The Emergence of the Sharing Economy: The Response Strategies of Pre-existing Taxi Industry Affected by Uber's Disruption

Kibum Kim* & Jeong-Dong Lee**

Abstract

What impact does the sharing economy have on existing businesses? This paper empirically examines how Uber transformed the taxi industry in New York City. Using a regression model controlling various potential influencing factors, we find no direct evidence that daily trips or revenue per taxi driver decreased since Uber entered the taxi industry. However, a closer investigation into other dimensions of taxi trips reveals that taxi drivers were forced to change their way of doing businesses to retain existing daily trips and revenue. Since Uber crowded out yellow taxis from the central area of Manhattan, yellow taxis responded by serving customers outside of the Manhattan borough. From enlarging their geographical coverage and serving customers that were previously ignored, yellow taxis were able to retain their previous level of taxi trips and market share. We also find that yellow taxis responded by improving their service quality to better serve customers' needs. Our result suggests that incumbents actively responded to Uber's entry and provided substantial benefit to consumers. Combined with the incumbent's response, the sharing economy transformed the existing market in a welfare-enhancing way. This paper provides managerial and policy implication on how incumbents affected by the disruptions of the sharing economy should respond. Even though it might be yet premature to examine the impact of Uber, results suggest that incumbents have effectively defended against Uber's entry so far. We conclude that the sharing economy and the existing economy can create positive value in our society through well-intentioned competition, complementing each other's weaknesses and strengths.

Keywords
the sharing economy, collaborative consumption, Uber, creative destruction, incumbent's response strategy

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1. INTRODUCTION

1.1. Research Purpose

What impact does the sharing economy have on existing businesses? Are incumbents under a real threat of being substituted by the disruption that the sharing economy brings into our society or are such concerns unfounded? This paper empirically examines how Uber transformed the existing taxi industry in New York City. Uber is known as a representative sharing economy company, with its business model consisting of Uber-drivers who use their own cars to transport consumers in need of rides. The on-demand ride service is operated on Uber's mobile platform by submitting trip requests and linking drivers with the consumers.

As an extension to previous studies on Uber, this paper analyzes several dimensions of taxi trip records that Uber might have affected and the consequent response strategies that incumbent taxis have executed. This empirical research provides managerial implications on how incumbents should respond to the disruption of the sharing economy as well as policy implications on how the sharing economy can harmonize with the existing economic system.

1.2. Research Background

The rise of the sharing economy or collaboration consumption in the twenty-first century has been widely appraised as an alternative that can resolve various current socioeconomic and environmental problems. Those possessing an extra bedroom can post it on sharing platform such as Airbnb and those with a vehicle in the garage can participate in ride-sharing through Uber or Lyft. The sharing economy, facilitated by the diffusion of the internet and mobile applications, allows us to participate in on-demand activities in a convenient way. The scope of sharing activities extends to a wide range of on-demand and O2O (online to offline) services from house-cleaning, caregiving to crowd-funding and knowledge sharing.

Despite its potential value, some question the tangible value that the sharing economy creates in our society. The sharing economy has been often criticized as a "share-the-scraps economy (Reich, 2015)" where big money goes to the platform owners and only scraps go to on-demand workers. In addition this debate, several countries including Korea suspended operations of Uber (King, 2015) and the lack of trust and security mechanism on Airbnb poses doubts about its potential value.

The question of whether an entrant with a disruptive business model or technology is merely substitution in the existing market or leads to actual market creation has been an important issue in industry dynamics. Thus, it is crucial to analyze what impact the sharing economy has on incumbents and what value it delivers to our society as a whole. Deeper investigation into the relationship between the sharing economy and affected incumbents can unveil such controversy and more accurately predict the future of the sharing economy.

1.3. Research Design and Contribution

Among the various industries the sharing economy is disrupting, this paper focuses on the transportation sector, more specifically the taxi industry in New York. Using the taxi data provided by the New York City Taxi & Limousine Commission (TLC) from January 2009 to June 2015, we compare several dimensions of yellow taxi trip records before and after Uber's entry. Uber launched in New York on May 2011, yielding four years of post-Uber entry data.

We develop a regression model controlling various factors that may have affected taxi trips in our model. We find no direct evidence that daily trips for taxis or revenue per driver decreased since Uber entered the taxi market. However, a closer investigation into other dimensions of the taxi trips record reveal that taxi drivers were forced to changed their way of doing businesses to retain its existing number of daily trips and revenue.

From the pick-up and drop-off location data, we find yellow taxis started to cover a large geographical area of New York since Uber entered the market. This implies that yellow taxis were crowded out from the main area of Manhattan due to increased competition. Incumbent taxis started to hail customers from a more dispersed area of New York and their active response against Uber's disruption allowed them to retain their number of daily trips and revenue.

Another important dimension is service quality. The fact that tip percentage and tip amount positively correlate with Uber's entry suggests that taxi drivers improved their service quality to better serve customer's needs.

From the findings above, we find that incumbent taxis were affected by Uber's entry and their response benefited customers. Yellow taxis started to serve customers that were previously ignored, enabling customers to hail taxis in more dispersed areas of New York. Also the fact that customers now receive better customer service aligns with the economic theory that increased competition improves consumer welfare.

Our paper makes several important contributions complementing previous studies. We provide managerial and policy implications concerning the response of incumbents affected by the disruptions of the sharing economy. Incumbents actively responded to Uber's market entry and appear to have provided substantial benefits to consumers. We find Uber had an impact on these incumbents and forced them to change their strategies in order to survive. While it might be premature to examine Uber's impact, the results suggest that the incumbents have defended themselves well so far. Without such a proactive response, taxis would have been severely hit by the substitution effect of Uber. We finally conclude that combined with the right response from incumbents, the sharing economy can transform the existing market in a welfare-enhancing way.

The next section reviews the existing literatures and the one following presents the methodology. Our data and hypothesis are introduced along with descriptive statistics on key measurements. Fi-

nally, we conclude with a discussion of our results and their implications.

2. RELATED LITERATURE

2.1. Market Creation versus Market Substitution

The entry of a firm into a market is a major area of study in both management and economics. The relationship between the entrant and the incumbent is sometimes explained through the concept of creative destruction, a process of industrial mutation that incessantly revolutionizes the economic structure from within, incessantly destroying the old one and incessantly creating a new one (Schumpeter, 2008). At a national or industry level, several studies theoretically and empirically examine Schumpeter's process of creative destruction and suggest that a high level of creative destruction is associated with economic growth (Aghion, Blundell, Griffith, Howitt, & Prantl, 2004; Aghion & Howitt, 1990; Reynolds, 1999). Levinsohn and Petropoulos (2001) empirically examines whether a creative destruction or pure destruction occurred in the textile and apparel industry from a long historical data and find that productivity increased in both industries due to intensified international competition.

