University Transportation Research Center - Region 2

Final Report

Freight Costs at the Curbside

Performing Organizations: The City College of New York
Rensselaer Polytechnic Institute

November 2016

Sponsor:
University Transportation Research Center - Region 2

University Transportation Research Center - Region 2

The Region 2 University Transportation Research Center (UTRC) is one of ten original University Transportation Centers established in 1987 by the U.S. Congress. These Centers were established with the recognition that transportation plays a key role in the nation's economy and the quality of life of its citizens. University faculty members provide a critical link in resolving our national and regional transportation problems while training the professionals who address our transportation systems and their customers on a daily basis.

The UTRC was established in order to support research, education and the transfer of technology in the field of transportation. The theme of the Center is "Planning and Managing Regional Transportation Systems in a Changing World." Presently, under the direction of Dr. Camille Kamga, the UTRC represents USDOT Region II, including New York, New Jersey, Puerto Rico and the U.S. Virgin Islands. Functioning as a consortium of twelve major Universities throughout the region, UTRC is located at the CUNY Institute for Transportation Systems at The City College of New York, the lead institution of the consortium. The Center, through its consortium, an Agency-Industry Council and its Director and Staff, supports research, education, and technology transfer under its theme. UTRC's three main goals are:

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The research program objectives are (1) to develop a theme based transportation research program that is responsive to the needs of regional transportation organizations and stakeholders, and (2) to conduct that program in cooperation with the partners. The program includes both studies that are identified with research partners of projects targeted to the theme, and targeted, short-term projects. The program develops competitive proposals, which are evaluated to insure the mostresponsive UTRC team conducts the work. The research program is responsive to the UTRC theme: "Planning and Managing Regional Transportation Systems in a Changing World." The complex transportation system of transit and infrastructure, and the rapidly changing environment impacts the nation's largest city and metropolitan area. The New York/New Jersey Metropolitan has over 19 million people, 600,000 businesses and 9 million workers. The Region's intermodal and multimodal systems must serve all customers and stakeholders within the region and globally.Under the current grant, the new research projects and the ongoing research projects concentrate the program efforts on the categories of Transportation Systems Performance and Information Infrastructure to provide needed services to the New Jersey Department of Transportation, New York City Department of Transportation, New York Metropolitan Transportation Council , New York State Department of Transportation, and the New York State Energy and Research Development Authorityand others, all while enhancing the center's theme.

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Project No(s):
UTRC/RF Grant No: 49198-17-26

Project Date: November 2016

Project Title: Freight Costs at the Curbside

Project's Website:
http://www.utrc2.org/research/projects/freight-costs-curbside

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TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2.Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Freight Costs at the Curbside		5. Report Date November 2016 6. Performing Organization Code
7. Author(s) Alison Conway, Ph.D.; Xiaokun Wang, Ph.D., Quanquan Chen, and Joshua Schmid		8. Performing Organization Report No. 49198-17 26
9. Performing Organization Name and Address City College of New York, 160 Convent Ave, New York, NY 10031 Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY		10. Work Unit No. 11. Contract or Grant No. 49198-17-26
12. Sponsoring Agency Name and Address University Transportation Research Center City College of New York-Marshak 910 160 Convent Avenue, New York, NY 10031		13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code
15. Supplementary Notes		

16. Abstract

This research aims to evaluate the different parking conditions that drivers face in critical areas of New York City, to examine the variables that impact their curbside behavior, and to develop recommendations to improve curb management. To accomplish this task, this study includes three major components: (1) an international review of literature and best practices; (2) a case study investigating existing parking availability and parking violation behavior in varying land use areas of Manhattan, New York City using available datasets from the NYC Department of City Planning, NYC Department of Finance and the NYC Department of Transportation; and (3) a case study employing a survival analysis modeling approach to investigate the relationship of parking duration with operator and regulatory factors using field data collected from a related study.

Results from these analyses suggest that there are overall, spatial, and temporal mismatches between parking supply available to commercial vehicles in NYC and modern freight demands. The report identifies a number of specific considerations that should be taken into account when determining zoning requirements, curb regulations, and street designs in an urban area with limited curbside space.

17. Key Words	18. Distribution Statement		
19. Security Classif (of this report)	**20. Security Classif. (of this page)**	**21. No of Pages**	**22. Price**
Unclassified	Unclassified		

Form DOT F 1700.7 (8-69)

Disclaimer

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Introduction

Like major cities throughout the US and around the globe, New York City (NYC) generates tremendous demand for freight delivery. At the same time, drivers aiming to fulfill this demand face extreme challenges. Due to the rapid pace of change in both freight demand and supply chain organization, parking and land use regulations have not kept up with growth in demand. Morris (2009) notes that beyond maintaining minimally acceptable service levels for pick up and deliveries, operational elements required by freight are often after-thoughts in planning due to their relative invisibility.

As the city has rapidly implemented new urban street designs to improve bicycle and pedestrian safety and efficiency and provide transit priority, new challenges for freight access have been introduced. For example, accessibility challenges imposed by curbside bicycle lanes include increased delivery distances, increased parking fines, inability to offload freight directly onto a curb, and increased risks to the driver associated with exposure to conflicts during parking and delivery (Conway et al., 2013). Together, these conditions result in long and unreliable delivery times, vehicle idling that generates excess air pollution, and often, illegal parking that subjects carriers to heavy fines, worsens already severe congestion by obstructing travel lanes, and increases interactions between trucks and other modes.

While the overarching challenges that urban delivery drivers face in urban areas, and in New York City specifically, have been well documented, the local variables that govern their decision-making at the curbside are less studied. This research aims to evaluate the different parking conditions that drivers face in critical areas of New York City, to examine the variables that impact their curbside behavior, and to develop recommendations to improve curb management. To accomplish this task, this study includes three major components. First, an international review of literature and best practices was conducted to identify urban parking challenges and best management practices. Second, a case study analysis investigated existing parking availability and parking violation behavior in varying land use areas of Manhattan, New York City. Finally employing data collected as part of a related study (Conway 2015), a parking duration model was estimated to identify factors that help explain commercial vehicles' parking duration. The following chapters detail findings from the literature review and from each case study; the final chapter details overall findings from this project and provides recommendations for improving curb management.

Literature Review

This project builds on previous work in the areas of urban parking, commercial vehicle parking, parking management, and survival analysis.

Parking Challenges

Urban parking is challenging for both passenger and commercial vehicles. One of the most critical components of parking-related research is the search for parking. Drivers searching for parking occupy valuable space in travel lanes, waste time and fuel while driving an excess distance and waiting to park, and frequently wasting additional time walking a long distance to reach their final destination. Previous studies have identified very high rates of searching for parking in urban areas. For example, in the area surrounding Harvard Square in Cambridge, Massachusetts, 30% of moving vehicles were searching for parking during the peak hour, with an average searching time of 12 minutes. These numbers are not unusual, with most large cities having an average search, or "cruising", time between 6 and 15 minutes (Geroliminis, 2015).

One reason for the amount of wasted time and fuel due to parking searches is a lack of planning on the part of the vehicle operator. Research has shown that a majority of drivers do not have a defined plan for parking before they near their destination, but rather start their search when they are at or near their destination (Chaniotakis and Pel, 2015). Another reason for parking searching is simply a lack of an adequate number of parking spaces to accommodate the vehicle demand. This is the case in Beijing, where vehicle usage is increasing at a rate far greater than parking facilities are being constructed. A recently-published study conducted by Beijing City University indicated that the amount of vehicles in Beijing exceeds the number of parking spaces by more than three million, forcing the majority of vehicles to park on narrow city streets, significantly reducing capacity (Wang et al., 2016).

In most urban areas, space is very limited, and multiple users – including passenger cars, commercial vehicles, transit, bicycles, and pedestrians - demand access to that space. Large commercial vehicles require a large amount of space to park; in urban areas, these vehicles typically park to make deliveries. To make pickups or deliveries, vehicles usually must be parked at or very close to the destination. When a legal parking space is not available, drivers must park illegally in order to serve their customers. In recent years, rapid growth in online shopping has increased the demand for ecommerce shipments; as a result, several cities have seen illegal parking behavior associated with parcel deliveries increase. From 2006 to 2009, parking fines in Toronto increased by 70%, with UPS, FedEx, and Purolator alone paying an estimated $2.5 million in fines in 2009 (Nourinejad et al., 2014). Observations conducted in Chicago in 2013 indicated that trucks parked illegally over 28% of the time, compared to 3% for passenger vehicles (Kawamura and Sriraj, 2015). Smaller urban areas are also facing similar issues; for example, in Fargo, North Dakota, delivery vehicles in higher-density areas must park illegally and block travel lanes because commercial vehicles do not have dedicated loading zones (Chatterjee et al., 2008). International studies have identified similar challenges; a 2015 Italian study analyzed scenarios that could be implemented in order to alleviate some urban freight issues, including the designation of parking zones that would vary between passenger vehicle parking and freight loading/unloading based on the time of day (Marcucci et al., 2015). In cities like New York, physical space available for commercial activity is only becoming more constrained as streets are transformed to improve multimodal operations and safety (Conway, 2015).

Commercial vehicle parking challenges are not restricted to urban areas. A 2005 Nebraska study indicated that a large proportion of truck drivers believed that there was too little truck parking in parts of the state, with utilization rates at public rest areas and private truck stops high and growing (Gaber et al., 2005). A 2014 Florida study showed similar results, indicating that the vast majority of rest areas along Interstate highways in the state had a maximum truck parking utilization rate near or above capacity, with capacity being exceeded by more than 100% in some cases (Bayraktar et al., 2014). In Europe, there exists a large demand for safe and legal truck parking that cannot be fully satisfied by available facilities. A 2014 Italian study highlighted some of the challenges facing European nations and the financial issues associated with "good" parking (Carrese et al., 2014). In all cases, trucks must park illegally when all legal parking spaces are in use, causing safety concerns.

The lack of available parking is not only due to space constraints but also to outdated zoning regulations that fail to account for freight demand. The Chicago Downtown Freight Study determined that among many other needed improvements, loading dock requirements needed to be revised and dedicated loading spaces needed to be added in "hot spot" areas (O'Laughlin et al., 2008). Morris (2004) noted that while deliveries to commercial properties in cities over the past 30 years have increased by 300 percent, regulations for the number of bays required for off-loading facilities in a number of US cities including New York have not changed in more than 40 years. In an evaluation of zip-code level freight demand and available curb space, Jaller, Holguin Veras, and Hodge (2013) found that in Manhattan there are ten ZIP codes for which the freight parking demand exceeds the available (lineal) curb space, even if all other users were removed from the system. In New York City, space requirements for both off-street and on-street loading are very low. Table 1 summarizes off-street parking and loading regulations from the City of New York Zoning Resolution (NYCZR) that apply in the Manhattan core, which extends from the southern tip of Manhattan to West 110th Street on the West Side and East 96th Street on the East Side (City of New York, 2011).

Table 1 Off-street Parking and Loading Zone Requirements in the Manhattan Core

Use	Requirements	
Off-Street Parking		
Residential Use	Max ratio of 0.2 per dwelling unit	
Retail Use	Max 1 space per 4000 sq. ft. or 10 spaces; whichever is less	
Other Commercial uses	Max 1 space per 4,000 sq. ft. or 100 spaces; whichever is less	
Off-Street Loading Berths		
Commercial uses	Min 1 loading berth after 25,000 sq. ft floor area	Dense Residential Districts; large-scale residential developments
Commercial uses	Min 1 loading berth after 8000 sq. ft or 25,000 sq. ft floor area	Varies by Commercial District

As can be seen from the Table, space requirements are very low for commercial land uses, and no loading docks are required for residential buildings. This is a particular concern as the rapid emergence of ecommerce has quickly transformed residential homes into freight trip generators. Wang and Zhou (2015) used the U.S. National Household Travel Survey (NHTS) data to investigate the freight trips generated by residential in the Albany, New York; their study found that "freight trips generated by residential units have comparable magnitude as the freight trips generated by businesses." Parking shortages are further exacerbated by lacking freight elevators in many multi-story buildings, which lead to longer delivery times and increased temporal demand for parking (Morris, 2007).

Parking Management

Recognizing the increasing challenge of commercial vehicle parking, cities throughout the world have sought to implement policies and technologies to improve conditions and to reduce impacts on surrounding regions. Parking challenges generally result from a mismatch between supply and demand. To address this mismatch, regions must take one of three general approaches: (1) provide additional space for commercial vehicle parking; (2) better manage existing space; or (3) manage the demand for parking capacity.

Provide Additional Space

While a number of cities have recognized a shortage of available space for commercial vehicle activity, only a few have implemented specific policies to increase available dedicated space. Paris Transport Department guidelines have been updated to impose a minimum of one delivery bay every 100 meters on city streets (Dablanc, 2011). Washington, DC implemented a “Downtown Curb-Space Management Program” on one of its congested downtown streets; specific actions taken as part of this program included the relocation of curb space by adding new signage and lengthening of loading zones from 40 feet to 100 feet wherever possible (Bomar et al., 2009). The city also designated off-street loading areas with paint and signage. To address increasing parcel traffic, in Philadelphia’s central business district, the parking authority implemented 36 “Package Delivery Zones” reserved specifically for registered package delivery companies (Dickson 2015).

