommodate traffic flow is also reduced. Thus, the reduction in effective width is a direct indicator of the loss of traffic space function due to parking occupation.

Empirical evidence across various developing cities demonstrates the consistency of this mechanism. A study of urban corridors in Jordan showed that the presence of curbside parking and roadside activity correlated with significant throughput reductions, with the magnitude of the impact varying depending on lane configuration [2]. In Varanasi, the relationship between effective width reduction and capacity reduction was quantitatively demonstrated; even relatively small width reductions resulted in comparable capacity penalties, while larger reductions resulted in nonlinearly increasing capacity losses [3]. A synthesis of the literature on side friction in developing cities also identified curbside parking as a key determinant of the degradation of urban arterial operational performance [4]. Recent analytical work further quantified how parallel curb parking and parking maneuvers can reduce traffic capacity at intersections, reinforcing the argument that curbside occupation has measurable operational consequences beyond simple vehicle counts [5].

Other studies have shown that when on-street parking is restricted or relocated to off-street facilities, there is a measurable improvement in capacity and service levels [6], [7]. These findings support the argument that road space is limited and competitive, and that reallocating it from parking to traffic functions can restore corridor capacity. In commercial areas, the conversion of sections of roadway to parking has been identified as a factor affecting traffic performance and necessitates a more integrated spatial planning approach [8]. Furthermore, the use of roadway for parking has also been shown to reduce traffic space and impact roadway performance in areas with high commercial activity [9]. Complementing this operational view, recent behavioral research indicates that parking facilities, traffic conditions, and the surrounding environment are important determinants of curbside illegal parking behavior [10].

However, some previous studies have identified gaps. Many studies express the impact of curbside parking through macro performance indicators such as capacity, degree of saturation, or level of service, but have not explicitly derived metrics that reflect the degree of conversion of traffic space into parking space at the segment scale. In commercial corridors where vehicles park in parallel on both sides despite the absence of formal facilities, the core issue is not merely how many vehicles are present. What matters more is how much of the segment length is taken up and how much usable roadway width is lost within a given time window. When longitudinal measures are not included, discussions often jump directly to traffic performance outcomes, while the actual magnitude of roadway space "conversion" remains unquantified.

A longitudinal perspective is appropriate because parking occupancy is dynamic and unevenly distributed along a corridor. Vehicles that remain parked for longer periods can create a cumulative effect, raising space pressure across the segment rather than at a single point. A framework that combines vehicle footprint with effective-width reduction makes the relationship between space occupancy and operational consequences more explicit [1], [3].

Against this background, this study evaluates (i) longitudinal occupation along a road segment affected by illegal two-sided parallel parking, (ii) the associated reduction in effective road width, and (iii) the resulting pressure on the corridor's movement function. By treating parking as a form of space competition within the urban transport system, the analysis provides a direct quantitative estimate of how much traffic space is reallocated to parking, and how that reallocation alters the operating condition of urban commercial corridors. Unlike previous studies that primarily infer parking impacts through traffic-performance outcomes, this study proposes a direct segment-scale measurement approach that combines longitudinal occupation and effective width loss to estimate time-varying space pressure in a commercial corridor.

2. RESEARCH METHOD

2.1. Location and Characteristics of Study Segments

This study applies a quantitative descriptive design to assess how traffic space is effectively reallocated to parking. The assessment is built on three operational indicators: (i) longitudinal occupation, (ii)

effective width reduction, and (iii) overall space pressure. The analysis is limited to operational consequences in terms of functional capacity and available movement space; it does not examine safety outcomes, traffic conflicts, or the legal dimension of parking behavior.

The case site is a 200 m segment of an urban commercial corridor where parallel parking regularly occurs on both sides in the absence of designated parking facilities. Under this configuration, access needs (curbside parking) frequently compete with mobility needs (through movement). For that reason, space-occupancy-based indicators are appropriate for representing the load imposed on the roadway space [2], [11].

Source: Google Earth, 2026

Figure 1. Map of Location and Observation Segments

2.2. Data collection technique

Data were collected using a four-day parking patrol survey consisting of two weekdays and two weekend days so that both regular trading conditions and weekend variation could be represented. This method was selected because it captures the temporal dynamics of curbside parking in a structured, time-stamped sequence, namely occupancy at fixed intervals as well as arrival-departure information that can be used to estimate duration and turnover. These outputs are directly useful for operational analysis in corridors influenced by on-street parking [12]. While video-based observation is also widely applied to document occupancy patterns and their operational effects, especially in high-activity roadside environments, the patrol survey offered a practical way to cover the entire segment repeatedly during the survey period [2], [3].