The impact of entrants on incumbents and the existing market is examined in various studies. In industry dynamics, a stylized fact about entry is that entry is often associated with high rates of innovation. Many case studies show that entry stimulates incumbents to introduce new products and processes that they were holding back (Geroski, 1995). In micro-economic theory, higher competition in a market due to frequent entries and exits displaces static equilibrium towards the direction of increasing consumers' welfare.

However, in real business, entrants affect the existing market and incumbents in unexpected ways due to the dynamic nature of firms. Firms faced with a new threat of competition by entrants tend to actively respond by changing their business model or strategies (Christensen, Suárez, & Utterback, 1998; Lee 2003). Christensen on his book, *The Innovator's Dilemma* (2013) claims that incumbents should actively explore any disruptive entrants and proactively respond in order to survive in today's highly competitive and fast-changing economy.

It is also important to mention that the impact of entrants on incumbents and the existing market is not uniformly the same. How an existing market is compromised, what the market specific characteristics are, and how different stakeholders are interlinked within the market lead to a different impact by a new entrant. Seamans and Zhu (2014) empirically analyzes the impact of Craigslist on a multi-sided market—the local newspaper, which consists of subscribers, classified ads and display ads. From the analysis of multi-sided markets with three sides, he finds that increased competition on one of the market affects the other sides.

The specific characteristics of entrants may also impact incumbents in different ways. Prince and

Simon (2015) examines whether incumbent airline companies improve service quality in response to the entry of low-cost carriers (LLC) and found that the incumbent's on-time performance (OTP) actually worsened after Southwest Airlines entered the market. The fact that Southwest Airlines was not only a top-performer in service quality but also a low-cost carrier led incumbents to respond through cutting costs, which ultimately lead to a drop in service quality. This result contradicts the idea of increased customer welfare upon the rise of competition and shed lights on the importance of considering which type of firm is entering the market.

This research examines the impact of the sharing economy on incumbents. More specifically, we analyze Uber's impact on the traditional taxi industry in New York City. Even though the sharing economy or collaborative consumption has been popular in the twenty-first century since Lessig (2008) mentioned it in his book Remix: Making Art and Commerce Thrive in the Hybrid Economy, the concept of sharing, buying, and co-producing goods and services directly from individuals has always existed.

What makes today's sharing economy special is the diffusion of internet and mobile applications that enable or facilitate transactions between the demand and the supply sides. Platforms allow people in demand of certain goods or services and those with the ownership of those to transact in a convenient and efficient way with low transaction or searching cost. Ritzer and Jurgenson (2010) highlight the nature of capitalism in the age of the digital "prosumer" and used this concept to explain the growth of sharing economy platforms such as Uber and Airbnb.

Most of the current researches on the sharing economy are qualitative focusing on the business model of the sharing economy (Cohen & Kietzmann, 2014) or its success factors (Hong, Kim, Choi, Lee, & Cho, 2012). A few quantitative researches exist and most rely on survey data. (Ballus-Armet, Shaheen, Clonts, & Weinzimmer, 2014; Hall & Krueger, 2015) Despite an increasing number of research on the sharing economy, there lacks empirical research on how the sharing economy impacts incumbents and conflicts with traditional economic systems.

The question of whether an entrant or a new technology substitutes the traditional market or leads to market creation has been an important issue in industry dynamics. Several studies analyzing the effect of P2P file-sharing on CD purchases in Canada present contradictory results. Some research finds no association between the number of P2P files downloaded and CD album sales while some claim that the market-creation effect was higher than the substitution effect (Andersen & Frenz, 2010; Barker & Maloney, 2015; Liebowitz, 2008).

As most firms with the sharing economy business models (such as Uber and Airbnb) were founded in the beginning of the twenty-first century, it might be premature to evaluate whether it was substitution or market creation that occurred. Still, a few empirical studies examining the effect of the sharing economy have recently been published.

Hwang (2015) analyzes changes in welfare before and after the sharing economy enters a market

from an economic perspective. Comparing consumers' and suppliers' surpluses, he finds that every agent including old customers, new customers, platforms and new suppliers are better off except for incumbent suppliers. The study claims that the sharing economy is welfare-enhancing if the business-creation effect is higher than the business-stealing effect.

In empirical studies, Zervas, Proserpio, and Byers (2014) analyzes the impact of Airbnb on the hotel industry in the US and discovers that its impact is non-uniformly distributed. The research estimates that a 1% increase in Airbnb listings resulted in a 0.05% decrease in quarterly hotel revenues. Choi, Jung, Ryu, Kim, and Yoon (2015) similarly analyze the impact of Airbnb on hotel revenues in Korea and found no relation between them. The study finds that economic indicators including the unemployment rate and exchange rate are more critical in hotel performance. Fang, Ye, and Law (2015) evaluates the effect of the entry of the sharing economy on the tourism industry and claims it creates jobs and generates new job positions as more tourists visit due to lower accommodation costs. As such, these conflicting results of the impact of the sharing economy reflect the needs for a more accurate and closer examination of its impact.

2.2. The Uber and Taxi Industry

The taxi industry is subject to a variety of potential limitations of competition that most notably include entry restrictions in many jurisdictions (OECD, 2007). The government's regulating of supply is seen as an efficient way of improving social welfare and increasing the market equilibrium price. However, some market failures do arise and a solution is by bringing in providers of substitute products and services into competition (OECD, 2007). The rise of the sharing economy in the twenty-first century and the launch of ride-sharing platforms such as Uber or Lyft are proposed as alternatives to taxis.

Uber, headquartered in San Francisco, California, was founded in March of 2009 as a transportation network company. A platform-based company, its business model consists of Uber-drivers who use their own cars to transport consumers in need of rides. The on-demand ride service is operated by Uber's mobile platform by simply submitting trip requests and linking drivers with the consumers. Since its first launch in San Francisco it rapidly expanded into various cities in the US including New York, Chicago, and Washington DC in May 2011. As of February 2016, the service is available in 379 cities from all over the world (Uber Technologies Inc., 2015). The company is now valued at 50 billion USD and is a hallmark of the sharing economy company in the transportation sector (Macmillan & Demos, 2015).

Among the many areas where Uber is available, this paper focuses on New York City where Uber expanded rapidly following successes in San Francisco and Los Angeles (Hall & Krueger, 2015). Several news articles stated how the iconic yellow taxicabs of New York were thought to be threatened by Uber's entry into the market.

