Journal of Economic Behavior and Organization 152 (2018) 1–16

Contents lists available at ScienceDirect

Journal of Economic Behavior and Organization

journal homepage: www.elsevier.com/locate/jebo

# An empirical analysis of taxi, Lyft and Uber rides: Evidence from weather shocks in NYC☆

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ARTICLE INFO

*Article history:*
Received 21 August 2017
Revised 4 June 2018
Accepted 5 June 2018

*JEL classification:*
D01
D03
L92
J22

*Keywords:*
Rain
Taxi
Uber
Lyft
Dynamic pricing

ABSTRACT

Using all taxi, Lyft and Uber rides in New York City, we show that the number of Uber and Lyft rides is significantly correlated with whether it rained. The number of Uber (Lyft) rides per hour is about 22 (19)% higher when it is raining, while the number of taxi rides per hour increases by only 5% in rainy hours-suggesting that surge pricing (prime time) encourages an increase in supply. We show that while the number of taxi rides, passengers and fare income all significantly decreased after Uber entered the market in May 2011, taxis do not respond differently to increased demand in rainy hours than non-rainy hours since the entrance of Uber. Last, we test whether Lyft's entry in the market affected Uber. Our estimates suggest that Uber was still growing after Lyft entered the market, but that Uber rides during rainy hours decreased by about 9%. Our findings suggest that dynamic pricing make Lyft and Uber drivers compete for rides when demand suddenly increases, i.e., during rainy hours.



## 1. Introduction

Standing or walking in the rain is an activity best avoided. In New York City (NYC), when faced with such inclement weather, the demand for personal transportation naturally increases. During such scenarios, taxi drivers spend less time searching for customers and could thus earn a higher wage. Nonetheless, it has been a common complaint that it is difficult to find a taxi in the rain.

☆ An earlier version of this paper circulated under the title: "Has Uber Made it Easier to Get a Ride in the Rain." We are grateful to the editor, two referees, and Cristina Blanco-Perez, Pierre Brochu, Henry S. Farber, Jason Garred, Anthony Heyes, Kim P. Huynh, Louis-Philippe Morin, Matt Webb and seminar participants at the 2018 ASSA annual meeting, Bank of Canada and SCSE for very useful remarks and encouragement. We thank Mitch Prior for outstanding research assistance. The paper was written while Kerry Nield was completing graduate studies at Carleton University. The views expressed in this paper are those of the authors. No responsibility for them should be attributed to the Bank of Canada. All errors are our own.

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https://doi.org/10.1016/j.jebo.2018.06.004

Previous explanations have considered that the dearth in availability may be due to daily income targeting behavior[1] by taxi drivers: on rainy days taxi drivers reach their target faster and work less hours.[2] This view has been rebutted by Farber (2015). In this recent study, he rejects the idea that target earnings behavior explains the difficulty to find taxis when it rains. Instead, Farber (2015) provides evidence that some drivers stop working because of the worsening driving conditions associated with rain; unfavorable working conditions for which there is no compensating differential. Taxi drivers face many market frictions: the rates for rides are fixed and the supply of vehicles is controlled.

As alternative services to taxis, Uber and Lyft entered the NYC market respectively in May 2011 and July 2014 with dynamic pricing and mobile driver-passenger matching technology. Surge pricing and prime time are pricing schemes respectively implemented by Uber and Lyft where passengers pay a higher rate for the ride during times of high demand; this higher pricing scheme gives incentives to drivers to provide rides in inclement conditions. Furthermore, unlike taxis which have a regulated supply by the medallion system, Uber and Lyft's mobile app based service allows almost anyone with access to a vehicle to operate as an Uber or Lyft driver. Uber and Lyft could thus be logical responses to unmet demand during adverse conditions.

