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Does it pay to park in front of a fire hydrant?

You're a New York motorist, running horribly late, and there's an empty space beckoning right outside your destination. Problem is, it's in front of a fire hydrant. Should you risk getting a ticket? Take some advice from **Chris Andrade**, **Jonathan Auerbach**, **Icaro Bacelar**, **Hane Lee**, **Angela Tan**, **Mariana Vazquez**, and **Owen Ward**

Parking in Manhattan is notoriously difficult. It is not uncommon for a driver to spend more than an hour circling the block in search of a spot.

It is no wonder that weary drivers are tempted by the empty space in front of fire hydrants – 30 feet of prime real estate where parking is prohibited by law. But is breaking the law worth the possibility of a ticket? What if you only stay for 5 minutes? What about an hour or more? In this article, we consider the economics of fire-hydrant parking using data from Manhattan.

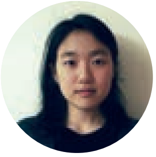
That is not to say we condone illegal parking. Fire hydrants are crucial for a city to function. Fire departments, of course, rely on them to fight fires. Hydrants are also used by street cleaning vehicles, construction crews, and contractors.

For these reasons, it is illegal to stop, stand, or park within 15 feet of a fire hydrant. New York City will slap you with a $115 fine if you are caught breaking the law.

Yet despite this 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, suggesting these drivers believe they are unlikely to be caught. That belief is understandable. Traffic enforcement agents may only visit a street once every few hours, if at all. But is it true?

Some facts about fire hydrants and traffic tickets

- **The first fire hydrant was invented in 1801 by Frederick Graff of Philadelphia.**
- **Fire hydrants are placed roughly every 500 feet in New York City, resulting in more than 100,000 total.**
- **If opened incorrectly, a hydrant can release more than 1,000 gallons of water a minute.**
- **It is illegal to park within 15 feet of a hydrant in New York City – although only one ticket can be issued for the same violation in any 3-hour period. Similar distances and fines are used in many other cities.**
- **Traffic police have been around since 1722 when they were first used to control traffic on London Bridge. The first NYPD traffic unit appeared in the 1860s. Members of the "Broadway Squad" had to be over 6 feet tall and were specifically charged with helping pedestrians cross busy streets (bit.ly/3Vy6XsE).**
- **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 offences account for over $500 million of the city's annual revenue.**



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More on the exponential race

The exponential distribution is useful for modelling a wide range of phenomena, from radioactive decay to the arrival of buses at a bus stop. We introduced the exponential distribution as the limit to the geometric distribution. That is, the exponential distribution is a good approximation of the following experiment. Divide the day into n periods (say each period is 1 second in length, evenly dividing the day into 86,400 periods). Suppose every period, the owner of an illegally parked vehicle tosses a coin with probability $p = a/n$. If the coin lands on heads, the owner returns. 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

$$\Pr(Y > nx) \approx (1 - p)^{nx} = \left(1 - \frac{a}{n}\right)^{nx} \to \exp(-ax) \text{ as } n \to \infty$$

where $\exp(-ax)$ is the survival function of the exponential distribution with rate a. (Technically, $(1 - a/n)^{nx+1} < \Pr(Y > nx) < (1 - a/n)^{nx-1}$ and both bounds converge to $\exp(-ax)$.)

A similar model could be assumed for the traffic enforcement agent, who tosses a coin with probability b/n to decide whether to check for parking in front of a given hydrant. Then, by the same argument, the time until the officer checks a space also follows an exponential distribution with rate b. We assume all coin tosses are independent.

A key property of the exponential and geometric distributions is that they are *memoryless*. Memorylessness means that if we find an illegally parked car, the amount of time we would wait until a traffic enforcement agent checks the spot does not depend on how long the car has been parked. This property is key to our analysis: We do not need to know how long a car has been parked to estimate the average time between checks, we only need the time from when we observe the vehicle until a ticket is issued.

Studying an *exponential race* is facilitated by a convenient probability formula. Let Y denote the length of time a car is parked illegally and Z the length of time until a ticket enforcement agent arrives – where Y follows an exponential distribution with mean $A = 1/a$, and Z, independently of Y, follows an exponential distribution with mean $B = 1/b$. Then the probability of a ticket, p, can be written as $p = \Pr(Y > Z) = A/(A + B)$. We estimate B and p from our field experiment, which allows us to estimate A.

The exponential race

Whether you realise it or not, when you park in front of a hydrant, you compete in a race – a race between you and a traffic enforcement agent. You win the race if you return to your car before the agent can ticket it.

The most common statistical model for studying races is the *exponential race*. The exponential race can be described by a simple coin-tossing game: Once you park in front of a hydrant, you toss a coin repeatedly, say every second. If the coin lands on heads, you return to your car. 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.

In this hypothetical game, the coins are weighted. It is unlikely that either the driver or the traffic enforcement agent will toss heads – reflecting the fact that a vehicle may block a hydrant for minutes or hours before the owner returns or a ticket is written. For this reason, instead of studying the weight of the coins (the probability the driver or agent will toss heads), it is convenient to study the waiting times (the length of time it takes for the driver or agent to toss heads). These waiting times are well approximated by an exponential distribution, which is where the exponential race gets its name (see "More on the exponential race").