In addition, several countries including Korea suspended Uber's operations. Regulations that re-

quire only licensed drivers to operate in this supply-regulated taxi market conflicted with Uber's operations whereupon anyone could become a driver. Taxi unions pushed the government to restrict Uber's entry from the beginning in order to secure their rent, leading to legal conflict and suspension of service in several countries around the world. Ongoing strikes by taxi drivers also suggested a need to closely examination the relationship between Uber and the taxi industry. Unveiling such controversies can lead to policy recommendations on how we can introduce the sharing economy with minimum conflict within existing economic system.

Wallsten (2015) examines the impact of Uber on the taxi industry in New York City and claims that the number of taxi trips decreased as Uber grew. Also, by empirically exploring the relationship between the number of taxi complaints as a proxy of service quality and Uber's entry, it claims that taxis in New York City and Chicago improved their service quality. While Wallsten (2015) analyzes how the number of yellow taxi trips changed since Uber entered the market, we consider both yellow and green taxis in order to investigate Uber's comprehensive effect on the taxi industry. Another study compares the price and pick-up and drop-off locations of taxis and Uber and finds that Uber tends to be more expensive than yellow taxis in certain circumstances (Salnikov, Lambiotte, Noulas, & Mascolo, 2015).

3. Hypothesis

3.1. Replacement Effect of Uber on the Number of Taxi Trips

In order to examine whether Uber substituted taxi trips, the number of daily taxi trips was measured. This variable reflects whether consumers who used to use taxis deviated onto Uber and ultimately led to a decrease in the number of taxi trips. The drop in number of taxi rides after Uber's entry would support the hypothesis that Uber substituted the taxi market. Wallsten (2015) verified this variable using yellow taxi data only and found that Uber replaced taxi trips in New York. We can expect the same result in our model.

3.2. Replacement Effect of Uber on the Revenue Per Taxi Driver

As an extension to our previous hypothesis, we hypothesize that the average daily revenue per taxi driver decreased for the abovementioned reasons. The drop in average daily revenue would clearly reveal the direct impact of Uber on incumbent taxi drivers. Barker and Maloney (2012) analyzed the effect of P2P downloads on CD sales and found that P2P downloads reduced CD demand by around 0.4%. Similarly, we can hypothesize that the business-stealing effect of Uber reduced the daily revenue of taxi drivers.

3.3. Taxi Drivers' Response Through Enlarging the Geographical Coverage

From Uber's rapid diffusion in both the central area of Manhattan as well as other boroughs of New

York, incumbent taxis would have been crowded out of the central area of Manhattan and moved to the greater New York metropolitan area.

Seamans and Zhu (2013) analyzes the impact of Craigslist on local newspapers and finds that incumbent local newspaper providers responded by differentiating themselves from each other. As such, we can formulate a hypothesis that incumbent taxis respond to Uber's entry by changing their routine targeting customers that were previously ignored. We can formulate the hypothesis that the standard deviation of pick-up and drop-off locations increased since Uber's entry and thus shows broader geographical coverage of New York.

3.4. Taxi Drivers' Response Through Improving the Service Quality

Wallsten (2015) uses the number of customer complaints in New York and Chicago as a proxy of service quality and finds that the number of complaints decreased after Uber entered the market. Complementing the previous study, this paper measures the tip percentage passengers paid as a proxy of service quality. In New York City, tipping around 15% of the total fare is known to be the general practice and we can hypothesize that taxi drivers responded by improving their service quality since Uber entered the market.

Several previous literatures examine the relationship between tip and service quality and finds that tipping highly correlates with service quality (Azar, 2004; 2005; Kerr & Domazlicky, 2009; Lynn & Grassman, 1990; Lynn & Graves, 1996; Lynn & McCall, 2000). Azar (2005) explains that tipping exists where consumers can monitor the worker more easily than the firm can and is a form of consumer monitoring since the tip can be determined according to service quality. Kerr and Domazlicky (2009) empirically found a negative correlation between delivery time and the tip percentage. The percentage tip decreased by 0.12% for every minute of delivery time. As the majority of customers evaluate the service quality of taxis and provide tips accordingly, tips can be a more direct measurement of service quality than the number of complaints where only a several hundreds of complaints are filed per week.

4. DATA AND VARIABLES

4.1. Data

This research uses yellow taxicabs' monthly trips record data released by the New York City Taxi and Limousine Commission (TLC). The data include micro-level transaction data from January 2009 to June 2015. The raw data include the date and time of pick-up and drop-off, number of passengers, trip distance in miles, pick-up and drop-off location in longitude and latitude, payment type (credit card, cash, etc.), fare amount, tip amount, toll amount, and the total amount by every trip recorded.

On average, there are around 14 million trips per month with the aggregate trip data during the seventy-seven months of research exceeding 10 billion trips. Following the sampling technique of Sampat, Mowery, and Ziedonis (2003), 1% of every month's trip records was randomly sampled into a data set consisting of 11 million trip records from January 2009 to June 2015. The cross-sectional trip record data is then broken down into a daily time-series data consisting of 2,341 days.

4.2. Variables

4.2.1 Dependent Variables

4.2.1.1. Number of Daily Trips

This variable measures the daily number of taxi trips in New York. The count data accounts for 1% of the population data as we randomly sample 1% from the raw data.

4.2.1.2. Average Daily Revenue by Yellow Taxi Driver

To examine a more direct impact of Uber on taxi drivers, the fares of the individual taxi trips for each day are summed and then multiplied by 100. This value gives the total amount of revenue earned by taxi drivers per day. This is then deflated using the consumer price index, with 2009 as the base year. Even though this proxy assumes that all taxi drivers and medallion vehicles are on the street 24/7, this proxy can represent how yellow taxi drivers' revenue was hit by the entry of Uber. According to the New York Taxi & Limousine Commission (TLC) (2016), the number of licensed drivers in New York City ranges from 48,521 in 2009 to 53,801 in 2015.

4.2.1.3. Geographical Coverage

The taxi trip record data contains the pick-up and drop-off location in terms of longitude and latitude on every trip recorded. The standard deviation of pick-up and drop-off locations is used as a proxy measuring geographical coverage.

4.2.1.4. Service Quality

The trip record data contains the tip amount when it is paid through credit card. The percentage of the tip is calculated by dividing the amount of the tip by total fare amount multiplied by 100. Since the proportion of payment by credit card increased, only the trips that were paid on credit card were considered when measuring the tip percentage as a proxy of service quality.

4.2.2. Independent Variables

4.2.2.1. Uber Entry

Uber launched in New York City on May of 2011 and experienced rapid expansion. Uber's trip record data since its entry would ideally depict the patterns of how it became a threat to the traditional taxi industry. Uber's weekly dispatched trips and unique dispatched vehicle data were acquired from TLC but only for a limited period. Therefore, Uber's entry is dummified based on the period of entry.

