Is parking in front of a fire hydrant worth it?

with Chris Andrade, Icaro Bacelar, Hane Lee, Angela Tan, Mariana Vazquez, and Owen Ward

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Central Question: What is the expected cost of parking in front of a fire hydrant?

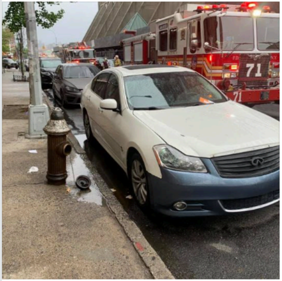
- Parking in Manhattan is notoriously difficult.
  - Some drivers spend more than an hour searching for a spot.
- Drivers are often tempted by the empty space near a fire hydrant.
  - Parking within fifteen feet of a hydrant is prohibited by law.
- But is breaking the law worth the possibility of a ticket?
  - What if you only stay for five minutes?
  - What about an hour or more?

It is illegal to stop, stand, or park within 15 feet of a fire hydrant

- New York City fines vehciles $115 if caught violating the law.
  - Fire departments need the space to fight fires quickly and effectively.
  - Hydrants are also used by street cleaning vehicles, construction crews, and contractors.
- Yet despite a possible fine, traffic enforcement agents ticket hundreds of Manhattan drivers every day for breaking the law.
  - Many violations occur less than a block from legal, metered parking.
  - This suggesting drivers believe they are unlikely to be caught and that the expected cost of blocking the hydrant is low. But is it true?

New York City Fire Department (FDNY)
May 5, 2021 ·

A vehicle blocked the fire hydrant at this morning's 3-alarm fire in the Bronx. A total of 12 civilians and one Firefighter were injured. FDNY urges New Yorkers to NEVER park on a fire hydrant. Blocking or obstructing a hydrant results in a delay in providing water to extinguish a fire. It is illegal to park within 15 feet of either side of a fire hydrant.



FDNY
@FDNY

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We model ticket-writing as an exponential race

- When a driver parks in front of a hydrant, they compete in a race.
  - The race is between the driver and a traffic enforcement agent.
  - The driver wins the race if they return to the car before the agent can ticket it.

- The exponential race is described by a simple coin-tossing game:
  1. Once the driver parks in front of a hydrant, they toss a coin repeatedly, say every second.
  2. If the coin lands on heads, they return to their car.
  3. At the same time, the traffic enforcement agent tosses a different coin every second. If the agent's coin lands on heads, the agent will check the hydrant.

- The winner of the race is the first person to toss heads.

The waiting times of an exponential game follow an exponential distribution

- In this hypothetical game, the coins are weighted.
  - It is unlikely that either the driver or the traffic enforcement agent will toss heads.
  - This reflects the fact that a vehicle may block a hydrant for minutes or hours before the owner returns or a ticket is written.
- Instead of studying the weight of the coins, it is convenient to study the waiting times—the length of time it takes for the driver or agent to toss heads.
  - The waiting times of an exponential race are well approximated by an exponential distribution.
- Determining the cost of hydrant parking is tantamount to determining the average waiting time until a driver returns and the average waiting time until traffic enforcement checks the hydrant.

To estimate the average waiting times, we conducted a field experiment

- During the afternoon of July 11th, 2022, we took six routes through Manhattan and recorded the license plate of each violation we saw.
  - Collectively, we found 138 violations between 1pm and 5pm.
- We then looked up whether those vehicles received tickets for parking in front of a fire hydrant on July 11th.
  - Out of the 423 tickets given in Manhattan on July 11, 7 were for the vehicles we identified. We also noted the time of the ticket.
- From this data, we estimate the average waiting times—as well as other interesting facts about ticketing in Manhattan.

We first estimate the probability that a violation will receive a ticket

- Of the 138 violations we found in our field experiment, only 7 were ticketed.
  - We conclude the probability an illegally parked vehcile will be ticketed is $7/138 \approx 0.05$ or $1/20$.
- Assuming all violations have a one in twenty chance of being ticketed, the total number of violations can be estimated as $423/0.05 = 8{,}339$, where 423 was the number of tickets issued.
  - i.e. We estimate 8,339 violations in total since that would explain the $8{,}339 \times .05 \approx 423$ tickets we observed.

We then estimate the average waiting time until traffic enforcement visits a spot

- Recall that we identified seven vehicles that were ticketed.
  - On average, 6 hours passed between the time we found the vehicle and the time traffic enforcement wrote a ticket.
  - We conclude that traffic enforcement agents check hydrants on average every 6 hours.

- This conclusion follows from the memoryless property of the exponential distribution.
  - We can ignore the fact that the vehicle was blocking the hydrant before we found it and assume the traffic enforcement agent began tossing their coin the moment we found the vehicle.

Finally, we estimate the average time a vehcile blocks a hydrant

- So far we have found:
  1. the probability an illegally parked vehcile will receive a ticket is .05.
  2. the average waiting time until traffic enforcement visits a spot is 6 hours.

- These estimates plus another property of the exponential distribution allow us to estimate the average time the hydrant is blocked.
  - If A denotes the average waiting time before the driver returns and B denotes the average waiting time before the agent checks the hydrant, then the probability the vehicle is ticketed is A / (A + B).
  - Since we know this probability is .05, and we estimate B to be 6 hours, it follows that A is approximately 18 minutes.