Manage Existing Space

Parking space can be better managed through the use of variable regulations, pricing, real-time management, or through improved enforcement. As part of the “Downtown Curb-Space Management Program” Washington, DC also added multi-space meters, added metered loading zones, and increased parking enforcement (Bomar et al., 2009). Nearly all commercial parking in midtown Manhattan has been converted to paid commercial parking, leading to significant reductions in vehicle parking times (although results are variable) and resulting increased curb availability for deliveries (Schaller et al., 2011).

Barcelona uses time-variable regulations on some of its main boulevards: curbsides are allocated as travel lanes during peaks hours, designated for deliveries during daytime off-peak hours, and used as residential parking during the night (Dablanc, 2011). NYCDOT has designated delivery windows in some areas to provide curb access during specified (usually early morning) hours; however, the effectiveness of these windows is constrained by receiver demands (Hodge, 2015). Delivery windows have proven to have little effect in some areas where unenforced service vehicles occupy these spaces for long durations.

Although not focused on freight applications, the TRL Information Centre (2008) provides a comprehensive summary of the state-of-the-art in available parking technologies: these include payment systems, information systems, enforcement systems, and pre-booking systems. The European FREILOT (2012) project includes a pilot test of a delivery space booking system for freight vehicles. In

Japan, Pilot Programs on urban freight have focused on the management of loading/unloading and parking spaces (Futumata 2009).

When enforcement is limited or ineffective, existing spaces are often occupied by other vehicles. The NYC THRU Streets program attempted to reduce illegal parking and to increase curb clear time (City of New York, 2004). The Chicago Downtown Freight Study recommended increasing enforcement to target non-commercial vehicles in loading zones (O'Laughlin et al., 2008). Bassock et al. (2013) noted that even when off-street loading zones are available, entrances may be obstructed when other vehicles park within space required for a truck turning maneuver.

Manage Demand

An additional strategy to address parking space shortage for commercial vehicles is to reduce demand for this space. Two common strategies to reduce the demand for space for large commercial vehicles are urban consolidation centers and off-hour delivery programs. The former aims to shift goods from large vehicles to smaller, usually "greener" vehicles through transloading at a centrally located sorting space. Panero et. al (2011) provide a comprehensive review of urban consolidation center experience. The off-hour delivery programs seek to shift freight trips to off-peak periods, when demand for road and curb space from passenger vehicles and transit is lower than during peak periods. Holguin-Veras et al. (2011) successfully demonstrated the benefits of a program to incentivize off-peak deliveries. While the pilot project clearly demonstrated the benefits of off-peak deliveries, expansion of the program has been limited by receiver barriers to accept deliveries during the off-peak.

Survival Analysis

This study employs survival analysis to evaluate parking durations. Often referred to as survival models, duration models are used to predict the time that will elapse before an event occurs. Different forms of duration models are tested with differing combinations of variables in order to determine the model that best fits the collected data. While few studies have applied survival analysis to investigate parking, this type of model has many applications in transportation. Survival or duration models are commonly used to predict the durations of traffic incident impacts. A study from Beijing utilized incident data to create accelerated failure time (AFT) models to predict response preparation time, travel time to an incident, time required to clear the incident, as well as the total time from notification to clearance. A Weibull AFT model was proposed for travel time to the incident, while a Gamma AFT model was proposed for the other three time periods. Results indicated that times were greater in the morning and increased as distance from the city center increased (Li, 2015). A Southeast Queensland, Australia study created AFT models for incidents categorized as “crashes”, “hazards”, and “stationary vehicles”. Weibull AFT models were found to be the best fit for the data, with times again being greatest in the morning and as distance from the city center increases (Hojati, Ferreira, Washington, & Charles, 2013). Survival analysis can also be used to predict failure of system components. A Swedish study analyzed rail life in that nation in relation to freight and passenger traffic over the segment of track. A Weibull survival model was proposed to predict the best time to perform track rehabilitation given several factors (Andersson, Björklund, & Haraldsson, 2016).

Case Study 1: Parking Availability and Violation Analysis

To better understand existing parking conditions for commercial vehicles in Manhattan, New York City and to identify differences in parking availability and behavior across neighborhood types, an analysis of critical parking violation areas was conducted in ArcGIS.

Data Description

To identify parking availability and parking violation characteristics in commercial, residential, and mixed land use areas, this analysis utilized a number of publicly available datasets, including: land use (PLUTO) and single-line street baseline data (Lion) from the NYC Department of City Planning; census tract geometries from the US Census Bureau; NYC Department of Finance parking violations; and a NYC Department of Transportation traffic sign database (STATUS).

Methodology

Critical Census Tract Selection

First, the NYCDOF parking violation records were prepared for analysis. January 2014 parking violation records were extracted from the database, which includes records since 2012. To extract commercial vehicle violations, vehicle registration type (commercial vs. passenger) was initially explored as an identifying variable; however, it was noted that out-of-state license plates, which make up a considerable share of local delivery vehicles, could not be identified as “commercial” via this method. As a result, the vehicle body type variable was used to identify commercial vehicle (CV) violations. In total, 102,638 records, including “Delivery”, “Refrigerated Truck”, “Semi-Trailer” and “Van” vehicle types were identified. Each record includes detailed information, including violation code, issue date, time, and location of the violation. Addresses were geocoded in ArcGIS; records missing the county or house number or including a void street name were deleted. In total, 99,615 violations (97% of original records) were geocoded successfully. It should be noted that these cited parking activities do not necessarily reflect all parking violations, but rather those that were subject to enforcement.

Both parking violations and parking sign locations were then mapped to individual census tracts. NYCDCP’s PLUTO database was employed to categorize census tracts by land use types. PLUTO contains comprehensive land use, building, and geographic category information (including census tract) for individual tax lots in NYC. For each tax lot, the total building area, residential area, office area, retail area, storage area and factory area are given. The total percentage of space dedicated to commercial (P_c) and residential (P_R) uses in each census tract were estimated using Equations 1 and 2.

$$P_c = \frac{\sum_t Commercial\ Area}{\sum_t Total\ Building\ Area}$$

$$(\mathbf{Eq.\ 1})$$

where:

Commercial Area = office area + retail area + storage area + factory area

t = set of tax lots belonging to the census tract

$$P_R = \frac{\sum_t Residential\ Area}{\sum_t Total\ Building\ Area}$$

$$(\mathbf{Eq.\ 2})$$

Census tracts were then categorized using the following criteria:

$P_C - P_R \geq 10\%$:	Commercial use census tract
$-10\% \leq P_C - P_R \leq 10\%$	Mixed use census tract
$P_C - P_R \leq -10\%$	Residential use census tract

Once sorted, the census tracts were ranked based on parking violation rates. The violation rate in each census tract was defined as the ratio of total violations counted divided by the total curb length (identified from the LION database) in that census tract. For each land use type, the top five tracts by violation rate were identified.

Parking Supply Analysis

On-street parking supply was directly evaluated using NYCDOT's STATUS parking regulation database. Curb spaces are regulated by parking regulation signage posted along the curb. The STATUS database is a geocoded database containing the text of every street sign in NYC. An algorithm was developed and implemented in Visual Basic to convert the sign text into a quantitative dataset showing the availability of curb parking/loading spaces. As many regulations - including street-cleaning days, truck loading zones and no standing zones - apply only during specific days or times, the dataset identifies the relevant regulations during discrete half hour periods. To evaluate overall supply, parking regulations were grouped into four categories:

- *Open parking*, which includes spaces available to any passenger or commercial vehicle with no time or meter restriction;

- *Restricted parking*, which includes metered and time limited spaces not dedicated for commercial use;
- *Dedicated commercial parking*, which includes commercial loading zones and commercial metered spaces; and
- *No parking,* which includes space where no vehicle can legally park.

Google Street images and geospatial mapping in ArcGIS were used to match hydrants and off-street parking entrances/driveways to corresponding blocks. A number of previous researchers have employed this tool in NYC, including Weinberger (2012) who used it to identify household off-street parking and Guo (2013) who used it to measure total parking supply available to households in low density areas of NYC.

In this project, the amount on-street available space during a specific time at a single street curb was converted into a total number of available spaces in a census tract by adding all available spaces of all curbs in that census tract (Eq. 3).

$$n = \frac{\sum_i (l_c/N_s - l_H^i - l_E^i)}{l_T}$$

(Eq. 3)

where:

n = Number of available spaces for commercial vehicles during a specific time segment at single street curb

i = signage type

l_c = Street curb length

N_S = Total number of activated parking signage along that curb

l_H = Length occupied by fire hydrant

l_E = Length occupied by curb cut (off street parking entrance or driveway)

l_T = Average truck parking space length, 33 feet (Jaller, Veras, et al. 2013)

The day was divided into 48 half-hour time segments, for example, 7 AM to 7:30 AM. After processing of the database, an average available parking space density during each half-hour segment for a given time frame from Monday to Friday was calculated. Average conditions during three distinct time frames were then evaluated:

- Morning (7 AM-10 AM);
- Midday (10 AM-2 PM); and
- Afternoon (2 PM-7 PM)

Individual blocks were also classified into one of two street types:

- ***Avenues*** are characterized by multiple travel lanes in each direction (whether one-way or two way), longer block lengths between intersections, and higher traffic volumes. In Manhattan, avenues typically run from north to south.
- ***Streets*** are characterized by fewer and narrower lanes carrying lower volumes at slower travel speeds and shorter block lengths between intersections. In Manhattan, streets typically run from east to west.

Parking Violations

The total number of parking violations in each census tract and land use type were determined directly from the mapped violations. The costs for each violation type are provided in Appendix A, and the specific citations issued in each census tract are detailed in Appendix B. Violations from six of the 55 categories identified were determined not to be relevant for commercial vehicles; these constituted 0.8% of the original 16,163 violations identified, and were removed from the dataset. The time distribution of violations in these census tracts could also be directly determined from the dataset; results were mapped as a histogram to identify trends. The costs of violations incurred in each census tract type were also examined. Individual violation costs range from $65 to $180 for different types of violations in New York City. To assess differences across census tract types, a weighted average violation cost was estimated for each census tract. The share of violations of each type within each census tract was also estimated.

To enable direct comparison of the violation distribution patterns in each type of land use area during the three time frames given variability in the size of the tracts, violation rates for each land use type were estimated by dividing the sum of all violations by the sum of available parking during a given time for all five census tracts.

Results and Discussion

Figure 1 show the top five commercial, mixed-use, and residential census tracts by parking violation rate in Manhattan. As can be seen from the figure, critical commercial areas are concentrated in midtown in the vicinity of major attractions such as Times Square and the Empire State Building and transportation hubs such as Penn Station and Grand Central Station. Critical mixed used areas are on the edges of the midtown commercial district. Four of the five critical residential census tracts are on the Upper East Side, while the fifth is in Midtown West close to Columbus Circle.

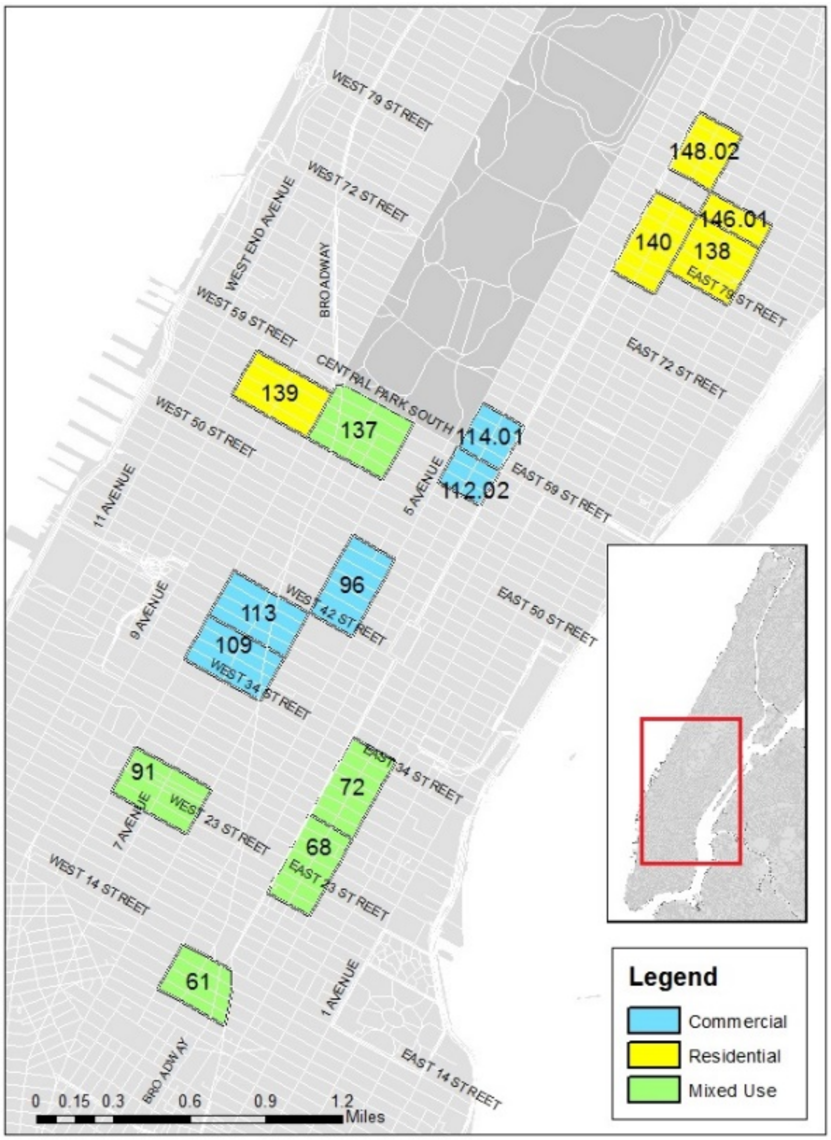

Figure 1 Selected Census Tracts in NYC

Parking Supply Results

Figure 2 shows the available parking on different roadway types in each area during each time period, and reveals some interesting patterns. Overall rates of parking space availability appear to be highest in residential census tracts. However, the characteristics of space regulation types are very different in residential census tracts compared to mixed-use and commercial census tracts. While in commercial census tracts, 85% of all available spaces are regulated as *dedicated commercial parking*, in residential census tracts, 89% of all available spaces are regulated as *restricted parking* or *open parking*. In mixed-use census tracts, 55% of all available spaces are *dedicated commercial parking*.