4.2.2.2. Green Taxi Entry

New York City launched a new taxi service named "Boro Taxi (Green Taxi)" in August of 2013 with the purpose of better serving customers hailing taxis outside the borough of Manhattan. Since 2013, the government announced it would issue 2000 licenses yearly for three years. Green taxis are prohibited from picking up customers within the Manhattan area where 90% of yellow taxi trips occur. Even though Green taxis are complementary to yellow taxis, the launch of green taxis would still have affected yellow taxis. Therefore, the green taxis' entry is dummified based on the period of its launch.

4.2.3. Control Variables

4.2.3.1. Market Characteristics

The tendency to use taxi as a means of transportation is closely related to economic status. The monthly unemployment rate in New York and GDP per capita in the US are included as market characteristics control variables.

4.2.3.2. Seasonality

To capture the seasonal effect on taxi trip records, monthly dummies are included for each of the twelve months. Including a vector of monthly dummies is known to be a standard way of deseasonalizing data (e.g., see Wooldridge, 2009).

4.3. Methodology

The empirical model of the impact of Uber on the taxi industry includes variables similar to those used in empirical strategic management studies. Kosova and Enz (2012) use similar modeling strategies to analyze the impact of 9/11 and the 2008 financial crisis on American hotel performance.

Cross-sectional trip record data were transformed into daily time-series data for analysis consisting of 2,341 days. Using the variables defined below, the time-series empirical model of estimation can be written in the general form as below:

$$Y_t = \text{Const} + \alpha\, Uber\_shock_t + \beta\, Green\_shock_t + \gamma\, \text{MktCharacter}_t + \delta\, \text{Seasonality}_t + e_t$$

t indexes days from 1 to 2,341 ranging from January 2009 to June 2015. Y_t represents the four dependent variables mentioned on the previous chapter; number of daily trips, the average daily revenue of yellow taxi drivers, service quality and geographical coverage. The entry of Uber and the launch of Green Taxis in New York are viewed as separate shock and market characteristics (GDP per capita, unemployment rate) and seasonal dummies were added as control variables.

Descriptive statistics in Chapter 5 suggests that autocorrelation exists in our time-series model for the case of number of trips and revenue per driver. Therefore, AIC (Akaike and Schwarz), HQIC (Hannan and Quinn information criterion), and SBIC (Schwarz's Bayesian information criterion) tests were conducted and the appropriate lag length was determined. Even though our unit of analy-

sis is per day, lags would most likely occur in monthly terms. A lag length of approximately thirty days (one month) was derived on both HQIC and SBIC tests therefore added on our previous regression model.

TABLE 1. Testing for Autocorrelation

Lags in Model	AIC (Akaike's Information Criterion)	HQIC (Hannan and Quinn Information Criterion)	SBIC (Schwarz's Bayesian Information Cirterion)
Daily (N=2347)	57 (2 months)	36 (1 month)	29 (1 month)
Monthly (N=77)	12 month	1 month	1 month

Adjusting the autocorrelation, the regression model is as follows:

$$Y_t = \text{Const} + \alpha\, Uber\_shock_t + \beta\, Green\_shock_t + \gamma\, \text{MktCharacter}_t + \delta\ \text{Seasonality}_t + \Sigma_{s=1}^{30}\ Y_{t-s} + e_t$$

5. SUMMARY STATISTICS

Summary statistics are presented in Table 2 with some of the key variables of trips record data. Separate statistics are presented based on whether Uber entered the taxi industry. The t-test verifies that all variables apart from the number of monthly trips across the split samples are statistically significant at 1%. The next chapter provides empirical analysis examining the unique effect of Uber through controlling diverse effects that might have affected changes in the mean differences.

TABLE 2. Summary Statistics

Variable	All Observations				Source
	Mean	Std. Dev.	Min.	Max.	
Uber Entry	0.62	0.48	0	1	UBER
Green Entry	0.28	0.45	0	1	TLC
Year	2011.75	1.86	2009	2015	TLC
Monthly Trips (#)	13,295,600	9,280.91	10,490,700	15,159,000	TLC
Distance (miles)	2.55	2.55	0.10	17.98	TLC
Total Fare ($)	12.20	8.05	3.81	59.3	TLC
Tip ($)	1.98	1.40	0	11.31	TLC
Tip Percentage	1.01	1.02	0	111.30	TLC
Number of Passengers	1.68	1.30	0	9	TLC
Pickup Longitude	-72.58	10.05	-74.01	0	TLC
Pickup Latitude	39.98	5.52	0	40.80	TLC
Drop-off Longitude	-72.61	9.94	-74.01	0	TLC
Drop-off Latitude	40.00	5.46	0	40.83	TLC
Unemployment Rate (%)	8.67	1.06	6.10	10.20	BLS
GDP per Capita (QTR)	429,225.08	1174.59	47352.82	51451.07	OECD

Source: New York City Taxi & Limousine Commission

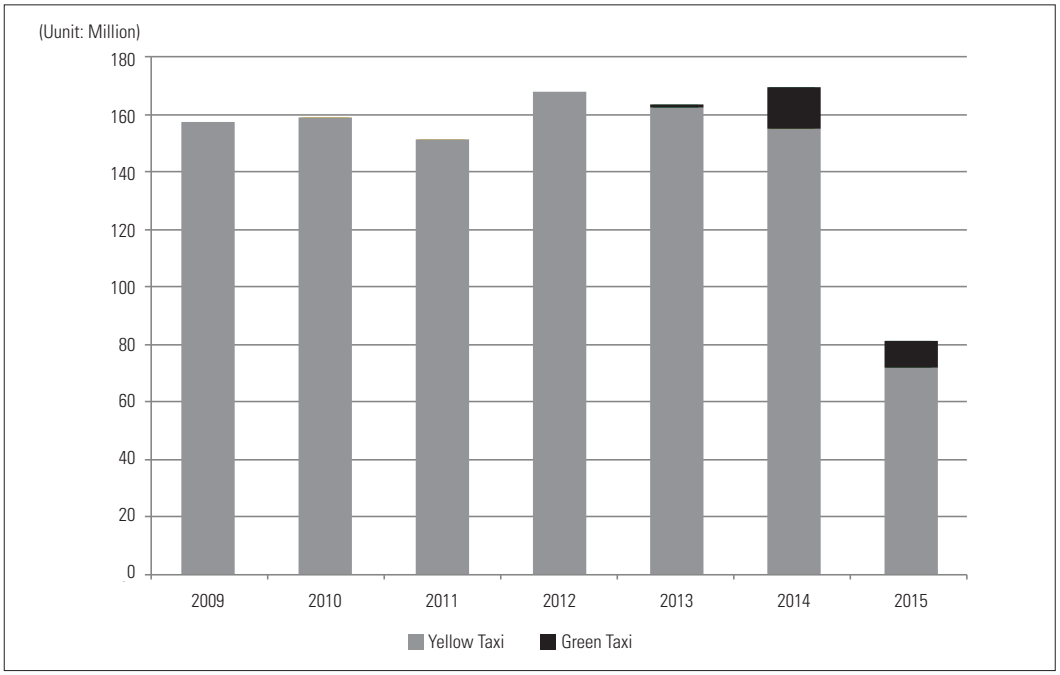
TABLE 2. Summary Statistics (continued)