Observations were recorded every 60 minutes from 06:00 to 18:00. A 60-minute interval was adopted to balance temporal sensitivity with field feasibility, because the study aimed to identify the hourly buildup and release of parking pressure along the full 200 m segment rather than short-term maneuver events. For each patrol round, the observer recorded the identity and curb position of each parked vehicle and then compared successive rounds to determine whether a vehicle had newly arrived, remained parked, or departed. Arrival time was assigned at the first interval in which a vehicle was observed, departure time at the first interval in which it was no longer present, and parking duration was estimated from the difference between those recorded times. At each interval, the enumerator noted:

1. the number of parked vehicles and their composition,
2. the position of vehicles along the segment,
3. arrival and departure times (to estimate parking duration),
4. whether parking occurred on both sides (left and right) simultaneously.

In parallel with the patrol survey, geometric measurements were taken to determine the initial roadway width and the remaining effective width under two-sided parking conditions. The 200 m segment was

referenced by start-end chainage along both curbs so that the position and cumulative occupied length of parked vehicles could be recorded consistently at each observation round. These measurements are important because the operational impact of curbside parking is strongly linked to the reduction of usable width available for moving traffic [3], [11]. Field photographs were also collected to confirm the parking configuration (parallel), identify pavement-edge boundaries, and check the consistency of occupancy conditions during selected hours.

2.3. Operational Parameters and Calculation Formulas

A space-based measurement framework was formulated to represent the degree to which traffic space is converted into parking space. Consistent with the space-occupancy framework, the analysis treats vehicle-occupied roadway space as the basis for assessing operational pressure [1]. Thus, space pressure is understood not only as the number of vehicles, but also as the proportion of physical space that changes function. In this study, EWR is the geometric reduction in usable width, whereas SPI is used as the main composite proxy for time-varying space pressure.

A. Longitudinal Occupation (OL)

Longitudinal occupancy is defined as the percentage of the length of the segment occupied by parking to the length of the observation segment at a given time interval. Longitudinal measurement is emphasized because parking occupancy does not occur at a single point, but rather accumulates along the corridor and changes over time [2], [3].

$$OL = \frac{L_P}{L_S} \times 100\%$$

Information:

L_p = length of space occupied by parking at a certain interval (m)

L_s = length of observation segment (m)

B. Effective Width Reduction (EWR)

Effective width reduction is calculated as the percentage reduction in usable width due to dual-sided parking. In this study, EWR is treated as the geometric width-loss component of space conversion. Literature indicates that effective width reduction is correlated with capacity and throughput penalties that can be nonlinear in high-friction corridors [13], and can be confirmed by the relationship between parking occupancy and road width limitations [11].

$$EWR = \frac{(W_0 - W_e)}{W_0} \times 100\%$$

Information:

W_0 = effective width without parking (m)

W_e = effective remaining width when parking (m)

C. Space Occupational Pressure Index (SPI)

The Space Pressure Index (SPI) is introduced as a composite indicator that reflects space competition in a single measure. Conceptually, pressure on the movement function increases when the occupied length grows (higher OL) while the usable width decreases (higher EWR). For dimensional consistency, SPI is

computed by multiplying OL by the width-reduction fraction (r), the proportional reduction, not the percentage value. With this formulation, SPI is interpreted as a segment-scale proxy for the proportion of functional road space that is effectively lost at each time interval:

$$SPI_t = OL_t \times \frac{EWR}{100}$$

Or equivalently:

$$SPI_t = OL_t \times r$$

where r is the width reduction in decimal form.