The expected cost of blocking a hydrant for 18 minutes is 6 dollars

- Since a hydrant is blocked for an average of 18 minutes, and the probability of a ticket is .05:
  - The expected cost of parking in front of a fire hydrant for 18 minutes is the cost of a ticket times the probability of getting a ticket: \$115 $\times$ .05 $\approx$ \$6.
- We can work out the expected cost for other time intervals as well.
  - Recall our assumption that the time between traffic enforcement visits follows an exponential distribution with mean 6 hours.
  - From this distribution, we can determine the probability a vehicle will be ticketed if parked in front of a hydrant for any given interval.
  - Multiplying this probability by \$115 yields the expected cost.

The expected cost of parking in front of a hydrant

Total Time Spent Blocking Hydrant	Expected Cost Paid by Vehicle Owner
5 minutes	$1.67
18 minutes	$5.83
1 hour	$18.50
24 hour	$113.30

- A short stop has an expected cost of less than $2.
- A day-long park is essentially guaranteed to cost $115.

Another cost is the revenue the city forgoes by not enforcing the law

- This cost is borne by taxpayers who must cover the shortfall or the recipients of other government services that must be reduced.
- If July 11th, 2022 is a typical day, New York City typically misses 19 out of 20 violations.
  - If each one of those violations would have resulted in a $115 ticket, the city failed to collect $910,340 in revenue. That's nearly $1 million a day.
- We can use the exponential distribution to work out the expected amount of additional revenue the city would collect if it checked hydrants more frequently.

Additional revenue expected from changing traffic enforcement checks

Average Time Between Visits	Additional Revenue Generated Daily
30 minutes	$400,000
1 hour	$250,000
6 hours	$0
24 hours	-$50,000

- Decreasing average waiting times to one hour would increase revenue by a quarter million dollars,
- Increasing it to twenty-four hours would reduce revenue by fifty thousand dollars.

Conclusion: Whether it pays to park in front of a hydrant depends on your perspective

- From the driver's perspective, the expected cost is low.
  - This may explain why the practice appears to be so common—the expected cost is comparable to metered parking, and the spots are often more convenient.
- From the city's perspective, the expected benefit of stricter enforcement may not be high.
  - While increasing enforcement could generate a quarter of a million dollars in revenue a day or more, it would require hiring and training more traffic enforcement agents.
  - The cost of those agents might well exceed the revenue raised.
- From the community's perspective, however, the cost of blocking a hydrant—and the benefit of stricter enforcement—is much higher.
  - Our work suggests the relatively low expected cost of a ticket does not sufficiently reflect these consequences.

References

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Appendix: Fire hydrants and traffic enforcement

- It is illegal to park within 15 feet of a hydrant in New York City—although only one ticket can be issued to a single vehicle in a day for the same violation.
- Traffic police have been around since 1722 when they were first used to control traffic on the London Bridge.
  - The first NYPD traffic unit appeared in 1860.
  - Members of the "Broadway Squad" had to be over 6 feet tall and were specifically charged with helping pedestrians cross busy streets.
- There are now roughly 4,000 uniformed traffic police in New York City, compared to 36,000 regular uniformed police.
  - Traffic enforcement agents direct traffic and enforce parking rules and regulations.
  - Parking tickets and related offenses account for over $500 million dollars of the city's annual revenue.

Appendix: Approximating the geometric distribution with the exponential

- Consider the following coin tossing game:
  1. Divide the day into n periods (say 86,000 seconds).
  2. Suppose every second, the owner of an illegally parked vehicle tosses a coin with probability $p = a/n$. If it lands heads, the owner returns
  3. Let Y be the number of periods the owner spends away from the vehicle. The probability the owner spends more than nx periods away is $\Pr(Y > nx) \approx (1-p)^{nx} = (1-a/n)^{nx} \underset{n\to\infty}{\longrightarrow} \exp(-ax)$.
     - n.b. $\exp(-ax)$ is the survival function of the exponential distribution
     - Technically $(1-a/n)^{nx+1} < \Pr(Y > nx) < (1-a/n)^{nx-1}$ and both bounds converge to $\exp(-ax)$.
- If the traffic enforcement agent similarly tosses a coin with probability b/n to decide whether to check for parking in front of a given hydrant, the time until the officer checks a space also follows an exponential distribution with rate b.

Appendix: Two important properties of the exponential distribution

- The exponential and geometric distributions are memoryless:
  - When we observe a violation, the amount of time it takes until a traffic enforcement agent checks the hydrant does not depend on how long the car has already been parked.
  - This means we do not need to know how long a car has parked to estimate the average time between checks. We only need the time from when we observe the vehicle until a ticket is issued.

- A simple formula for the probability of winning an exponential race:
  - Let X denote the length of time until a ticket enforcement agent arrives and Y the length of time a car is parked illegally.
  - Assume X follows an exponential distribution with mean $A = 1/a$, and Y, independently of X, follows an exponential distribution with mean $B = 1/b$.
  - Then the probability of a ticket, p, can be written as $p = \mathsf{Pr}(X < Y) = A/(A + B)$.
  - In our study, we estimated B and p with a field experiment, which allowed us to estimate A.