Variable	Pre-Uber Entry		Post-Uber Entry		Mean Difference
	Mean	Std. Dev.	Mean	Std. Dev.	
Uber Entry	0	0	1	0	+1.00
Green Entry	0	0	0.45	0.49	+0.45***
Year	2009.77	0.73	2012.94	1.21	+3.17***
Monthly Trips (#)	13,260,400	9,520.34	13,316,800	9,228.41	+564.57
Distance (miles)	2.53	2.55	2.56	2.54	+0.03***
Total Fare ($)	10.82	7.07	13.03	8.48	+2.21***
Tip ($)	1.91	1.33	2.01	1.43	+0.09***
Tip Percentage (%)	0.99	1.24	1.02	0.93	+0.03***
Number of Passengers	1.67	1.24	1.69	1.34	+0.02***
Pickup Longitude	-72.62	9.90	-72.55	10.14	+0.07***
Pickup Latitude	40.00	5.45	39.97	5.56	+0.03***
Drop-off Longitude	-72.64	9.82	-72.59	10.01	+0.05***
Drop-off Latitude	40.01	5.41	39.99	5.50	+0.02***
Unemployment Rate (%)	9.36	0.60	8.26	1.07	-1.09***
GDP per Capita (QTR)	48,005.60	482.278	49962.10	794.30	1,956.50***

Source: New York City Taxi & Limousine Commission
Note: In the last column, we take the difference between the mean of the variables before and after Uber's entry during our study period.
**Significant at 10%, **Significant at 5%, ***Significant at 1%*

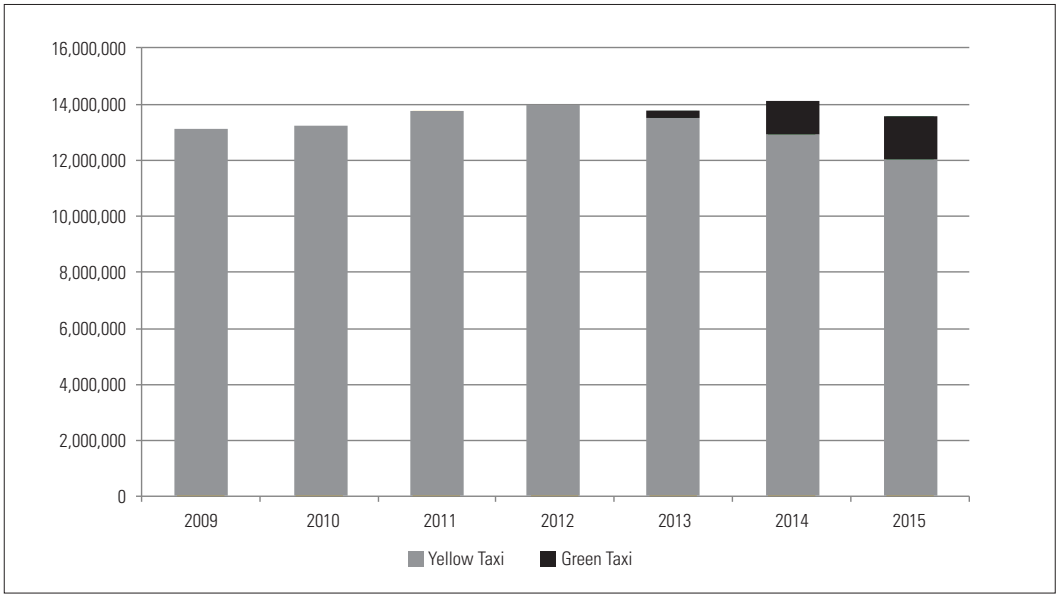
Figure 1 shows the total number of yellow and green taxi trips dispatched every year. As a month in 2011 is not available and the data spans to June 2015, a monthly average is calculated for every year from 2009 to 2015 on Figure 2. This shows that the total numbers of trips dispatched by yellow and green taxis remained fairly stable and Figure 3 suggests that seasonal variation exists in our time-series data.

FIGURE 1. Number of Yearly Yellow and Green Taxi Trips



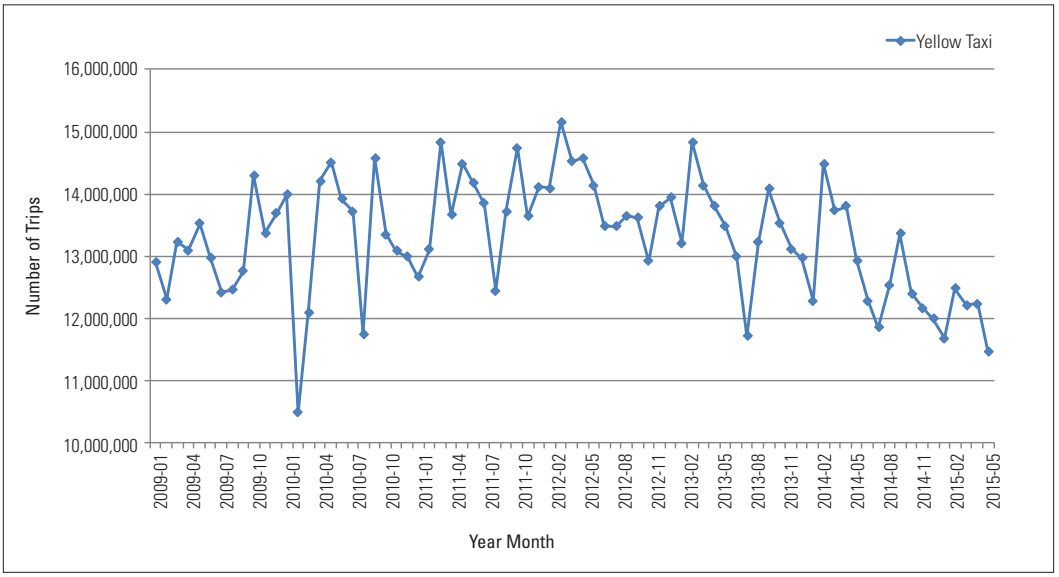
Source: New York City Taxi & Limousine Commission