This formulation ensures that the SPI represents the proportion of two-dimensional space (length × width) that is functionally converted at each time interval. To account for mixed vehicle types, the occupied length at each interval was first converted into equivalent parked length. The representative parked length of each vehicle class (MP, SM, BB, TB, and KTB) was multiplied by its observed frequency, and the weighted mean of these class lengths produced an average equivalent parked length of 4.34 m per vehicle. Thus, vehicle composition affects OL through length conversion before hourly aggregation. For example, at 09:00–10:00 the average number of parked vehicles was 111.25. Multiplying by 4.34 m yields an occupied length of 482.8 m. With a total observed curb length of 400 m (200 m on each side), OL = (482.8/400) × 100 = 120.7%. Because the width-reduction fraction was 0.367, SPI = 120.7 × 0.367 = 44.3%. This example shows that SPI should be read as a segment-scale proxy of functional space loss rather than as a direct measurement of delay, speed, or degree of saturation.

2.4. Data Analysis Procedure

The analysis is carried out sequentially as follows:

1. Determination of segment boundaries and division of distance references (chainage) to facilitate identification of parking occupation locations along the corridor.
2. Parking occupancy recap per time interval (per hour) from patrol surveys to describe the temporal dynamics of parking occupancy, as used in the repeated observation approach in parking occupancy studies [14].
3. Estimation of the length of occupied space (Lp) per hour based on the distribution of parked vehicles along the segment at each observation interval.
4. Calculation of Longitudinal Occupation (OL) per hour, so that an occupation profile is formed according to time and the period with the highest occupation intensity can be identified [2].
5. Calculation of the constant Effective Width Reduction (EWR) from the difference between initial geometric width and remaining effective width under two-sided parking.
6. Calculation of the hourly Space Pressure Index (SPI) by integrating OL with the EWR fraction to identify periods with the highest segment-scale space pressure.
7. Operational interpretation is conducted by linking the OL-EWR-SPI pattern to corridor trade activity while avoiding direct claims about traffic volume, speed, or degree of saturation that were not measured in this study.

2.5. Research Flowchart

The research flowchart summarizes the step-by-step procedure used to assess how traffic space is converted into parking space in an urban commercial corridor. The workflow consists of two main components: data collection and operational analysis. Data collection starts with identifying the space-occupation problem on the selected segment and defining a 200 m observation boundary. A four-day parking patrol survey is then carried out to capture occupancy dynamics at fixed time intervals. At the

same time, geometric measurements are taken to document the initial roadway width and the remaining effective width under two-sided parking conditions.

The operational analysis translates the field observations into space-based parameters. Survey records are first used to estimate the occupied length and compute the longitudinal occupation level (OL). The geometric reduction in effective width (EWR) is then determined to represent the loss of usable cross-sectional space caused by curbside parking. Finally, OL and the EWR fraction are combined to produce the Space Pressure Index (SPI), which helps identify the time periods with the highest space pressure. These computed indicators provide the quantitative basis for the Results and Discussion section.
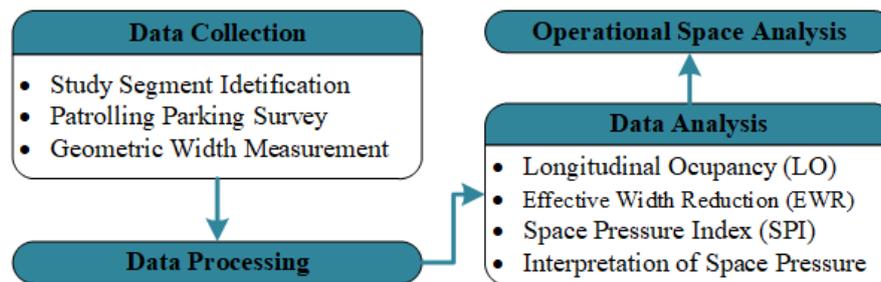

Figure 2. Research Flowchart

3. RESULTS AND DISCUSSION
3.1. Parking Characteristics in the Study Segment

Results from the four-day parking patrol survey show that occupancy in the study segment is dynamic and, during peak commercial activity, tends to accumulate longitudinally rather than fluctuate randomly. This temporal build-up mirrors observations from commercial corridors in many developing-city contexts, where curbside parking intensifies during business hours and eases during transition periods [2], [14].