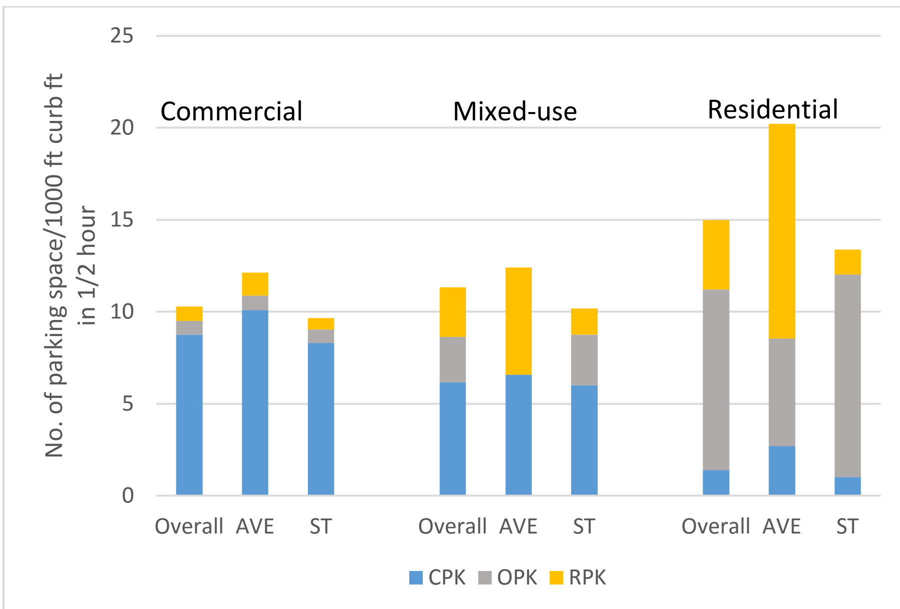

Figure 2 Available Parking Space by Location and Roadway Type

In commercial census tracts, space regulations are similar on ***avenues*** and ***streets***. In mixed-use areas, where overall there is a similar share of dedicated commercial parking, ***avenues*** have more *restricted parking* than ***streets***. In residential land use areas, ***avenues*** and ***streets*** have only about 10% *dedicated commercial parking*. ***Avenues*** are dominated by *restricted parking* (57%), while streets primarily have *open parking* (82%).

Temporal distributions for each census tract type are shown in Figure 3. During all three time frames, the overall rates of parking space availability are highest in residential census tracts. However, as previously noted, much of this space is *open parking*. With residents frequently parking their vehicles for very long durations, turnover rates are very low for these spaces. Parking availability rates in mixed-use areas are slightly higher than in commercial areas.

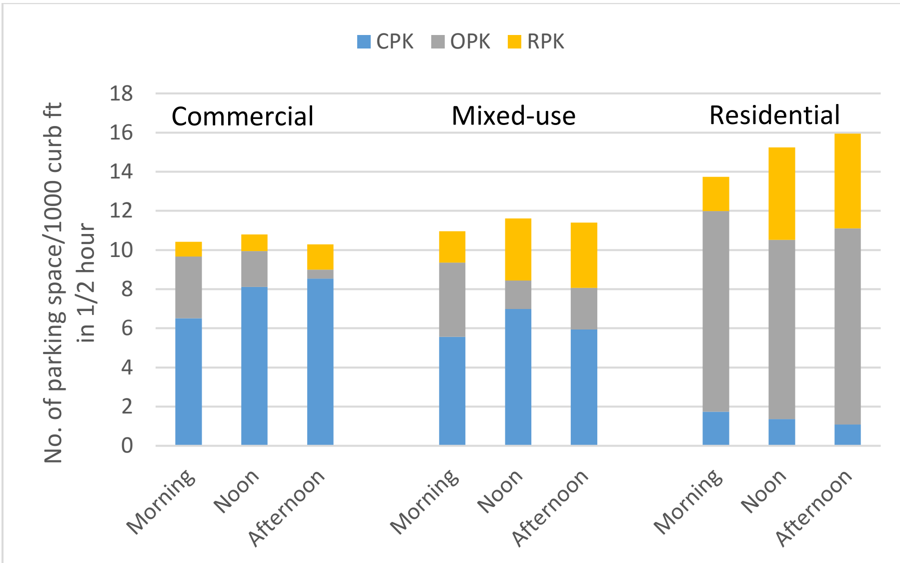

Figure 3 Available Parking Space by Time of Day

In residential areas, parking space availability rates increase from morning to midday and from midday to afternoon, while in both mixed-use and commercial areas, available parking space rates increase from morning to midday, but then decrease from midday to afternoon. This pattern occurs because many spaces are designated as "No Standing" during the morning and evening peaks from "8 AM-10 AM" and "4 PM-6 PM" when the curbside is regulated as a bus lane or moving lane in several locations. In commercial census tracts, the percentage of *dedicated commercial parking* spaces increases from the morning to the afternoon. Mixed-use areas are similar to commercial areas; however, while overall parking space availability is slightly higher, *dedicated commercial parking* space is lower than in commercial use areas. In mixed-use areas, 50-60% of the parking supply is *dedicated commercial parking*.

Parking Violation Results

Figure 4 shows the total violation rates during each time period in each land use type. Violation rates are highest in commercial census tracts. In each time frame, violation rates in commercial use census tracts are double (or more) the rates in mixed-use and residential areas. This higher violation rate is likely due to higher demand for parking. In commercial areas, violation rates experience a quick drop from morning to midday and then from midday to afternoon. The violation rate distributions in mixed-use and residential areas are similar; both have a slight increase from morning to midday, then show a decrease from midday to afternoon. Interestingly, the violation rates in residential census tracts are higher during morning and midday than those in mixed-use census tracts. This is likely due to a large number of parcel deliveries occurring in the late morning and at midday in residential areas.

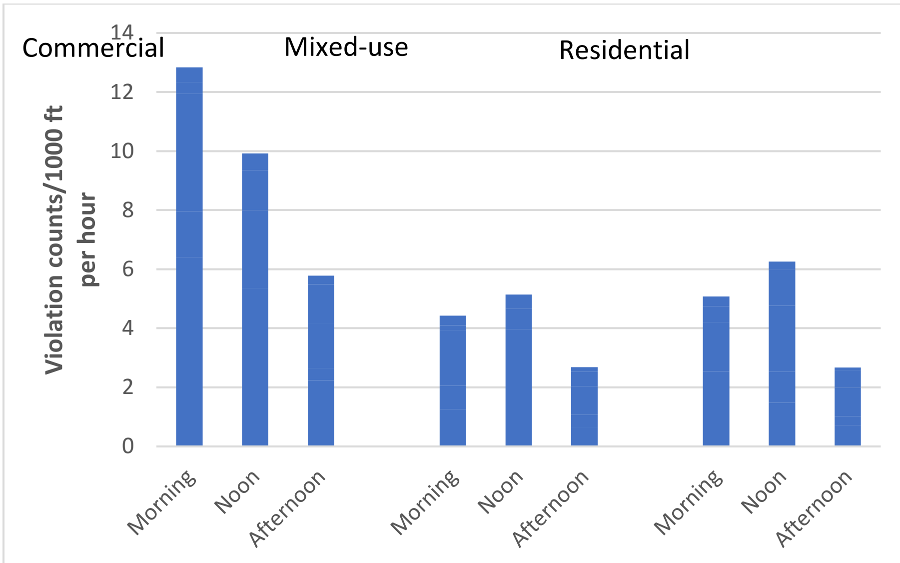

Figure 4 Parking Violation Rate According to Different Land Use Census Tracts

Figure 5 separates out the land use areas into individual census tracts and maps out absolute violations; here we can see that the Figure 4 trends are mostly consistent across the commercial and mixed census tracts. In all but one of the commercial tracts, the share of daily violations during an average morning hour is much higher that at midday. In most mixed use tracts, morning and midday violation rates are similar. However, in the residential census tracts, there are stark differences between the tracts; while in three residential tracts, violations are much higher during midday hours, on the other two tracts, violation rates are much higher in the morning.

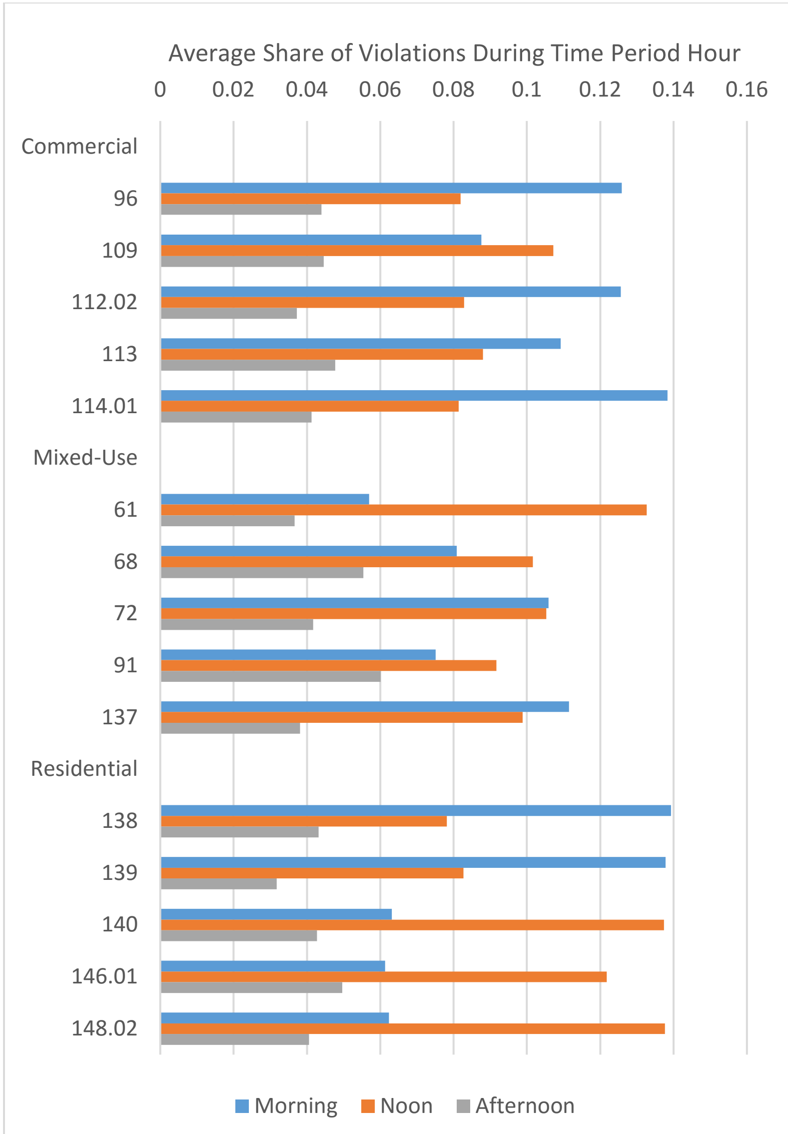

Figure 5 Average Hourly Share of Violations by Time Period

As noted above, 49 relevant parking violation codes were found in the selected census tracts. These codes were grouped into four general categories for evaluation. The four categories for evaluation are:

- **Meter and Overtime Violations**: Meter violations are violations that (1) occur at a meter, including failure to pay and overtime parking or (2) involve parking for longer than the permitted duration at another legal parking space.
- **Moving Lane Violations**: Moving lane violations are issued when a vehicle obstructs a motor vehicle, bus, or bicycle travel lane.

- **Curbside/Off-street Violations**: Curbside/Off-street violations are issued when a vehicle parks in a location at the curbside or off-street where parking for that vehicle type is prohibited.
- **Operating Violations:** Operating violations include violations are issued when the driver is operating an improperly registered vehicle, operating an improperly-equipped vehicle, of conducting prohibited activity.

Figure 6 shows the distribution of violations by type occurring in each census tract type. For each land use type and violation type, the bar shows the minimum share of violations, the maximum share of violations, and the weighted average share of violations occurring in a census tract of that type. As can be seen from the figure, operating violations make up only a small share of violations across all census tract types. In the five observed mixed-use areas, 42-60 percent of violations were meter violations, a higher average share than in commercial and residential census tracts, although there is greater variability in the other census tract types. In mixed use areas, on average, a much a lower share of vehicles park illegally at the curbside or off-street. In commercial areas, moving lane violations are less common on average, and are also less variable than in the other census tract types.