Previous studies on intertemporal substitution of labor supply find mixed evidence of intertemporal substitution effects when individuals face increased earning opportunities. (See Blundell and MaCurdy (1999) for a review of the literature.) Fehr and Goette (2007) conduct a field experiment at a bicycle messenger service in Switzerland in which they vary temporarily the piece rate paid to messengers. They find a large positive elasticity of hours of work, but a negative elasticity of effort per hour. In another experiment, Chang and Gross (2014) document that pear packers in California respond to unexpected overtime by decreasing their effort. In Oettinger (1999), the author studies labor supply of stadium vendors at baseball games and finds that the number of vendors who worked in a game is positively related to changes in expected wages.

In contrast to earlier studies (e.g., Chen and Sheldon (2015)), we have the unique opportunity of comparing the response to exogenous circumstances of three groups of workers, taxis, Lyft and Uber in NYC, who are subject to different market structures. Another key feature of our analysis is that we can test whether the market changed since Uber and Lyft entered the on-demand transportation network in NYC.

This paper makes at least four contributions. First, we provide an empirical examination of whether the number of Uber and Lyft rides increases more than the number of taxi rides when it rains. For this analysis, we rely on all taxi, Lyft and Uber rides in NYC from April–September 2014 and January 2015 to December 2016 and merge this data set with weather data from the National Weather Service Observatory in Central Park. The results suggest that the number of Uber and Lyft rides per hour is significantly correlated with whether it rained. More precisely, the number of Uber (Lyft) rides per hour is about 22 (19)% higher when it is raining, suggesting that dynamic pricing encourages an increase in supply.[3] This increase in transactions when it rains likely reflects a large increase in both demand and supply. On the other hand, the number of taxi rides per hour increases by only 5% in rainy hours during this time period. This is indicative that the market frictions faced by taxis are discouraging a larger response to increased demand. These results suggest that Uber and Lyft drivers are more responsive to rain than taxis and provide suggestive evidence that it is partly because of the increase in fare coming from dynamic pricing.

Second, we test whether rain increases the number of *daily* rides. We provide evidence that the number of Uber rides increases by approximately 10% during rainy days and that an additional hour of rain increases the number of Uber rides per day by approximately 2%. On the other hand, there is weak evidence that the daily number of taxi rides is related to rain. The number of taxi rides increases by approximately 2% during rainy days. This is suggestive evidence that Uber drivers, like taxi drivers, do not have a daily target income level and that Uber driver labor supply is best characterized by the neoclassical model.

Third, we use data for all trips taken in NYC taxi cabs before (January 2010–April 2011) and after (2014–2016) Uber and Lyft's rise in popularity, and show that the number of taxi rides per hour decreased by approximately 25% after Uber entered the New York market in May 2011. The results indicate that hourly fare income and the number of passengers per hour for taxis significantly decreased after Uber entered the market. Moreover, we show that the number of taxi rides in both rainy and non-rainy hours have similarly decreased since Uber entered the market, suggesting that taxis are not responding differently to increased earning opportunities since the entrance of new competitors.

Finally, we test whether Lyft's entry in the market affected Uber. Our estimates suggest that Uber was still growing after Lyft entered the market, but that Uber rides during rainy hours decreased by about 9%. Our findings suggest that dynamic pricing makes Lyft and Uber drivers compete for rides when demand suddenly increases, i.e., during rainy hours.

[1] See Koszegi and Rabin (2006) for a model of reference-dependent preferences and loss aversion. They build on the work of Kahneman and Tversky (1979) and Tversky and Kahneman (1991) and develop a model where a person's utility depends on a reference point.

[2] In a seminal article, Camerer et al. (1997) present evidence suggesting that taxi drivers have income reference-dependent preferences, so that taxi drivers have a daily income target and stop working once they reached this target. Note that Camerer et al. (1997) were not particularly interested in rain and did not claim that on rainy days taxi drivers reach their target faster and work less hours. We thank Colin Camerer for pointing this out.

[3] Unfortunately, our data set does not allow us to test whether the increase in labor supply of Uber and Lyft drivers during rainy hours is due to the extensive or intensive margin.