FIGURE 2. Monthly Average Number of Taxi Trips by Year



Source: New York City Taxi & Limousine Commission

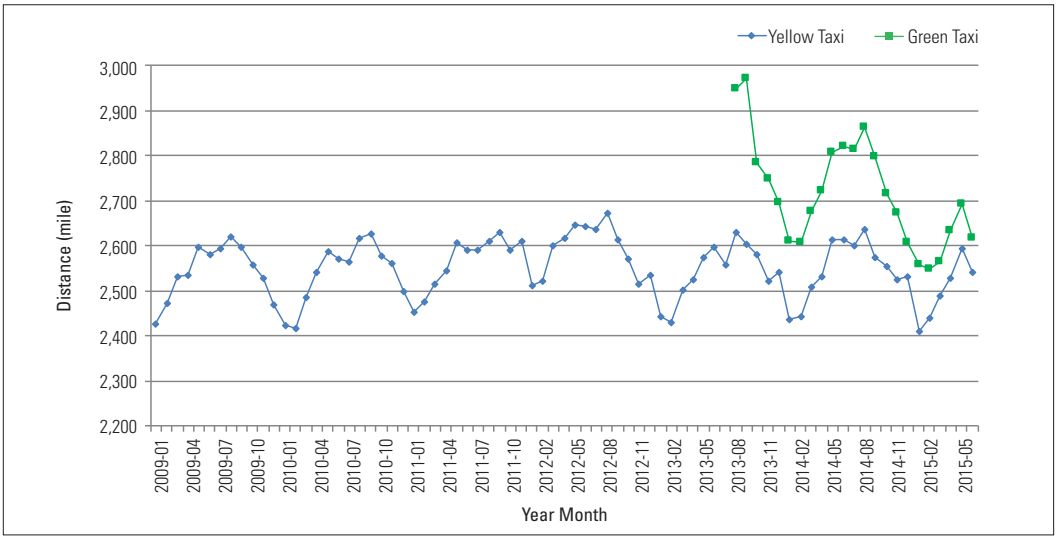
FIGURE 3. Number of Monthly Yellow Trips



Source: New York City Taxi & Limousine Commission

Figure 4 depicts the average trip distance in miles for the yellow and green taxis since January 2009 to Jun 2015. It clearly shows that a seasonal trend exists. The trend for green taxis is added from August 2013 and the average trip distance follows a similar fluctuation of yellow taxis but with an average distance higher than yellow taxi trips.

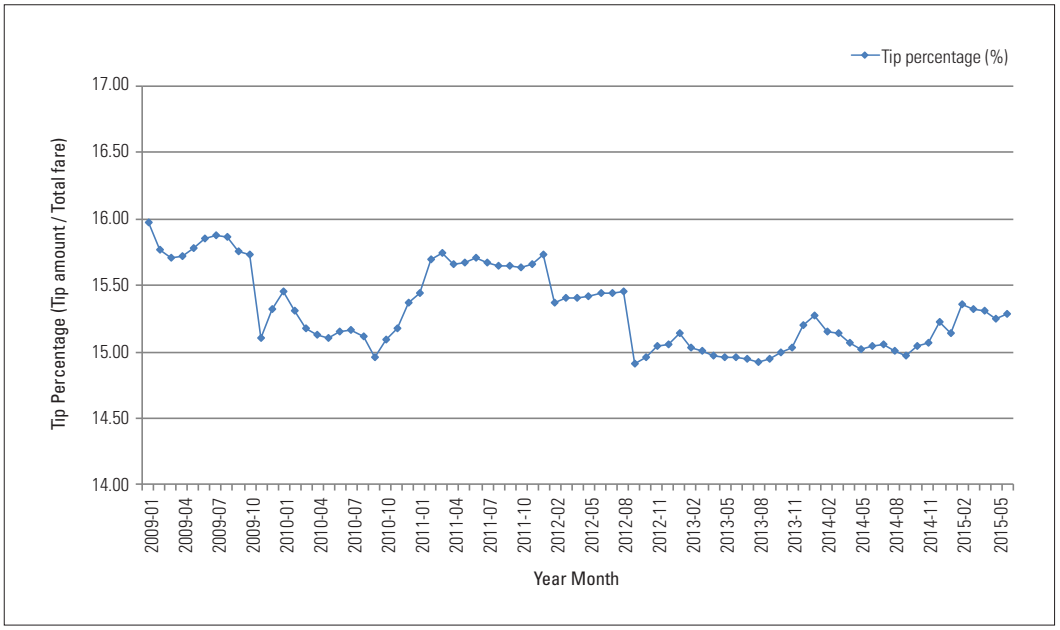
FIGURE 4. Average Travel Distance per Trip in Miles



Source: New York City Taxi & Limousine Commission

Figure 5 shows the trends in tip percentage by customers suggesting that tip percentage ranges between 15% to 16%. The descriptive statistics of the data analyzed suggests that the average tip amount during the period of the study is 15.31%, consistent with the general practice in New York.