Figure 7 shows the time distribution of each violation type in each census tract type. In commercial census tracts, curbside/off-street violations peak in the morning, with an absolute maximum during the 9 AM hour. Moving lane violations are also higher in the morning than later in the day in both commercial and residential census tracts. The concentration of moving lane violations in the morning may be due to the presence of dedicated curbside travel and bus moving lanes during these hours; after the morning peak, these lanes become available for parking. In all three census tract types, meter violations occur throughout the day in both the morning and afternoon periods. However, in commercial census tracts, more frequent violations can be observed in the early morning (7-8 AM) hours. In residential census tracts, both moving lane violations and meter violations peak during the 10 AM hour, slightly later than other types of parking violations. This is likely due to a change in regulation that occurs on commercial corridors in many residential census tracts when spaces dedicated for commercial loading earlier in the morning become metered parking; vehicles may either remain parked in these spaces from the dedicated commercial hours or may be required to double park after this change occurs. In all three census tract types, meter violations are also frequent in the early afternoon. All violation types appear to show a spike during the 1 pm hour; the reason for this is unclear, although one reasonable explanation may be higher enforcement during this hour.

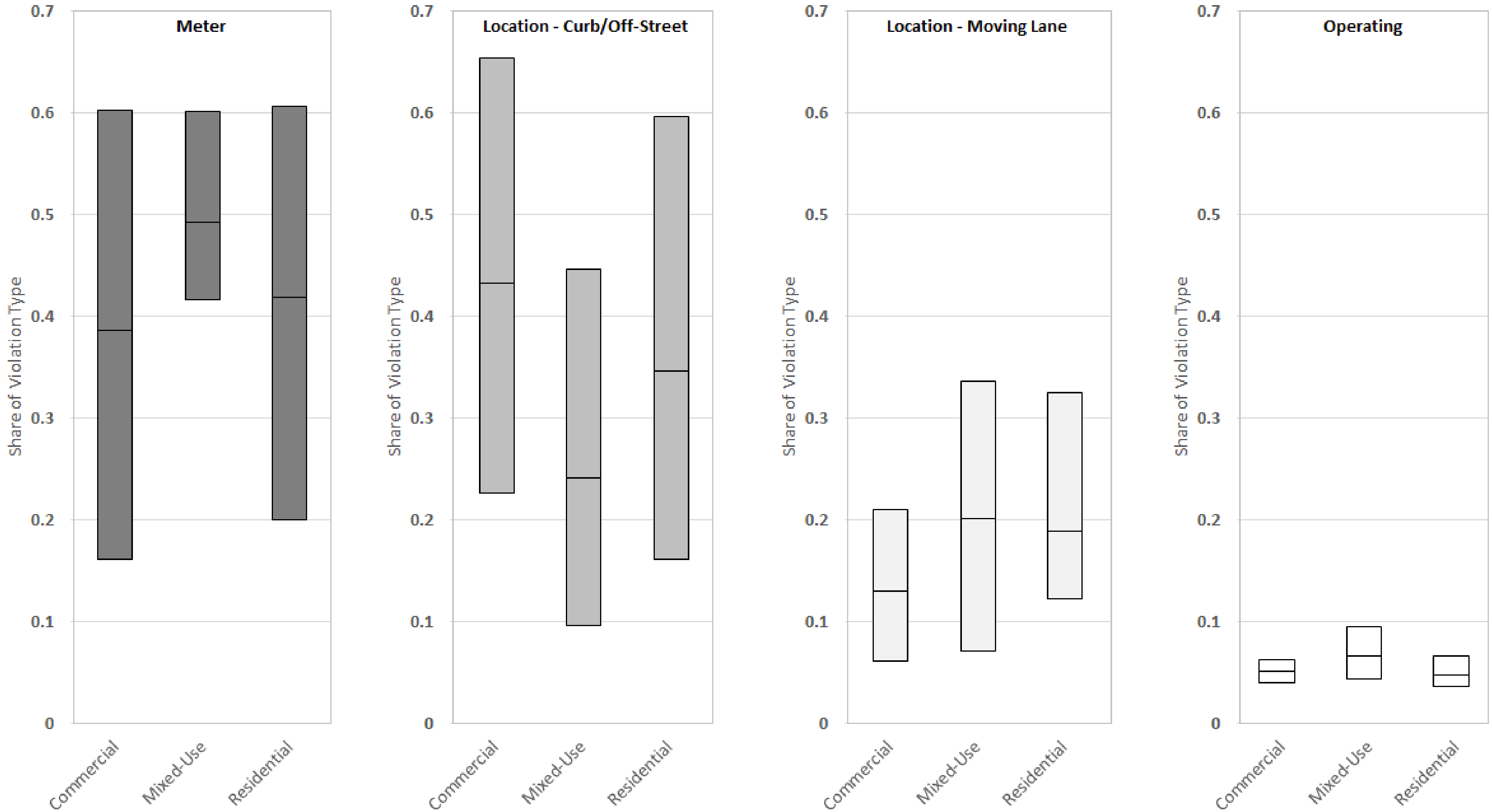

Figure 6. Distribution of Census Tract Share of Violations

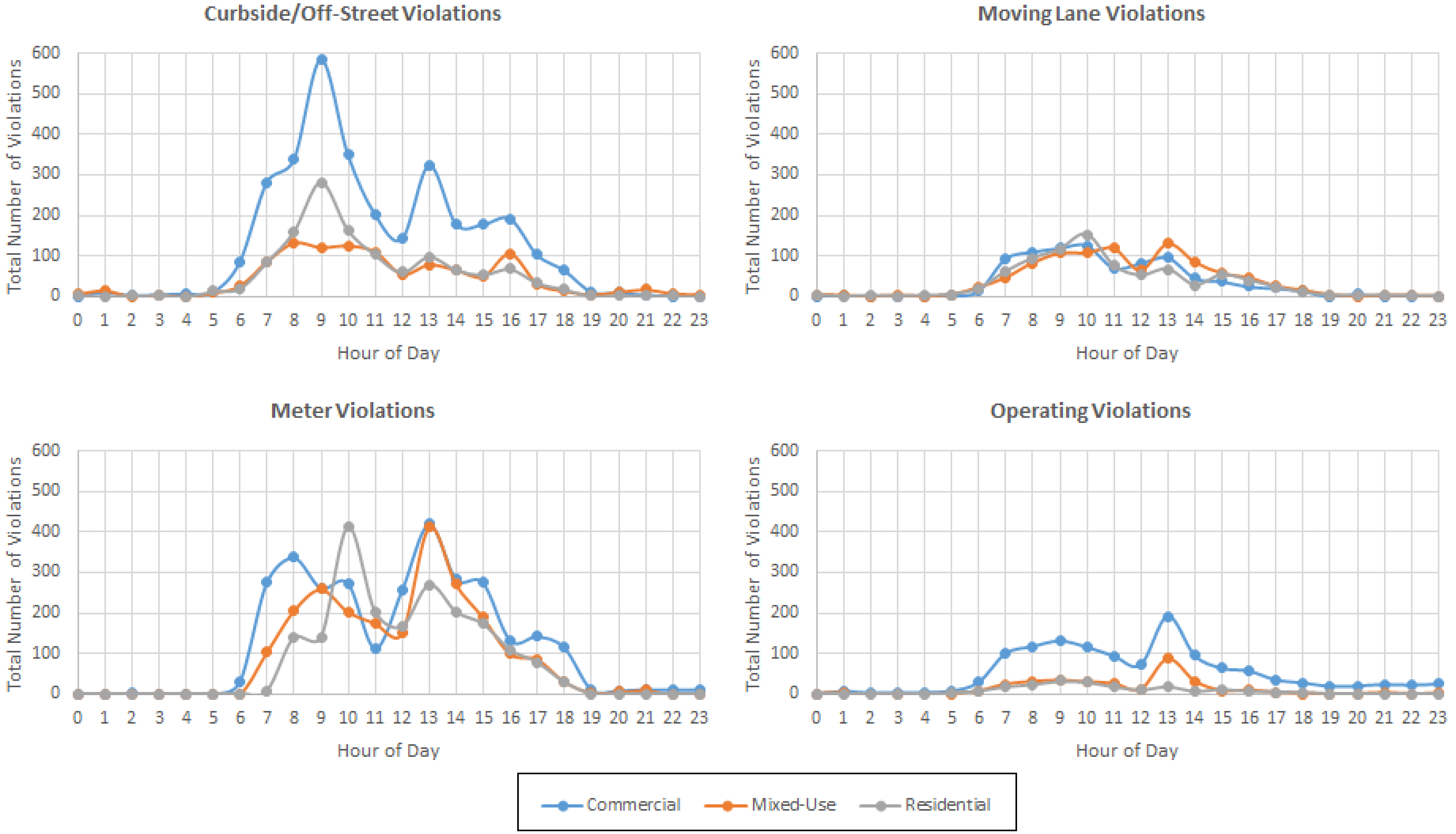

Figure 7 Time Distribution of Violation Types by Land Use Type

Figure 8 shows the distributions of two more specific categories of violations - “no standing or parking” and “double parking” - for each land use and roadway type. While rates for these two violation categories are highest in commercial census tracts, the overall violation rate in residential areas is slightly higher than in mixed-use areas. Examining differences by roadway type reveals that ***avenues*** in residential areas have the highest violation rate, even compared to commercial ***streets*** and ***avenues***. This very high violation rate likely occurs because commercial vehicles delivering to narrow residential ***streets*** with extremely low parking turnover rates very frequently choose to park (or double park) on the nearest ***avenue***. For ***streets*** the violation rate in commercial land use areas is more than triple the violation rate in both mixed-use and residential land use areas.

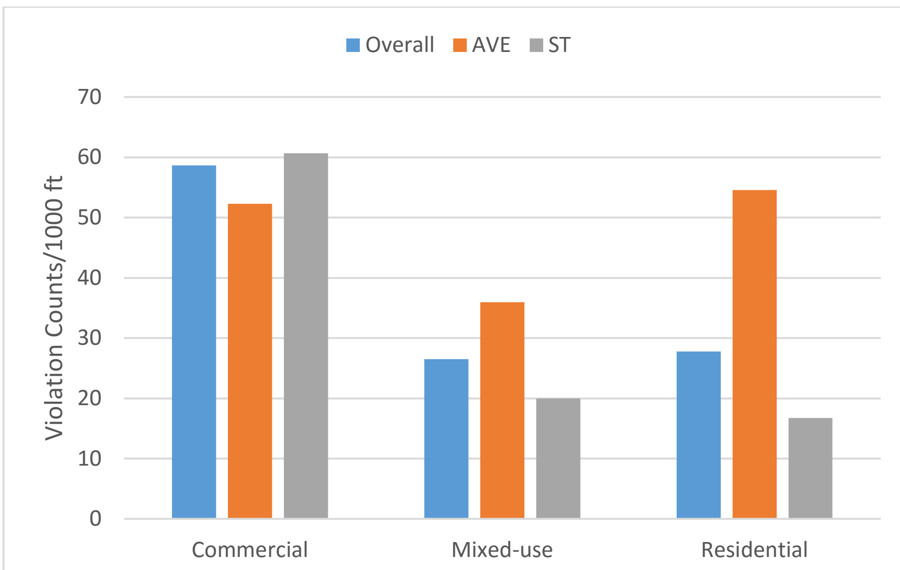

Figure 8 “No standing or parking” and “Double parking” Violation Rates by Area and Roadway Type

Table 2 shows the weighted average costs incurred for a violation in each census tract and in each land use type. As can be seen from the table, rates within census tracts of the same land use type vary, with maximum values close to $100 in census tracts of all three land use type, and minimum values close to $80.

Table 2 Average Violation Cost by Census Tract

Census Tract	Total Violations	Total Cost	Average Cost
Commercial			
112.02	926	$92,150	$99.51
114.01	1306	$129,400	$99.08
96	1822	$176,340	$96.78
113	1554	$128,435	$82.65
109	1698	$139,450	$82.13
Weighted Average			$91.13
Mixed-Use			
68	926	$92,150	$99.51
91	1306	$129,400	$99.08
137	1399	$121,675	$86.97
72	1554	$128,435	$82.65
61	1698	$139,450	$82.13
Weighted Average			$88.79
Residential			
146.01	386	$37,910	$98.21
139	871	$83,755	$96.16
138	768	$66,050	$86.00
140	1256	$100,390	$79.93
148.02	903	$71,845	$79.56
Weighted Average			$86.03

Figure 9 shows the distribution of violation types within each of these census tracts. As can be seen from the figure, those census tracts with more of the more expensive moving ($115) and curbside/off-street violations ($101 average) have higher average costs than those where more operating ($71 average) and meter violations occur ($65).