Table 1. Average Number of Vehicles Parked per Interval

Time Interval	Weekdays (vehicles)	Weekend (vehicle)	Average (vehicle)
[06.00–07.00]	51	22.5	36.75
[07.00–08.00]	78.5	41.5	60
[08.00–09.00]	109.5	69.5	89.5
[09.00–10.00]	154.5	68	111.25
[10.00–11.00]	129	85.5	107.25
[11.00–12.00]	115	80.5	97.75
[12.00–13.00]	116.5	81	98.75
[13.00–14.00]	112.5	71	91.75
[14.00–15.00]	72.5	75	73.75
[15.00–16.00]	46	45.5	45.75
[16.00–17.00]	39	43	41
[17.00–18.00]	42.5	36.5	39.5

Table 1 summarizes the average number of parked vehicles by time interval across the observation days. Occupancy starts to rise in the early morning (06:00–07:00) with an average of 36.75 vehicles, then increases sharply and reaches its highest level at 09:00–10:00 with 111.25 vehicles. After the peak, the

number of parked vehicles remains elevated through late morning and midday, staying relatively high until 12:00–13:00 (98.75 vehicles), before gradually tapering off in the afternoon.

Taken together, these values suggest an accumulation phase from morning to midday. Instead of brief spikes, the segment experiences a sustained high-occupancy plateau across several consecutive intervals. This implies that the occupied space does not merely appear and disappear; it extends and persists along the segment during peak activity periods. The behavior is consistent with the notion of longitudinal curb occupancy, in which space pressure is shaped by the continuity of occupation over time, not only by the vehicle count observed in a single interval [3], [10].

The distribution of parking durations provides additional context to this pattern. Survey results show that the majority of vehicles (68.09%) parked for less than 15 minutes, indicating a fairly dominant rotational component. However, there was a significant proportion of vehicles with parking durations between 30 and 60 minutes (9.29%) and more than 60 minutes (5.52%). The presence of these long-duration vehicles contributes to the formation of relatively stable occupation blocks during peak periods.

The literature suggests that the combination of high occupancy rates and the presence of long-duration vehicles amplifies the longitudinal accumulation effect in commercial corridors [2], [10]. Thus, despite active vehicle rotation, the presence of fixed parking during peak periods has the potential to maintain high occupancy rates for several consecutive intervals. This condition provides an important basis for quantitative analysis of the amount of converted space in the following longitudinal occupancy subsection.

Table 2. Distribution of Parking Duration

Parking Duration	Number of Vehicles	Percentage (%)
< 15 minutes	2432	68.09%
15–30 minutes	611	17.11%
30–60 minutes	332	9.29%
> 60 minutes	197	5.52%
Total	3572	100%

Given that the study location lacks official parking spaces, vehicle type composition is an important variable in determining the extent of occupied space. The distribution of parked vehicle types during the observation period is presented in Table 2.

Table 3. Composition of Parked Vehicle Types

Type	Amount	Percentage (%)
MP	2402	67.23
SM	855	23.94
BB	71	1.99
TB	82	2.3
KTB	162	4.54
Total	3572	100

Based on Table 3, passenger cars (MP) dominate with a proportion of 67.23%, followed by motorcycles (SM) at 23.94%, while other vehicle types are relatively small (<5%). The dominance of passenger cars indicates that the character of parking occupation in the study corridor is spatially more influenced by long-dimensional vehicles, so the potential for converting traffic space into parking space tends to be significant.

In conventional parking studies with formal parking lots, the turnover rate is generally calculated as the ratio of the number of parked vehicles to the number of available parking spaces. However, in corridors with illegal parking without fixed parking arrangements, the formal parking space-based approach becomes less representative. Therefore, this study uses a vehicle equivalent length approach to describe the intensity of rotation and longitudinal pressure on road segments.

With an observation segment length of 200 meters on both sides of the road (a total of 400 linear meters), and the average length conversion of each vehicle type according to parallel parking characteristics, the total cumulative occupation length was 15,501 meters over the four days of observation. When compared to the effective segment length, this value is equivalent to approximately 38.75 full occupation cycles, or an average of 9.69 cycles per day.

These results point to a high level of longitudinal turnover. However, high turnover does not automatically translate into lower space pressure during peak periods. This is reflected in the sustained vehicle concentration from 09:00 to 13:00, which produces an occupancy plateau that persists for several consecutive hours.