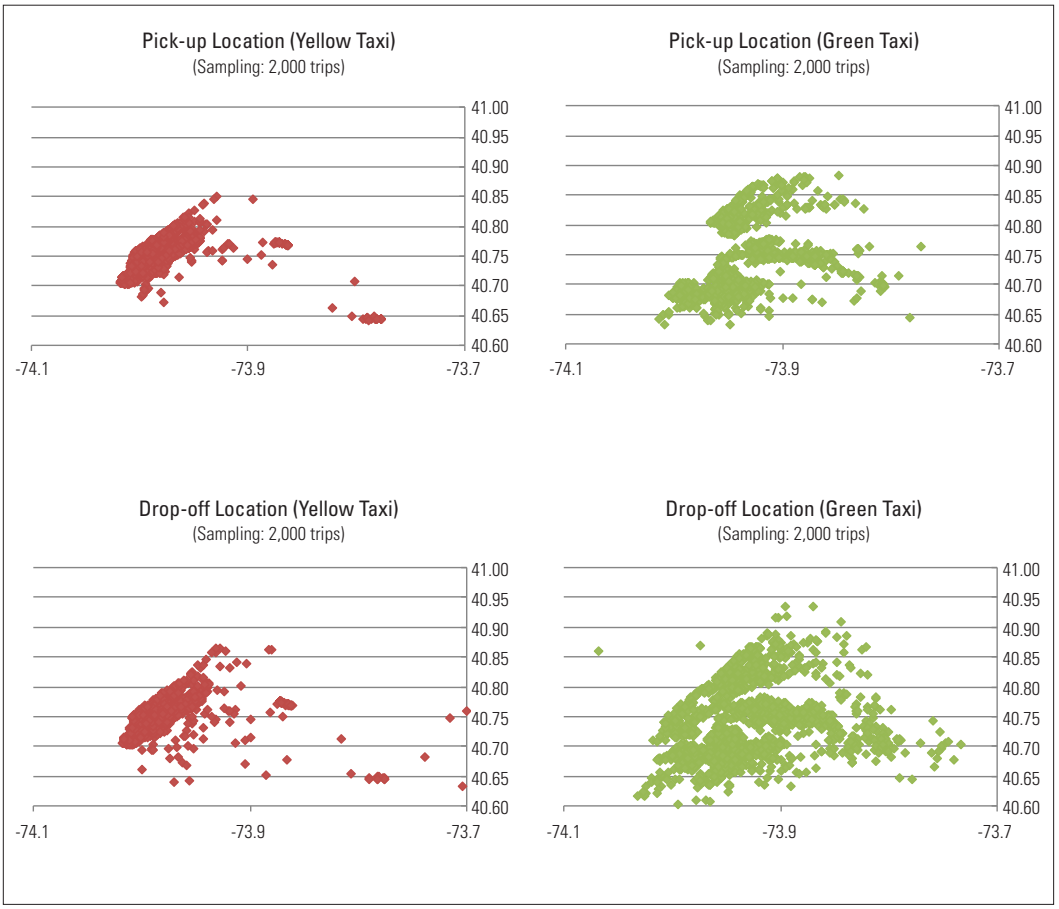
FIGURE 5. Average Tip Percentage by Month (%)



Source: New York City Taxi & Limousine Commission

Figure 6 compares the location of pick-ups and drop-offs between yellow taxis and Green Taxis from the 2,000 randomly sampled observations from the year 2015. It shows that Green Taxis cover a wider range of areas of New York compared to the yellow taxis. For both yellow and Green taxis, drop-off locations are more dispersed compared to pick-up locations implying that there are more customers traveling from central Manhattan to outside of the borough.

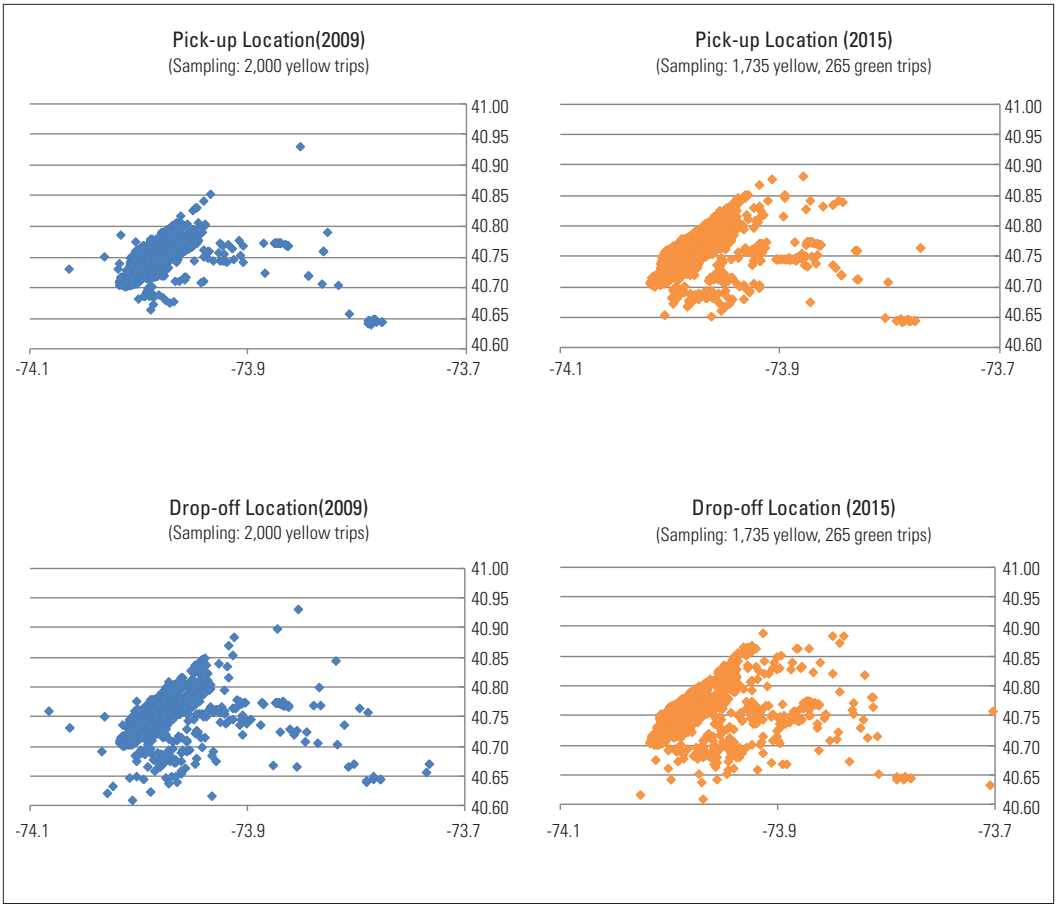
FIGURE 6. Comparison of Yellow and Green Taxi Pick-up and Drop-off Locations (2015)



Source: New York City Taxi & Limousine Commission

Figure 7 compares the pick-up and drop-off locations between 2009 and 2015 from a random sample of 2,000 observations. Since the Green Taxi was introduced in 2013, all 2000 samples in 2009 are yellow taxis. For the year 2015, 13.25% (265) Green Taxis were added to the 2,000 samples, the same proportion of Green Taxi trips that occurred in 2015. The scatter chart depicts that the area pick-up and drop-off locations became more dispersed in 2015 compared to 2009.

FIGURE 7. Comparison of Pick-up and Drop-off Locations between 2009 and 2015



Source: New York City Taxi & Limousine Commission

6. EMPIRICAL RESULTS

6.1. Number of Daily Trips

Table 3 presents the OLS regression results estimating the number of daily yellow taxi trips. Model (1) and Model (2) do not include the lag terms, and contrary to our hypothesis, the results suggest that the number of trips increased since Uber entered the market and decreased upon the launch of Green Taxis. Model (3) and Model (4) considers autocorrelation in our time-series data and results show that Uber and the Green Taxis' entries did not have a significant effect on the number of daily trips. Overall, the four models do not provide evidence that the number of yellow taxi trips dropped since Uber entered the market.