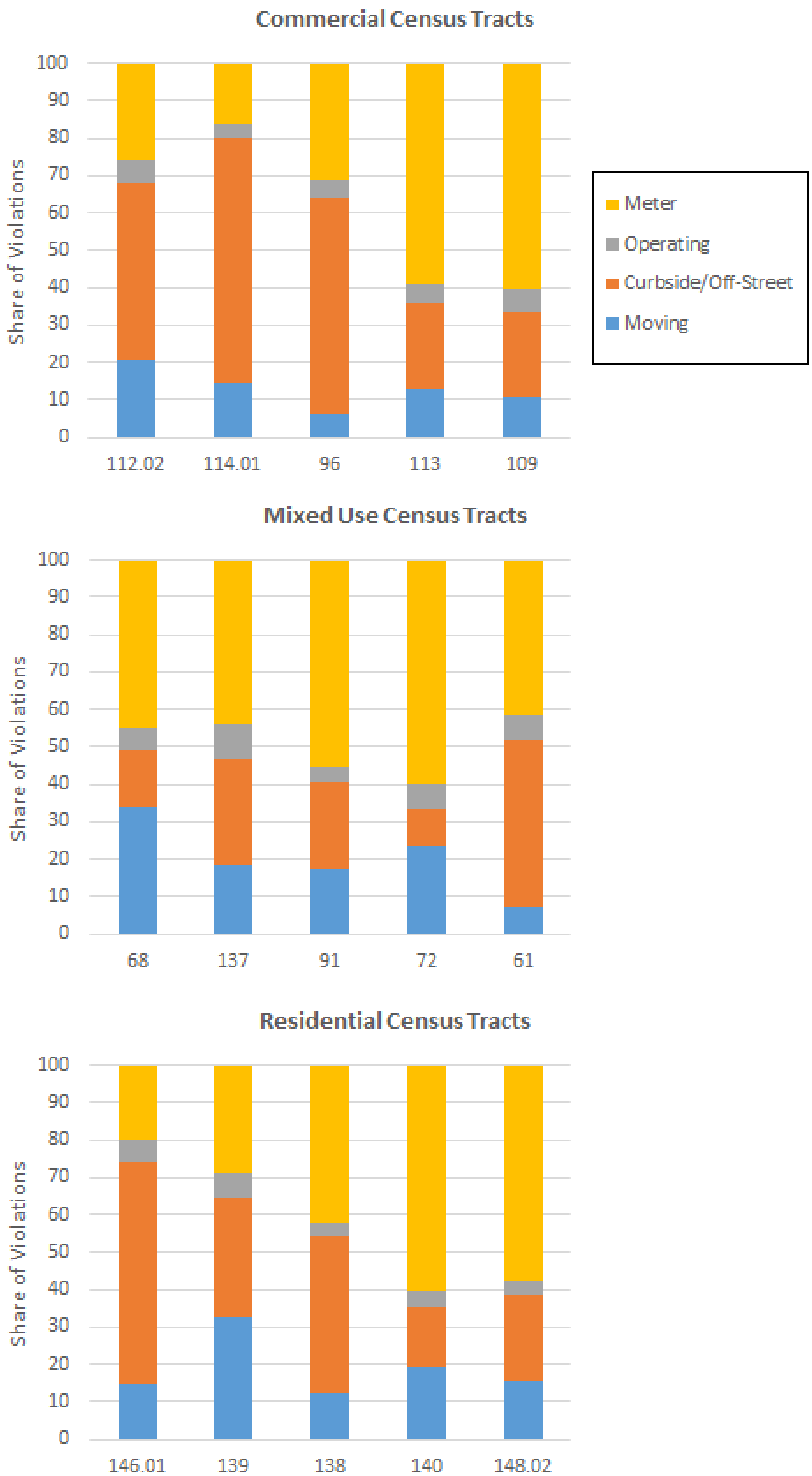

Figure 9 Census Tract Share of Violations by Type

Implications for Planning

Results from this analysis suggest that in all land use areas, there are high overall parking violation rates for commercial vehicles, indicating a general lack of available capacity to meet demand. Existing zoning regulations that define required on- and off-street space for parking in different land use types should be revisited. There are also clear mismatches between the temporal and spatial distributions of expected freight demand and the observed available supply of dedicated parking. Tradeoffs in space availability occur throughout the day. In some areas, curbside lanes which later become parking space are dedicated as bus lanes or motor vehicle travel lanes during peak hours. Delivery activity occurring during these hours can lead to a lane obstruction, and ultimately a moving lane violation. In other areas, spaced dedicated for exclusive commercial use during morning hours (e.g. 7-10 AM) becomes metered parking later in the day. While this space may serve traditional food and retail deliveries well, parcel and other on-demand deliveries occurring later in the day must compete with other uses for limited parking. On residential streets, very little space is dedicated for commercial activity. Most existing parking spaces on these streets are not regulated by time-limits or meters; as a result, they have very low turnover rates. With no legal parking option and frequently the potential to obstruct an entire travelway by double parking on a narrow street, commercial vehicles often choose to park on higher volume avenue corridors. In addition to examining the zoning requirement as noted above – particularly for residential buildings – reassessment may be necessary to determine the compatibility of time-variable parking capacity with temporal demands.

Violation costs vary depending on the violation type. In areas where vehicles must obstruct a travel lane (motor vehicle, bus, or bicycle) while conducting delivery activities, they will face higher fines. As additional space – particularly curbsides – becomes dedicated for bus and bicycle use and as overall parking decreases following complete streets implementations, moving lane violations and curbside violations that obstruct other uses (e.g. taxi stands, crosswalks, bus stops) are likely to increase. As a result, so too will the fines paid by commercial vehicle operators. This added cost should be taken into consideration when evaluating design alternatives that remove curbside parking and prevent curbside loading/unloading.

Case Study 2: Parking Location and Duration Analysis

To understand and predict the expected duration of commercial vehicles' parking under various conditions, a model was developed, estimated, and interpreted, using field data that the team collected as part of a related project.

Data Description

This analysis makes use of dataset created by a team at the City College of New York (CCNY) as part of a broader study of commercial vehicle activity on multimodal urban streets (Conway et al., 2016). Researchers conducted direct field observation at four locations in New York City: Chinatown, Midtown, and the Upper West Side in Manhattan, and Fordham Heights in the Bronx. Chinatown is located on Manhattan's Lower East Side, with narrow streets that predate the grid system present across most of the borough. The studied block is located immediately southwest of the Manhattan Bridge. At the west end of the block is Chatham Square. This is a dense commercial corridor, with no off-street parking and bicycle lanes. The studied block of West 34th Street in Manhattan is home to the Empire State Building, which occupies the entire southeastern quadrant. As the most direct connection between the Midtown and Lincoln Tunnels, it is a heavily-traveled corridor with bus lanes in both directions. Herald Square is at the western end of the block. The block contains several large retail establishments, offices, and apartments. The studied block of West 77th Street is bounded on the north by the American Museum of Natural History, the south by several large apartment buildings, and to the east by Central Park. As with East Broadway, this block contains bicycle lanes. Contrasting with the Manhattan locations, the Grand Concourse is a wide boulevard with a central two-way roadway restricted to passenger cars that is flanked by one-way service roads. The three-block stretch that was studied contains retail establishments ranging from small to big-box stores at street level, with apartments on the upper floors of most buildings. The service roads on the Grand Concourse contain bicycle lanes. While each case study area is a dense urban environment, the conditions are quite different. Overall, the dataset includes 183 observations of commercial vehicle parking events. Unlike the parking violation data utilized in Case Study 1, this dataset includes vehicles that were parked both legally and illegally.

Methodology

While relatively small, the dataset lists many characteristics pertaining to each event. Before model construction, descriptive statistics for these characteristics were estimated and evaluated:

- **Vehicle characteristics:** For each event, the vehicle type was recorded. Vehicles were classified as single unit trucks, cargo vans, semitrailers, refrigerated trucks, or “other”.
- **Service characteristics:** The type of delivery activity was also recorded; these were classified as; parcel deliveries, which includes movement by UPS, FedEx, and UPS as well as smaller parcel carriers; food or beverage deliveries, which can include movements to retail establishments and restaurants or to residences; non-delivery services, including utility companies or emergency services; other; or unknown.
- **Availability of parking:** For the purposes of this dataset, an “acceptable legal parking location” was defined as a legal spot located on the same block as the destination. Available parking was classified as “at location” if the available spot was directly in front of a building to which a delivery was made. Available parking was classified as “on block” if it was on the same black as a delivery location, but not directly in front of a building. For each event and type, the availability of such parking was directly observed.
- **Parking location:** The vehicle’s exact parking location was also directly observed, and classified by regulation type. Observed parking locations included: legal spot; double parking; bus stop; no parking/no standing/fire hydrant; and left shoulder.
- **Parking duration:** The parking duration is defined as the time from when the vehicle arrives to the curb until it exits the curb. Arrival and departure times were directly observed. Some durations may be truncated if (1) a vehicle was already parked at the beginning of an observation period or (2) a vehicle was still parked at the end of an observation period.
- **Subject to enforcement:** For each parked vehicle, whether or not an enforcement officer (on-foot or in-vehicle) passed the vehicle was directly observed.
- **Cited:** For each parked vehicle, whether or not an enforcement officer (on-foot or in-vehicle) issued a citation to the vehicle was directly observed.

When modeling a set of data, it is often advantageous to have extremely specific variables in order to model trends as accurately as possible. Yet, due to the limited size of the dataset that was chosen, more general categories had to be created in order for a model to be created. A set of binary indicator variables that correspond to each of the categories outlined in the previous section as well as other relevant information was created to allow for modeling. Each indicator variable holds a value of one if true, equaling zero otherwise.

The parking duration is expressed in minutes. A list of variables created for analysis is listed in Table 3.

Table 3 Model Variables

Variable Name	**Description**
Duration_Min	Parking duration in minutes
LogDurat	Natural log of parking duration = ln(Duration_Min)
V_Single	Single unit truck
V_Van	Van
V_Other	Other vehicle type
D_Parcel	Parcel delivery
D_FoodDr	Food/drink/grocery delivery
D_Servic	Service delivery
D_Other	Known delivery that is not parcel, food/drink, or service
D_Unknow	Unknown delivery type
AL_Front	Legal parking available in front of building
AL_OnBlo	Legal parking available on block
Legal	Vehicle parked legally
P_Open	Closest parking on block is open/free
P_Metere	Closest legal parking is metered

In the duration model specified, the dependent variable was the parking duration in minutes, with various combinations of the other variables forming the set of independent variables. NLOGIT 5 was used to estimate and test the duration models. To begin the analysis, a nonparametric duration model was run in NLOGIT 5 to determine the best parametric model type. The hazard function and survival function were compared to the various types of parametric duration models, with it being determined that the best type of model for this dataset is a Weibull model, which assumes that

The hazard function is defined as:

$$h(t) = (\lambda P)(\lambda t)^{P-1}$$

(Eq. 4)

while the survival function is defined as:

$$s(t) = \exp[-(\lambda t)^{p}]$$

(Eq. 5)

where $\lambda = \exp(-\beta X) = \exp(-[\beta_1 X_1 + \beta_2 X_2 + \cdots])$

A total of 36 models were created. These models tested several different combinations of variables, with ten considering location. The natural log of parking duration was set as the dependent variable in all cases. Different vehicle types, delivery types, and locations were set as the base. For vehicle type, either vans or single-unit trucks were set as the base, while deliveries set parcels or food and drink as a base. T-statistics for model coefficients, the number of significant variables, and the types of variables that were significant were compared in order to determine the best model.

The effect of a variable on parking duration can be determined by examining the hazard ratio, which shows the relative effect the presence of a variable has on the hazard function. A hazard ratio greater than one indicates that the presence of the variable increases the hazard function, while a hazard ratio less than one indicates that the presence of the variable decreases the hazard function. An increasing value of the hazard function corresponds to a decreasing parking duration, thus a hazard ratio greater than one indicates that the variable has a negative effect on parking duration.

In order to analyze the effect a change in a variable would have on the duration, one can also compute the elasticity using $elasticity = \frac{\partial \mu}{\partial x} \times \frac{x}{\mu}$ where μ indicates the expected value of duration.

With the calibrated model, it is possible to make predictions as to how vehicle parking durations would be affected by changes in vehicle characteristics. For a Weibull survival model, it can be derived that

$$t = -\left(\frac{\ln S(t)}{\exp(-\beta x)}\right)^{\frac{1}{p}}$$

(Eq. 6)

That is, for each given survival rate, the corresponding duration time can be derived.

Results and Discussion

Table 4 summarizes the locations of parking events.

Table 4 Observations by Location

Neighborhood	Street	Between	Observation Count
Midtown	W 34th St	5th-6th Aves	21
Chinatown	East Broadway	Catharine-Market Sts	70
Fordham Heights	Grand Concourse	E 184-E 187th Sts	8
Fordham Heights	Grand Concourse	E 187-E 188th Sts	12
Fordham Heights	Grand Concourse	E 188th St-Fordham Rd	5
Upper West Side	W 77th St	Central Park West-Columbus Ave	67

Observed vehicles included about 51% single-unit trucks and 41% cargo vans; the remaining 8% (14 vehicles) were other vehicle types, including three refrigerated trucks and two semitrailers. The observed vehicles were parked for several different purposes. Related items were grouped together in categories for analysis. Nearly one-third (31.7%) of all observed vehicles were delivering parcels of some type. This includes vehicles owned by UPS, FedEx, and the United States Postal Service. Nearly one-quarter of vehicles (24.6%) were delivering some form of food or beverage, whether it be large quantities to a retail establishment or restaurant or groceries to an apartment. Approximately one-fifth of observations (19.1%) were service vehicles, including those owned by utility companies or emergency services. A similar amount made deliveries that did not fit into the aforementioned categories (20.2%), and eight vehicles (4.4%) made a delivery of unknown type.

Of the 183 observed vehicles, only 48, or slightly more than 26%, parked in a legal location. Half of vehicles had no possible legal parking location within one block. The types of illegal parking locations chosen by vehicles are listed in Table 5.