In addition, while most vehicles park for short durations, a non-negligible share remains longer than 30 minutes (14.81%) and longer than 60 minutes (5.52%). These longer-stay vehicles help stabilize occupancy during peak hours, even as other vehicles come and go. The combination of strong demand and persistent space claims supports the interpretation that longitudinal occupancy accumulates in the study corridor. This observation motivates the subsequent quantitative estimation of converted traffic space, presented in Subsection 4.2 through the calculation of longitudinal occupancy (OL).

3.2. Longitudinal Occupation of Road Sections

To quantify the spatial magnitude of traffic-space conversion, the occupied length was estimated from the average number of parked vehicles per time interval, converted into an equivalent vehicle length. The observation covers a 200 m segment on both sides of the roadway (400 linear meters in total). Using an average equivalent length of 4.34 m per vehicle, the occupied length was calculated for each interval. The resulting longitudinal occupation (OL) values are reported in Table 4.

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Table 4. Length of Occupied Space and Longitudinal Occupation

Interval	Average Vehicle	Occupied Length (m)	OL (%)
[06.00–07.00]	36.75	159.4	39.9
[07.00–08.00]	60	260.4	65.1
[08.00–09.00]	89.5	388.4	97.1
[09.00–10.00]	111.25	482.8	120.7
[10.00–11.00]	107.25	465.5	116.4
[11.00–12.00]	97.75	424.3	106.1
[12.00–13.00]	98.75	428.4	107.1
[13.00–14.00]	91.75	398.2	99.6
[14.00–15.00]	73.75	320	80
[15.00–16.00]	45.75	198.6	49.6
[16.00–17.00]	41	177.9	44.5
[17.00–18.00]	39.5	171.4	42.8

Table 4 shows that the highest OL occurred at 09:00–10:00, reaching 120.7%. In practical terms, this means that the cumulative length of parked vehicles was greater than the available observation length during the peak hour. Such values are typically associated with very tight spacing, near-continuous curb occupation, and intensive use of roadside space in the absence of formal parking layout.

OL values above 100% also persisted across multiple adjacent intervals: 10:00–11:00 (116.4%), 11:00–12:00 (106.1%), and 12:00–13:00 (107.1%). Rather than a brief spike, the corridor experienced a sustained high-occupation plateau during peak commercial activity. Over these hours, a large portion of the segment functioned less as movement space and more as stationary parking space.

From an operational standpoint, rising OL represents not only a larger number of vehicles but also longitudinal accumulation along the segment. Previous studies note that this accumulation amplifies the effect of narrowing, because parked vehicles form a continuous "block" that reduces maneuvering flexibility for moving traffic [2], [10]. Accordingly, even with relatively high turnover, a persistent concentration of occupancy can still impose substantial pressure on the section's operating capacity.

The occupancy also tended to cluster around intervals associated with intense trading activity. This clustering can produce near-full occupation in certain parts of the segment while other parts remain less occupied. In practice, such uneven occupation may create localized bottlenecks and intermittent obstructions even when the aggregated OL has not yet reached its maximum [3].

In comparable studies of commercial corridors in developing cities, OL values above 80% are often interpreted as high space pressure, because the remaining usable space becomes limited and maneuvering flexibility declines [8], [14]. In the present case, OL exceeded 100% in several intervals, indicating an extremely intensive level of space conversion. These results suggest that traffic-space conversion in the study corridor is not occasional or partial; it occurs in a sustained manner, particularly during trading hours. For that reason, occupied length alone should be complemented with the geometric width-loss measure and their integration into SPI to capture the full space-pressure pattern.

3.3. Effective Width Reduction (EWR)

Field measurements show that the roadway has a total geometric width of 12.00 m. Two-sided parallel parking, with an average occupied width of 2.20 m on each side, converts 4.40 m of the cross-section into parking space. As a result, the remaining effective width for vehicle movement is 7.60 m, which corresponds to a 36.7% reduction from the initial width. This EWR value is geometric and therefore constant across time intervals because the cross-sectional parking configuration is the same when two-sided parking occurs.

The role of this measure in the study is to provide the transverse component of space conversion. Rather than treating EWR as a separate time-varying outcome, the hourly dynamics are reported through SPI, which combines this constant width-loss fraction with the observed longitudinal occupation.