Determining the economics of hydrant parking is tantamount to determining the average waiting time until a driver returns and the average waiting time until a traffic enforcement agent checks a hydrant. These averages tell us how long a typical driver parks in front of a hydrant, and how long it takes for a typical agent to check a hydrant. When combined with the exponential distribution, we can determine how likely it is you will receive a ticket if you park in front of a hydrant for a given amount of time, as well as how much revenue the city could make by increasing enforcement.

To estimate the average waiting times, we conducted a field experiment. During the afternoon of 11 July 2022, we took six routes through Manhattan streets and recorded the time and licence plate of each violation we saw. Collectively, we found 138 violations between 1 p.m. and 5 p.m. A month later, we looked up whether those vehicles received tickets for parking in front of a fire hydrant on 11 July, using data available on the New York City Open Data Portal (bit.ly/3Bc1IXs). We also noted the time of the ticket.

Out of the 423 vehicles that were ticketed, seven were on our list. From these vehicles, we estimate the average waiting times as well as other interesting facts about ticketing in Manhattan. The estimates reflect the state of Manhattan on 11 July, the day we conducted our field experiment. In so far as 11 July was a typical day, the estimates also reflect the state of Manhattan generally. Whether our results are in fact typical could be tested with additional field experiments.

After analysing the data, we find that the expected cost of a violation is low – a lot less than you might think.

The chances of a ticket in Manhattan

The first calculation we make is an estimate of the probability that a typical violation will receive a ticket. While we identified 138 violations in our field experiment, only seven of those violations were ticketed. Therefore, we estimate the probability of a vehicle illegally parked in front of a hydrant receiving a ticket as $7/138 \approx 0.05$ or 1/20.

Assuming all violations have a one in 20 chance of being ticketed, the total number of violations can be estimated as $423/0.05 \approx 8{,}400$, where 423 was the number of tickets issued. In other words, there must have been 8,400 violations in total if all violations have a one in 20 chance of being ticketed, since that would explain the $8{,}400 \times 0.05 \approx 423$ tickets we observe.

Traffic enforcement checks

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 ▶

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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.

Another property of the exponential distribution allows 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 0.05, and we estimate B to be 6 hours, it follows that A is approximately 18 minutes.

The expected cost of 5 minutes of parking

So far we have determined that a hydrant is blocked for an average of 18 minutes, and the probability of a ticket is one in 20. 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 × 0.05 ≈ $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 the cost of a ticket yields the expected cost. These costs are reported in Table 1. A short stop has an expected cost of less than $2, while a day-long park is nearly certain to set you back $115.

Better enforcement could bring in millions of dollars

One might consider another cost: the revenue the city forgoes by not enforcing the law. This cost may be borne by taxpayers who must cover the shortfall or the recipients of other government services that must be reduced.

If 11 July 2022 is a typical day, New York City misses roughly 19 out of 20 violations every day. If each one of those violations would have resulted in a $115 ticket, the city failed to collect $910,340 in revenue.

We can use the exponential distribution to work out the expected amount of additional

TABLE 1: Expected costs of parking in front of a fire hydrant

Time spent blocking a hydrant	Expected cost
5 minutes	$1.67
18 minutes	$5.83
1 hour	$18.50
24 hours	$113.30

TABLE 2: Expected additional revenue New York City could collect if it checked fire hydrants more frequently

Average time between hydrant visits	Daily additional revenue generated
30 minutes	$400,000
1 hour	$250,000
6 hours	$0
24 hours	–$50,000

revenue the city would collect if it checked hydrants more frequently (that is, if it decreased the average waiting time between visiting a hydrant). Note that while the city could in theory collect nearly $1 million a day, in practice an unrealistic amount of enforcement would be necessary. We predict that decreasing average waiting times from 6 hours to 1 hour would increase revenue by only $250,000. Alternatively, reducing enforcement by increasing the average waiting time from 6 hours to 24 hours would only reduce revenue by $50,000 (Table 2).

So, does it pay to park in front of a hydrant?

From the perspective of the driver, the expected cost of blocking a hydrant 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. Not only are they closer, but blocking the fire hydrant does not require drivers to keep feeding the meter. Failing to pay the meter can result in its own $65 ticket.

From the perspective of the city's coffers, the expected benefit of stricter enforcement may not be high. While increasing enforcement could generate revenue of $250,000 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 perspective of the community, however, the cost of blocking a hydrant – and the benefit of stricter enforcement – is much higher. The New York City Fire Department posts pictures of blocked hydrants that impede fire-fighting and contribute to unnecessary injury and death. Our work suggests the relatively low expected cost of a ticket does not sufficiently reflect these consequences.

Increasing fines or parking enforcement may better align the cost of a violation from the perspective of the driver with that of the community. New technologies, like camera enforcement, could reduce the cost of enforcement borne by the city. Camera enforcement is already used to identify speeding vehicles and collect tolls. This technology could be modified to identify vehicles that block fire hydrants. If cameras are prohibitively expensive, proximity sensors could be used to alert traffic enforcement agents when a hydrant is blocked so that they can investigate a potential violation. ■

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Above: Facebook post from New York City Fire Department warning of the potential dangers of parking in front of fire hydrants