Table 5 Types of Illegal Parking

Illegal Type	Count	Percentage	Percentage of Illegal
Double Parking	108	59.0%	80.0%
Bus Stop	13	7.1%	9.6%
No Parking/Standing Zone/Fire Hydrant	13	7.1%	9.6%
Left Shoulder	1	0.5%	0.7%
Legal Spot	48	26.2%	

Eighty percent of vehicles that parked illegally and nearly 60% of all observed vehicles double-parked when making deliveries. This is not surprising, as limited curb space often forces vehicles to double-park when making deliveries in New York. It should be noted that outside of midtown, double parking in a travel lane is legal, but double parking obstructing a bicycle or bus lane is not. One of the illegally-parked vehicles parked in the left shoulder of the Grand Concourse service road, while all remaining illegal vehicles were parked in a bus stop or no parking/standing zone, the latter including vehicles that blocked fire hydrants. Overall enforcement was very low; while 135 of the 183 vehicles double parked or parked illegally in another location and 31 were passed by an enforcement officer, only 6 illegally parked vehicles received a citation.

Observed vehicles parked for highly variable durations, ranging from a minimum of two minutes to a maximum known duration in excess of two hours. Of the 183 collected observations, six observations had missing duration information and were thus omitted from the duration analysis. Figure 10 contains a histogram of the remaining 177 observations. These results are grouped into bins of 4 minutes wide starting at 1.0 minutes. As evidenced in the histogram, 66 observations, or approximately 37% of the total, had a parking duration shorter than 5 minutes. The most common observation, 2 minutes, is contained within this interval. 118 observations, exactly two-thirds of the total, were parked for approximately 12 minutes or less. Only 17 observations, or less than 10%, were for a duration of 45 minutes or longer.

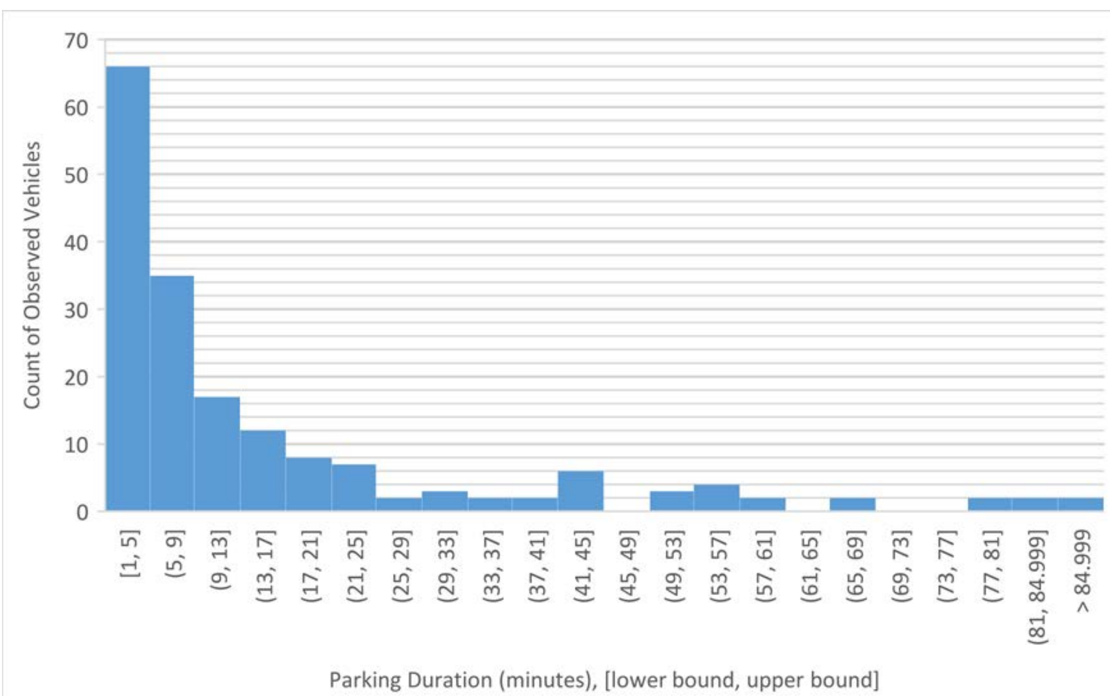

Figure 10 Parking Duration Histogram

In this dataset, several observations were more than two standard deviations above the sample mean. This includes the maximum value, which is five standard deviations greater than the sample mean. While several of these observations could be considered outliers, the decision was made to keep all observations with a valid parking duration. The estimates will be skewed toward longer durations due to the presence of extreme values, but it is important to note that vehicles parked for an extremely long duration, while relatively rare, have a significant impact on parking availability in a neighborhood. A truck parked in one location for 90 minutes, for example, occupies a space that could be used by 18 different trucks each making a delivery that takes less than 5 minutes during the same period of time. A conservative estimate leaves room for a delivery to last longer than predicted without causing the system to collapse.

Table 6 summarizes the characteristics of the 36 binary variables created to assess their impact on parking duration.

Table 6 Binary Variable Summary

Variable Name	Description	Min	Max	Mean	Med.	S.D.
Duration_Min	Parking duration in minutes	1	125	15.66	7	21.50
LogDurat	Natural log of parking duration = ln(Duration_Min)	$-8.34E^{-4}$	4.83	2.03	1.95	1.20
V_Single	Single unit truck	0	1	0.53	1	0.50
V_Van	Van	0	1	0.40	0	0.49
V_Other	Other vehicle type	0	1	0.08	0	0.27
D_Parcel	Parcel delivery	0	1	0.33	0	0.47
D_FoodDr	Food/drink/grocery delivery	0	1	0.24	0	0.43
D_Servic	Service delivery	0	1	0.18	0	0.39
D_Other	Known delivery that is not parcel, food/drink, or service	0	1	0.21	0	0.41
D_Unknow	Unknown delivery type	0	1	0.04	0	0.20
AL_Front	Legal parking available in front of building	0	1	0.27	0	0.44
AL_OnBlo	Legal parking available on block	0	1	0.22	0	0.42
Legal	Vehicle parked legally	0	1	0.25	0	0.43
P_Open	Closest parking on block is open/free	0	1	0.21	0	0.41
P_Metere	Closest legal parking is metered	0	1	0.25	0	0.44
P_ComMet	Closest legal parking is commercial metered	0	1	0.14	0	0.34
I_DP	Vehicle was double parked	0	1	0.6	1	0.49
I_B	Vehicle parked in bus stop	0	1	0.07	0	0.26
I_NP	Vehicle parked in other no parking/standing zone	0	1	0.07	0	0.26
I_LS	Vehicle parked in left shoulder/median	0	1	0.01	0	0.08
OfficerP	Parked vehicle passed by police officer	0	1	0.16	0	0.37
TicketIs	Parking citation issued to vehicle	0	1	0.03	0	0.18
Midtown	Observation located in Midtown Manhattan	0	1	0.12	0	0.32
ChinaT	Observation located in Chinatown	0	1	0.37	0	0.48
UWS	Observation located on the Upper West Side of Manhattan	0	1	0.37	0	0.48
Fordham	Observation located in Fordham Heights, the Bronx	0	1	0.14	0	0.35

When creating and testing the various models, several important observations were made regarding the collected data. Very early in the model creation process, it was observed that the presence of available legal parking on a block was insignificant to the duration a freight vehicle was stopped. Only one observation contained a vehicle parked on the left shoulder/median, making this type of illegal parking insignificant due to lack of data. Whether a vehicle was of a type other than van or single-unit truck had no significant effect on parking duration, again likely due to lack of data and wide variety of vehicles in this category. Deliveries of parcels and food or drink were determined to be insignificant with respect to each other, as they were the two possible base cases. Delivery location was found to be insignificant, possibly due to the relatively-small number of observations at each location. A police officer passing a parked vehicle does imply that a vehicle is parked for a longer duration, but a citation being issued is not a significant predictor of duration, as not all vehicles are parked illegally and enforcement is sporadic and inconsistent. Deliveries of a known type that were not parcels, food, or drink were found to have a significantly greater parking duration. The estimation results for the selected model is shown in Table 7.

Table 7 Model Specification

Variable/Parameter	Coefficient	t-statistic	Hazard Ratio	Hazard Ratio t-statistic
Constant	3.025	20.93	---	---
V_Van	-0.471	-2.83	1.61	2.28
D_Servic	0.729	3.34	0.48	4.71
D_Other	0.767	4.42	0.46	6.72
D_Unknow	-0.975	-2.91	2.67	1.79
I_DP	-1.003	-5.85	2.75	3.25
I_NP	-0.659	-1.59	1.94	1.16
OfficerP	0.647	2.53	0.52	3.43
Log Likelihood	-268.37			
Number of observations	177			
Weibull parameter P	1.00839			

Deliveries classified as “service” and “other” can be expected to have a parking duration significantly greater than those of other types under ideal conditions, as the hazard ratios are 0.48 and 0.46, respectively. Conversely, as the indicator variable corresponding to deliveries of an unknown type has a hazard ratio equal to 2.67, meaning that vehicles performing such deliveries can be expected to be parked for a shorter duration. Since deliveries of parcels, food, and beverages are considered to be the base cases, this implies that vehicles delivering parcels, food, or beverages are expected to be parked for a shorter duration than vehicles delivering any other type of known good. Vans have a negative coefficient and a hazard ratio of 1.61, indicating that a van is expected to be parked for a shorter duration than other vehicle types. An officer passing a parked vehicle has a hazard ratio equal to 0.52, indicating that a parked vehicle that was passed by a police officer is likely to have parked for a longer duration. Both types of illegal parking considered have negative coefficients and hazard ratios greater than one, indicating that vehicles parked illegally tend to park for a shorter duration. Yet, the hazard ratio for double parking is significantly higher than that for parking in a no parking or no standing zone, indicating that drivers who double-park are likely to remain in that location for a significantly shorter time period than those who park in other ways, whether it be legally or illegally. There is no significant difference between the parking durations of vehicles that park legally and those that park illegally in a bus stop.

Weibull parameter P is very close to 1, indicating that time has little effect on the hazard function value. The predicted survival function is a good fit to the actual values. Figure 11 plots the predicted survival function with the actual survival rate values. At durations of approximately 19 minutes or less, the survival rate is slightly overestimated, while it is underestimated above 19 minutes. The predicted survival rate at a given duration never deviates from the actual by more than approximately 0.1, with the actual deviation often being significantly less.

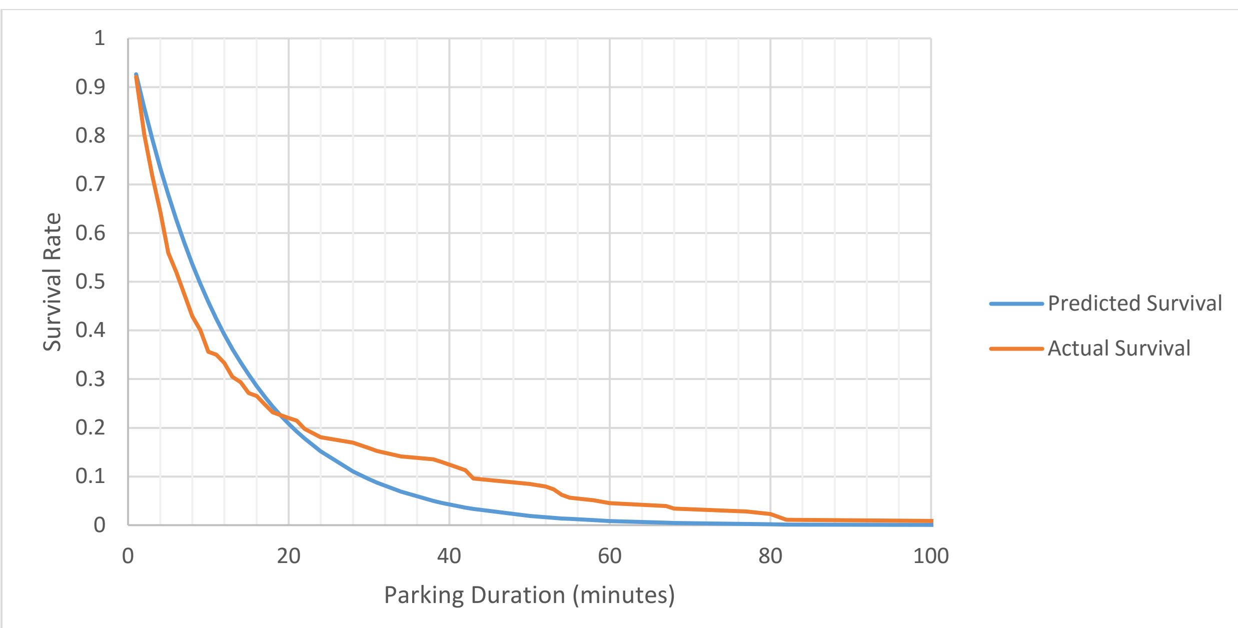

Figure 11 Survival Functions

Table 5 summarizes the predicted parking durations corresponding to each survival rate. These numbers can be interpreted as, for example, when all other conditions are held at the average values, 5% of vans would park for less than 0.496 minutes, 25% for less than 2.742 minutes, half would park for less than 6.558 minutes and 25% would park for more than 13.04 minutes. As can be seen above, vans can be expected to park for a shorter duration than other vehicle types, while “service” and “other” deliveries tend to take a longer duration. Illegally-parked vehicles are projected to park for approximately one-half the duration of legally-parked vehicles or less. This is consistent with the hazard ratios discussed in the preceding section.