Table 5. Effective Width Reduction Due to Parking

Parameter	Mark
Initial geometric width	12.00 m
Left side parking width	2.20 m
Right side parking width	2.20 m
Total occupied width	4.40 m
Remaining effective width	7.60 m
Percentage reduction in width	36.70%

3.4. Space Pressure Index (SPI) as a Proxy Indicator

Space pressure in commercial corridors is shaped by both the length of curb occupation and the width of roadway lost to parking. To capture these two dimensions in one time-sensitive measure, this study uses SPI as a composite proxy indicator. SPI = OL × r, where r is the width-reduction fraction (0.367). SPI therefore estimates the proportion of corridor space that is functionally unavailable for movement during each time interval; it does not directly measure traffic delay, speed, or degree of saturation. With a fixed width reduction of 36.7%, SPI was calculated hourly following variations in OL. The hourly SPI results are presented in Table 6.

Table 6. Space Pressure Index (SPI) per Interval

Interval	OL (%)	SPI (%)
[06.00–07.00]	39.9	14.6
[07.00–08.00]	65.1	23.9
[08.00–09.00]	97.1	35.6
[09.00–10.00]	120.7	44.3
[10.00–11.00]	116.4	42.7
[11.00–12.00]	106.1	38.9
[12.00–13.00]	107.1	39.3
[13.00–14.00]	99.6	36.6
[14.00–15.00]	80	29.4
[15.00–16.00]	49.6	18.2
[16.00–17.00]	44.5	16.3
[17.00–18.00]	42.8	15.7

Based on Table 6, SPI reaches its highest value at 09:00–10:00, at 44.3%. This indicates the strongest observed segment-scale space pressure during the survey period. SPI values above 40% also occur at 10:00–11:00 (42.7%), showing that severe pressure persists beyond a single interval. During 08:00–09:00 and 13:00–14:00, SPI remains in the 35–39% range, pointing to a sustained pressure plateau during periods of intense trading activity. Because SPI combines longitudinal accumulation with width loss, higher SPI values imply less maneuvering room and a greater likelihood of operational interference within the corridor.

However, these implications should be interpreted as proxy indications of pressure, not as direct measurements of speed reduction, delay, or capacity loss, since those variables were not observed in the present survey. Accordingly, SPI is useful as a screening metric for identifying critical hours for parking control and corridor management. Its practical value lies in showing when parking occupation most strongly competes with movement space, while future studies can extend the framework by linking SPI to observed traffic volume, travel speed, and degree of saturation. This managerial reading is also consistent with recent research showing that reallocating or regulating on-street parking can improve broader mobility outcomes when corridor space is managed more strategically [15].

4. CONCLUSION

This study examined how traffic space in an urban commercial corridor is effectively reallocated to parking by combining three measures: longitudinal occupation, effective width reduction, and their integration into a composite Space Pressure Index (SPI). The proposed approach enables a quantitative, time-sensitive description of space pressure without requiring safety-based assessment or traffic microsimulation.

The findings show that curbside parking in the study segment is time-dependent and tends to accumulate during peak commercial hours. Longitudinal occupation reached its highest value at 09:00–10:00 (120.7%), indicating that the cumulative length of parked vehicles exceeded the effective length of the observed segment. In parallel, two-sided parallel parking reduced the effective roadway width by 36.7% relative to the initial geometric width. Together, these results demonstrate that space conversion occurs simultaneously in both dimensions: length and width.

When the two dimensions are combined, SPI peaks at 44.3%, implying that close to half of the road space is no longer functioning as movement space during the busiest period. SPI values above 40% over multiple consecutive intervals further indicate that space pressure is not sporadic; it forms a recurring high-pressure phase during peak activity hours. Practically, this framework can help local authorities identify peak enforcement windows, prioritize curbside control hours, and evaluate whether parking-supply or relocation measures are needed in urban commercial corridors.

Overall, the study reinforces that illegal parking in commercial corridors should not be viewed only as a regulatory or visual-order issue. It is a measurable form of space conversion with clear operational implications for corridor management. Nonetheless, the present study remains limited to spatial parking pressure. SPI was not calibrated against observed traffic volume, travel speed, delay, or actual degree of saturation, so it should be interpreted as a proxy measure of operational pressure rather than a validated substitute for conventional traffic-performance indicators. Future work can extend this framework by linking SPI to PCU-based capacity-loss estimates, applying MKJI or HCM performance procedures, and evaluating parking-management interventions to assess how much corridor mobility can be restored under high-pressure conditions.

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