Table 8 Parking Duration Estimates

		S(t)			
		0.95	**0.75**	**0.5**	**0.25**
Vehicle Type	**Van**	0.496	2.742	6.558	13.04
	Base (Other)	0.791	4.373	10.46	2080
Delivery Type	**Service**	1.052	5.816	13.91	27.66
	Other	1.092	6.037	14.44	28.71
	Unknown	0.194	1.073	2.566	5.10
	Base (Parcel/Food/Drink)	0.511	2.822	6.750	13.42
Parking Type	**Base (Legal)**	1.248	6.897	16.50	32.80
	Double Parked	0.462	2.551	6.102	12.13
	No Parking Zone	0.649	3.589	8.584	17.07

Implications for Planning

The model calibrated in the previous chapter allows us to estimate parking duration if a parking event possesses certain characteristics. Extrapolating this, we can make a rough estimate for the amount of space required if all observed vehicles were to park legally. Of the observed vehicles, 60% double parked, 7% parked in a no parking/standing zone, 25% parked legally, and the remaining 8% parked illegally in a manner that is not defined above, whether it be in a bus stop or a median. As 25% of the observed vehicles parked legally, one could make an assumption that four times the currently-available parking space would be required for all vehicles to be accommodated legally. However, this would be a flawed assumption, as vehicles that double park or park in a no parking/standing zone tend to park for a shorter duration than legally-parked vehicles potentially because the illegal parking spots are close to the delivery sites. It is necessary to recognize the differences of parking durations between illegal parking and legal parking.

The causality between parking duration and delivery time is not clear; vehicles parked illegally may hasten their delivery time to minimize risk of a citation, while drivers with only a short delivery to make may choose to park illegally knowing that in a small time period there will be a low risk of citation. If all vehicles are able to park legally, one could assume that all vehicles will remain parked for the longer, legal time. Assuming that all vehicles park for a typical "legal space" duration, an equation for the multiplier, designated as "SpaceFactor", can be formulated as:

$$SpaceFactor = 1 + \sum_{IllegalTypes} R_i \frac{\%Illegal_i}{\%Legal}$$

(Eq. 7)

where R_i is the ratio of legal parking duration to parking duration of illegal type *i*. $\frac{\%IllegalType_i}{\%Legal}$ relates the percentage of observations of an illegal parking type to the percentage of legal parking observations, scaling the ratio based on the amount of vehicles parking in each fashion. R_i can be calculated by dividing the estimated durations for legal parking listed in Table 5 by the durations of an illegal parking type. As illegal types other than double parking and parking in a no parking/standing zone are not significantly different from the base case, these have an R_i equal to 1. Table 6 lists the ratios for all illegal parking types observed.

Table 9 Ratios Ri of Legal Parking Duration to Illegal Parking Duration

Illegal Type	**Value**
Double Parked	2.703
No Parking/Standing	1.922
Other Illegal	1.000

Plugging these values into the "SpaceFactor" equation, one can determine that the SpaceFactor equals 8.306, meaning that over eight times the amount of currently available parking space must be made available if all vehicles are expected to park for a "legal" parking duration. This estimation provides an upper bound for the parking space demand. Overall, the amount of space needed would fall somewhere between the four times currently available space required if no double parked vehicles park for a longer duration when given a "legal" option and eight times currently available space required if all commercial vehicles park for as long as the currently legally parked vehicles. In a dense environment such as New York City, even the lower four times increase in parking capacity to accommodate demand is likely infeasible. However, the large factor indicates that commercial parking space should be increased significantly to reduce the number of vehicles parking illegally.

Conclusions and Future Research

Major Findings from Case Study Analyses

Results from this analysis of parking supply and parking violation behavior suggest that there are currently discrepancies in New York City between the parking demanded by commercial vehicles and the space available for commercial vehicle parking. While parking violations are not a perfect predictor of parking demand as they are only issued when vehicles are parked illegally and when enforcement officers are active, violations are an indicator of unmet demand. By examining violation patterns and comparing them to available supply, general conclusions can be inferred about the locations of unmet demand. By evaluating observed parking durations vs. vehicle and operator factors, some conclusions can be drawn:

Supply vs. Demand

The high violation rates observed in all three census tract types and the field observations evaluated in the duration analysis suggest that in Manhattan, overall available parking space is inadequate. Trends in parking supply availability also contradict expected delivery times for the types of activities occurring in these areas. As detailed in Case Study 1, *dedicated commercial parking* availability is highest in the morning in residential census tracts, and lowest during the same period in mixed-use and commercial areas. For more traditional retail and restaurant deliveries that are commonly made to commercial districts and on commercial streets in mixed-use areas, the morning is a typical delivery time. Parcel deliveries, which are conducted to both commercial and residential land uses and constitute the majority of movements to residential buildings, are more distributed throughout the day, often occurring in the late morning or early to mid-afternoon.

Parking Locations for Residential Deliveries

In residential areas, commercial vehicles tend to park on wide ***avenues***. Parking turnover rates are higher on these ***avenues*** than on nearby ***streets*** due to time limits or metering; however, here, parcel trucks must compete with other commercial users for limited parking. On ***avenues***, commercial vehicles can often double park in a travel lane without entirely obstructing flow on a street, as often happens on single lane one-directional ***streets***; however, here they interrupt flow on relatively high volume corridors, potentially resulting in broad network delays and related emissions impacts.

Parking Duration vs. Service Type

While it was predicted that expected parking duration for known delivery types would be shortest for parcel deliveries, no significant difference was found between durations of parcel deliveries and food or beverage deliveries. This may be due to variability in the curbside models employed by parcel carriers. While many parcel deliveries involve a single driver operating a single vehicle parking for a very short duration to make a single delivery, observed vehicles also included parcel vehicles that parked for long durations while a driver made multiple deliveries using the vehicle as a base of operations. Service vehicles were found to park for significantly longer durations.

Parking Durations vs. Parking Location

As predicted, a double parked vehicle has significantly shorter duration that those parked in other locations. However, the type of legal parking chosen, the presence of legal parking spaces on a block, overall whether or not a vehicle parked legally, and the neighborhood where the vehicle was observed were found to have no significant connection with parking duration. This lack of significance may be due to lack of data, as certain neighborhoods had very few observations and only a relatively small number of observations used each type of legal parking.

Parking Duration vs. Enforcement

As expected, the likelihood that a police officer passed a parked vehicle is positively associated with the parking duration; the longer a vehicle is parked, the more likely it is to be passed by an enforcement officer. However, a vehicle being issued a citation was found to have no significant association with parking duration. This result is difficult to interpret given the very small number of citations issued.

General Conclusions and Implications for Curb Management

It is clear that solutions are needed to address existing discrepancies between supply and demand for commercial vehicle parking. Planning strategies that could be employed to address differences include:

- *Updating zoning requirements for commercial parking and loading:* Current zoning regulations do not mandate commercial loading zones for residential land uses, and requirements for mixed and commercial land uses are outdated. Additional off-street loading space or on-street loading zones could alleviate traffic impacts from illegal parking behavior.

- *Updating parking regulations on residential streets, especially where there is high-density residential development:* Currently there is very little parking turnover and very little commercial dedicated space on residential streets, leading to frequent double parking on nearby avenues. Provision of dedicated space at the site of residential buildings could prevent vehicles from obstructing nearby high volume avenues, while pricing or time-restrictive parking policies could promote increased parking turnover.
- *Evaluating the effectiveness of time-variable and dedicated commercial parking regulations*: Current time-specific parking policies (e.g. curbsides dedicated as moving lanes during morning hours, "Commercial Vehicle Parking Only, 7 AM – 10 AM") do not necessarily reflect actual demands. These types of parking regulations should be examined to determine their effectiveness to meet rapidly changing demands, particularly those generated by ecommerce and just-in-time operations. Commercial vehicle drivers also behave differently depending on the type of activity that they serve. While additional data is needed to better asses the impacts on parking duration for different types of operators, results do confirm that service vehicles generally park for longer durations that other commercial vehicle types. It may be necessary to explicitly dedicate space for specific types of commercial uses (e.g. parcel delivery vs. service vehicles).
- *Considering freight costs in street redesign*: Drivers face higher violation costs in areas where they obstruct travel lanes and in areas where they park in other illegal locations at the curbside. If curbside space becomes dedicated for other uses, and parking space becomes more constrained, moving lane violations, including "Double Parking", are likely to become increasingly common. These not only pose a higher cost to the operator, but also to other travelers in the network in the form of congestion. These costs should be explicitly considered when evaluating street design and curb regulation alternatives.

Future Research

Given the results of this analysis, there are several ways in which future research could proceed. This project did not directly evaluate parking demand. While Case Study 1 approximated freight trip demand distributions from parking violation data, this data is biased by enforcement rates that may not be constant by day or hour. Additionally, the small size of the dataset used for Case Study 2 likely impacted the final model specification. While it is possible that trucks of several different types have significantly different parking durations or that durations differ from neighborhood to neighborhood, the limited number of observations may have been the cause of the variables corresponding to these characteristics being deemed insignificant. Additionally, in order to create categories that were large enough to model, categories of trucks and delivery types were merged. “Other truck types” includes a wide range of vehicles, while the “food and drink” deliveries contain deliveries to retailers and residences.

Freight trip generation models should be employed to more accurately estimate demand at the block level. The field observation dataset should be expanded significantly by collecting several hundred additional observations in these neighborhoods and others. The duration analysis could then be repeated on the expanded dataset in order to determine if other factors affect parking duration. A larger dataset would allow very specific categories to be defined, increasing the accuracy of the estimation.

Ultimately, this duration model could be applied to a freight optimization scenario. With knowledge of vehicle and delivery types as well as likely parking conditions, it is possible for one to predict the amount of time a vehicle will be parked at a location. In the case of a building that needs to accept multiple deliveries, delivery durations could be estimated, while in the case of a logistics or shipping firm delivering goods, the number of deliveries made during a driver’s shift could be optimized if the expected duration of each delivery on the route is known. This information would also be useful for estimating local traffic impacts from commercial delivery behavior; better estimation of parking (and particularly double parking) durations under specific regulations on specific street types would enable direct evaluation of curb management alternatives.

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Appendix A: NYC Parking and Moving Violations

Source: NYC DOF (2015). Violation Codes, Fines, Rules & Regulations. NYC Department of Finance. Accessed from: *http://www1.nyc.gov/site/finance/vehicles/services-violation-codes.page*. <15 November 2015>.

Violation Code	Violation	Cost
1	Failure of an intercity bus to prominently display a copy of an intercity bus permit.	$515
2	Failure of an intercity bus to properly display the operator's name, address and telephone number.	$515
3	Intercity bus unauthorized passenger pickup or discharge	$515
4	Vehicles parked illegally south of Houston Street in Manhattan in metered spaces reserved for buses from 7am - 7pm daily. Vehicles with bus plate types parked longer than the 3 hour maximum and/or not displaying a DOT-issued bus permit.	$115
5	Failure to make a right turn from a bus lane.	$115
6	Parking a tractor-trailer on a residential street between 9PM and 5AM.	$265
7	Vehicles photographed going through a red light at an intersection	$50
8	Vehicle idling in a restricted area.	$115
9	Blocking an Intersection: Obstructing traffic at an intersection also known as "Blocking the Box".	$115
10	Stopping, standing or parking where a sign, street marking, or traffic control device does not allow stopping.	$115
11	Hotel Loading/Unloading: Standing or parking where standing is not allowed by sign, street marking or; traffic control device.	$115
12	Snow Emergency: Standing or parking where standing is not allowed by sign, street marking or; traffic control device.	$95
13	Taxi Stand: Standing or parking where standing is not allowed by sign, street marking or; traffic control device.	$115
14	General No Standing: Standing or parking where standing is not allowed by sign, street marking or; traffic control device.	$115
16	Truck Loading/Unloading: Standing or parking where standing is not allowed by sign, street marking or; traffic control device.	$95
17	Authorized Vehicles Only: Standing or parking where standing is not allowed by sign, street marking or; traffic control device.	$95
18	Bus Lane: Standing or parking where standing is not allowed by sign, street marking or; traffic control device.	$115
19	Bus Stop: Standing or parking where standing is not allowed by sign, street marking or; traffic control device.	$115
20	General No Parking: No parking where parking is not allowed by sign, street marking or traffic control device.	$65
21	Street Cleaning: No parking where parking is not allowed by sign, street marking or traffic control device.	$65
22	Hotel Loading/Unloading: No parking where parking is not allowed by sign, street marking or traffic control device.	$60
23	Taxi Stand: No parking where parking is not allowed by sign, street marking or traffic control device.	$65
24	Authorized Vehicles Only: No parking where parking is not allowed by sign, street marking or traffic control device.	$65

25	Standing at a commuter van stop, other than temporarily for the purpose of quickly picking up or dropping off passengers.	$115
26	Standing at a for-hire vehicle stop, other than temporarily for the purpose of quickly picking up or dropping off passengers.	$115
27	No parking in a zone reserved for people with disabilities (off-street only) where parking is not allowed by sign, street marking or traffic control device (Note: Includes a $30 New York State Criminal Justice surcharge.)	$180
28	Overtime standing (diplomat)	$95
29	Altering an intercity bus permit	$515
30	Stopping or standing by an intercity bus in its assigned on-street bus stop location other than when actively engaged in the pick-up or discharge of its passengers	$515
31	Standing of a non-commercial vehicle in a commercial metered zone.	$115
32	Parking at a broken or missing meter for longer than the maximum time permitted.	$65
33	"Feeding Meter" -- parking in a metered space for a consecutive period of time longer than allowed, whether or not an additional coin or coins are deposited or another method of payment is used.	$65
34	Expired Meter -- parking in a metered space where the meter works and the time has ended. Drivers get a 5-minute grace period past the expired time on Alternate Side Parking signs and any other parking spaces with specific times listed (i.e.. 8:30am - 9:30am). During the 5-minute grace period, parking tickets cannot be issued.	$65
35	Parking in a meter space for the purpose of displaying, selling, storing, or offering goods for sale.	$65
36	Exceeding the posted speed limit in or near a designated school zone.	$50
37	Muni Meter -Parking in excess of the allowed time	$65
38	Muni Meter -- Failing to show a receipt or tag in the windshield.	$65
39	Parking for longer than the maximum time permitted by sign, street marking or traffic control device.	$65
40	Stopping, standing or parking closer than 15 feet of a fire hydrant. Between sunrise and sunset, a passenger vehicle may stand alongside a fire hydrant as long as a driver remains behind the wheel and is ready to move the vehicle if required to do so.	$115
42	Parking in a Muni Metered space in a commercial metered zone in which that Muni Meter is working and indicates the time has ended.	$65
43	Parking in a commercial metered zone in which the meter is working and indicates that the time has ended. (Note: the difference is that 42 is Muni Meter and 43 is Meter)	$65
44	Parking in a commercial metered zone for longer than the maximum time allowed.	$65
45	Stopping, standing or parking in a traffic lane; or if a vehicle extends more than 8 feet from the nearest curb, blocking traffic.	$115
46	Standing or parking on the roadway side of a vehicle stopped, standing or parked at the curb; in other words also known as "double parking". However, a person may stand a Commercial Vehicle alongside a vehicle parked at the curb at such locations and during such hours that stopping, standing and parking is allowed when quickly making pickups, deliveries or service calls. This is allowed if there is no parking space or marked loading zone on either side of the street within 100 feet. "Double parking" any type of vehicle is not allowed in Midtown Manhattan (the area from 14th Street to 60th Street, between First Avenue and Eighth Avenue inclusive). Midtown double parking is not allowed between 7:00am – 7:00pm daily except Sundays. (Read Code 47)	$115
47	Stopping, standing or parking a vehicle in Midtown Manhattan (the area from 14th Street to 60th Street, between First Avenue and Eighth Avenue) other than parallel or close to the curb.	$115
48	Stopping, standing or parking within a marked bicycle lane.	$115

49	Stopping, standing or parking alongside or opposite any street construction or obstruction and thereby blocking traffic.	$95
50	Stopping, standing or parking in a crosswalk. Note: Crosswalks are not always identified by painted street markings.	$115
51	Stopping, standing or parking on a sidewalk.	$115
52	Stopping, standing or parking within an intersection.	$115
53	Standing or parking in a safety zone, between a safety zone and the nearest curb, or within 30 feet of points on the curb immediately opposite the ends of a safety zone.	$115
55	Stopping, standing or parking within a highway tunnel or on a raised or controlled access roadway.	$115
56	Stopping, standing or parking alongside a barrier or divided highway unless permitted by sign.	$115
57	Parking a vehicle within the area designated as The Blue Zone, Monday through Friday 7:00am -7:00pm. The Blue Zone is bounded by the northern property line of Frankfort Street, the northern property line of Dover Street, the eastern property line of South Street, the western property line of State Street, the center line of Broadway and the center line of Park Row.	$65
58	Parking a vehicle on a marginal street or waterfront i.e. any street, road, place, area or way that connects or runs along waterfront property. Parking on a marginal street or waterfront is permitted if authorized by posted sign.	$65
59	Standing or parking at an angle to the curb, except where allowed by rule or sign. Where angle parking is not authorized by a sign, a Commercial Vehicle may stand or park at an angle only for loading or unloading and if it leaves enough space for traffic flow.	$115
60	Standing or parking at an angle to the curb, except where authorized by rule or sign.	$65
61	Except where angle parking is allowed, stopping, standing or parking other than parallel to curb or edge of roadway. Or, parking opposite the direction of traffic.	$65
62	Standing or parking a vehicle beyond markings on the curb or the pavement of a street which marks a parking space, except when a vehicle is too large to fit in that "marked" parking space. Where a vehicle is too large, it shall be parked with its front bumper at the front of the space and the rear bumper extending as little as possible into the next space.	$65
63	Standing or parking a vehicle in any park between one-half hour after sunset and one-half hour before sunrise, except at places allowed for the parking of vehicles.	$95
64	No standing except consul / diplomat plates with Dept. of State decals only.	$95
65	Overtime standing consul / diplomat vehicles 30-minute limit D decals only.	$95
66	Parking a trailer or semi-trailer which is not attached to a motor vehicle used for towing it, unless loading or unloading at an off-street platform.	$65
67	Parking in front of a pedestrian ramp	$165
68	Not parking as marked on a posted sign	$65
69	Failing to show a muni-meter receipt, commercial meter zone.	$65
70	Standing or parking a vehicle without showing a current registration sticker.	$65
71	Standing or parking a vehicle without showing a current inspection sticker.	$65
72	Standing or parking a vehicle with NY Plates and showing a damaged or fake inspection certificate.	$65
73	Standing or parking a vehicle showing an expired, damaged, void, fake, or incorrect registration sticker.	$65
74	Standing or parking a vehicle without properly showing its current plates on the outside of the vehicle attached tightly not more than 48, or less than 12, inches from the ground, clean, not covered by glass or plastic, with nothing preventing it from being read clearly.	$65
75	Standing or parking a vehicle in which the License Plate number and/or the actual description of the vehicle does not match the information on the registration sticker.	$65

77	Parking a bus, unless allowed by signs. A charter bus may park where parking is permitted at its point of origin or destination. A school bus may park in front of and within the building lines of a school.	$65
78	Parking a Commercial Vehicle on a residential street between 9PM and 5AM unless doing business within 3 blocks. Parking is allowed during this time if the vehicle is owned or operated by a gas or oil supplier or maintenance company or by any public utility.	$65
79	For a bus without passengers, waiting at a curb or other street location i.e., a layover; with passengers, waiting at a curb or other street location for more than five minutes, except in locations allowed by sign or by the Commissioner in writing.	$115
80	Standing or parking a vehicle without head lamps, rear lamps, reflectors or other required equipment.	$60
81	No standing except diplomat	$95
82	Standing or parking a Commercial Vehicle unless all seats, except the front seats, and rear seat equipment removed. The name and address of the owner must be on the registration certificate plainly marked on both sides of the vehicle in letters and numerals not less than 3 inches in height. (Vehicles with Commercial Plates are considered to be Commercial Vehicles and must be altered accordingly.	$115
83	Standing or parking a vehicle which is not properly registered.	$65
84	Parking a Commercial Vehicle on any city street with its platform lift in the lowered position while no one is with the vehicle.	$65
85	Parking a Commercial Vehicle more than 3 hours, where parking is allowed.	$65
86	Standing or parking a vehicle to make pickups, deliveries or service calls for more than 3 hours, unless allowed by posted signs, between 7AM and 7PM, except Sundays, in Manhattan from 14th to 60th Streets and First to Eighth Avenues.	$115
89	Standing or parking a Commercial Vehicle unless all seats, except the front seats, and rear seat equipment removed. The name and address of the owner must be on the registration certificate plainly marked on both sides of the vehicle in letters and numerals not less than 3 inches in height. (Vehicles with Commercial Plates are considered to be Commercial Vehicles and must be altered accordingly.	$115
91	Standing or parking a vehicle which is not properly registered.	$65
92	Parking a Commercial Vehicle on any city street with its platform lift in the lowered position while no one is with the vehicle.	$65
93	Stopping, standing or parking on paved roadway to change a flat tire, unless permitted by posted sign.	$65
94	Vehicle Release penalty associated with NYPD's Violation Tow Program.	$100
96	Standing or parking within 50 feet of the nearest rail of a railroad crossing.	$95
97	Parking in a vacant lot. A vehicle may be parked on a vacant lot having a municipally authorized driveway upon written permission of the owner.	$65
98	Standing or parking in front of a public or private driveway. The owner or renter of a lot accessed by a private driveway may park a passenger vehicle registered to him / her at that address in front of the driveway provided the lot does not contain more than 2 dwelling units and that parking does not violate any other rule or restriction.	$95
99	All other parking, standing or stopping violations.	vary

Appendix B: Detailed Parking Violations by Code and Census Tract

		Commercial Census Tracts					Mixed-Use Census Tracts					Residential Census Tracts				
		96	**109**	**112.02**	**113**	**114.01**	**61**	**68**	**72**	**91**	**137**	**138**	**139**	**140**	**146.01**	**148.02**
Total # Tickets		1822	1698	926	1554	1306	1698	926	1554	1306	1399	768	871	1256	386	903
Total Cost		$176,340	$139,450	$92,150	$128,435	$129,400	$139,450	$92,150	$128,435	$129,400	$121,675	$66,050	$83,755	$100,390	$37,910	$71,845
Av. Ticket Cost		$96.78	$82.13	$99.51	$82.65	$99.08	$82.13	$99.51	$82.65	$99.08	$86.97	$86.00	$96.16	$79.93	$98.21	$79.56
Violation Code	**Cost**	**Moving Lane Violations**														
18	$115	1	14	6	0	0	0	0	0	1	4	24	0	8	5	4
45	$115	1	4	0	5	2	0	10	8	4	10	7	3	29	6	7
46	$115	6	29	10	26	15	30	26	9	19	43	58	184	204	44	119
47	$115	98	132	178	157	172	2	248	179	116	195	3	85	2	0	0
48	$115	6	4	0	9	0	14	2	1	1	7	2	11	0	1	11
Violation Code	**Cost**	**Meter Violations**														
33	$65	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
34	$65	2	1	0	3	0	0	0	0	0	1	0	1	0	0	0
37	$65	33	8	4	28	1	23	48	42	21	30	208	15	306	15	158
38	$65	67	33	2	50	0	45	109	101	54	37	116	102	455	59	362
39	$65	0	7	0	8	0	0	0	0	0	0	0	0	0	2	0
42	$65	139	284	73	263	61	48	44	76	85	123	0	16	1	0	0
43	$65	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0
69	$65	332	690	163	566	149	154	181	281	279	426	0	116	0	0	0

		Commercial Census Tracts					Mixed-Use Census Tracts					Residential Census Tracts				
		96	109	112.02	113	114.01	61	68	72	91	137	138	139	140	146.01	148.02
Violation Code	Cost	Curbside or Off-Street Location Violations														
9	$115	0	1	0	2	0	0	2	0	0	0	0	0	0	0	0
10	$115	0	0	0	5	0	0	1	0	4	9	6	8	0	6	0
11	$115	13	0	1	3	0	0	1	0	0	3	0	0	0	0	0
13	$115	0	9	6	21	1	0	0	0	5	10	0	15	0	0	5
14	$115	963	257	334	212	424	83	67	28	119	232	118	169	28	147	16
16	$95	9	0	1	0	399	57	0	0	1	1	57	1	41	22	62
17	$95	9	26	1	32	3	1	4	0	0	16	3	12	9	7	3
19	$115	10	24	82	49	6	5	33	11	19	43	18	12	19	3	23
20	$65	1	3	1	8	5	107	8	9	3	39	4	28	4	8	17
21	$65	0	1	0	0	0	7	9	15	4	0	71	6	51	15	42
23	$65	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0
24	$65	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0
27	$180	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0
40	$115	8	24	9	14	12	11	3	12	5	27	33	19	50	20	39
50	$115	0	0	0	1	0	0	0	0	1	1	0	0	0	0	0
51	$115	0	32	0	0	3	0	0	0	0	2	2	6	0	0	0
53	$115	0	0	0	0	0	4	0	1	3	1	6	2	0	0	0
64	$95	44	5	0	10	0	0	0	0	0	0	0	0	0	0	0
78	$65	1	1	0	0	1	13	2	0	19	5	3	2	0	2	2
89	$115	0	2	0	1	0	0	0	0	0	0	0	0	0	0	0
97	$65	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
98	$95	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0

		Commercial Census Tracts					Mixed-Use Census Tracts					Residential Census Tracts				
		96	109	112.02	113	114.01	61	68	72	91	137	138	139	140	146.01	148.02
Violation Code	Cost	Operating Violations														
8	$115	6	2	7	5	2	0	1	3	2	10	0	12	0	0	0
35	$65	11	0	0	2	0	0	1	1	0	53	0	0	0	1	0
59	$115	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
60	$65	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
61	$65	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0
62	$65	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
70	$65	15	6	2	13	5	7	1	8	3	8	1	1	10	0	5
71	$65	12	36	29	19	10	7	8	10	4	17	2	2	9	2	15
72	$65	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0
73	$65	0	0	0	0	0	0	0	0	0	2	1	0	0	1	0
74	$65	1	3	0	1	4	1	2	1	0	2	0	2	2	0	1
82	$115	9	29	5	11	12	0	0	3	7	7	9	9	4	7	0
83	$65	2	1	1	0	0	1	3	0	2	1	0	1	1	0	1
84	$65	23	30	11	29	19	26	33	27	17	33	15	31	21	11	11

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Funded by the U.S. Department of Transportation

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