TABLE 3. Effect of Uber Entry on the Number of Daily Trips

Dependent Variable	Number of Daily Trips			
	(1)	(2)	(3)	(4)
Uber Entry	199.453*** [51.190]	230.050*** [50.228]	48.568 [33.484]	52.661 [33.256]
Green Taxi Entry	-159.952*** [53.818]		-36.148 [34.484]	
Constant	1365.152 [1775.089]	2810.282 [1710.069]	136.021 [1218.337]	386.771 [1194.650]
GDP per Capita	0.035 [0.034]	-0.001 [0.032]	0.011 [0.023]	0.004 [0.022]
Unemployment Rate	144.907*** [25.493]	175.556*** [23.353]	41.752*** [18.987]	47.970 [18.037]
Lag Term	No	No	Yes	Yes
Green Taxi Dummy	Yes	No	Yes	No
Month Dummies	Yes	Yes	Yes	Yes
Observations	2,341	2,341	2,311	2,311
Adjusted R-squared	0.123	0.120	0.660	0.660

Source: New York City Taxi & Limousine Commission

6.2. Daily Revenue per Driver

To examine a more direct impact of Uber on taxi drivers, a regression analysis was conducted on the daily revenue per driver. On all models regardless of lag terms, we find a robust result that daily revenue is positively related to Uber's entry. In contrast, The Green Taxis' entry reduced yellow taxi revenue. From these results, we reject our hypothesis that Uber led to a drop in revenues and trip distances.

TABLE 4. Effect of Uber Entry on the Revenue per Driver

Dependent Variable	Revenue per Driver			
	(1)	(2)	(3)	(4)
Uber Entry	7.274*** [1.283]	7.807*** [1.258]	1.745** [0.842]	1.823** [0.836]
Green Taxi Entry	-2.785** [1.349]		-0.636 [0.834]	
Constant	-170.678*** [44.497]	-145.515*** [42.825]	-43.958 [30.568]	-38.766 [29.798]
GDP per Capita	0005*** [0.0009]	0.004*** [0.0008]	0.001** [0.0006]	0.001** [0.0006]

Unemployment Rate	2.926*** [0.639]	3.459*** [0.585]	0.766* [0.452]	0.892** [0.421]
Lag Term	No	No	Yes	Yes
Green Taxi Dummy	Yes	No	Yes	No
Month Dummies	Yes	Yes	Yes	Yes
Observations	2,341	2,341	2,311	2,311
Adjusted R-squared	0.226	0.224	0.709	0.709

Source: New York City Taxi & Limousine Commission

6.3. Service Quality

Table 5 shows that the tip percentage and tip amounts mildly increased since Uber entered the taxi industry. This reflects that taxis started to improve their service quality in response to Uber's entry.

TABLE 5. Effect of Uber on Tip Percentage and Tip Amount

Dependent Variable	Tip Percentage (%)		Tip Amount ($)	
	(1)	(2)	(3)	(4)
Uber Entry	0.261*** [0.026]	0.266*** [0.026]	0.057*** [0.007]	0.047*** [0.007]
Green Taxi Entry	-0.024 [0.028]		0.052*** [0.007]	
Constant	34.500*** [0.908]	34.716*** [0.873]	3.892*** [0.240]	3.420*** [0.233]
GDP per Capita	-0.0004*** [0.00001]	-0.00004*** [0.00002]	-0.00003*** [0.000004]	-0.00002*** [0.000004]
Unemployment Rate	-0.182*** [0.013]	-0.177*** [0.012]	-0.053*** [0.003]	-0.064*** [0.003]
Lag Term	No	No	No	No
Green Taxi Dummy	Yes	No	Yes	No
Month Dummies	Yes	Yes	Yes	Yes
Observations	2,341	2,341	2,341	2,341
Adjusted R-squared	0.311	0.311	0.451	0.439

Source: New York City Taxi & Limousine Commission

6.4. Geographical Coverage

Table 6 and Table 7 present the regression results of the standard deviation of pick-up and drop-off locations in terms of latitude and longitude. The result is robust on both latitudinal and longitudinal locations. The standard deviation significantly increased on both pick-up and drop-off locations after Uber entered the market. This implies that yellow taxis were crowded out by Uber's growth in the central Manhattan area of New York. In order to retain the same amount of customers and prevent loss from happening, yellow taxis started to travel where they had not previously served. The fact that Green Taxis' entry decreased geographical coverage is consistent with the fact that Green Taxis were launched to serve customers commuting to the outer boroughs and greater metropolitan area.

TABLE 6. Effect of Uber on Geographical Coverage (Latitude)

Dependent Variable (Latitude)	Pick-up Latitude		Drop-off Latitude	
	(1)	(2)	(3)	(4)
Uber Entry	0.335*** [0.039]	0.230*** [0.041]	0.396*** [0.039]	0.291*** [0.041]
Green Taxi Entry	-1.086*** [0.065]		-1.094*** [0.065]	
Constant	8.008*** [0.271]	4.569*** [0.186]	7.228*** [0.271]	3.764*** [0.187]
Unemployment Rate	-0.287*** [0.027]	0.069*** [0.018]	-0.210*** [0.027]	0.149*** [0.018]
Lag Term	No	No	No	No
Green Taxi Dummy	Yes	No	Yes	Yes
Month Dummies	Yes	Yes	Yes	Yes
Observations	2,341	2,341	2,341	2,341
Adjusted R-squared	0.137	0.034	0.156	0.053

Source: New York City Taxi & Limousine Commission

TABLE 7. Effect of Uber on Geographical Coverage (Longitude)

Dependent Variable (Longitude)	Pick-up Longitude		Drop-off Longitude	
	(1)	(2)	(3)	(4)
Uber Entry	0.676*** [0.071]	0.482*** [0.075]	0.779*** [0.072]	0.584*** [0.075]
Green Taxi Entry	-2.008*** [0.118]		-2.020*** [0.118]	
Constant	14.395*** [0.495]	8.033*** [0.342]	13.000*** [0.493]	6.603*** [0.341]
Unemployment	-0.507*** [0.050]	0.153*** [0.033]	-0.370*** [0.050]	0.294*** [0.033]
Lag Term	No	No	No	No
Green Taxi Dummy	Yes	No	Yes	Yes
Month Dummies	Yes	Yes	Yes	Yes
Observations	2,341	2,341	2,341	2,341
Adjusted R-squared	0.144	0.039	0.163	0.059

Source: New York City Taxi & Limousine Commission

7. DISCUSSION AND CONCLUSION

To summarize these empirical results, we find no direct evidence that the number of either yellow taxi daily trips or revenue per driver decreased since Uber entered the market. However, a closer look into other dimensions of the taxi trip records suggests that Uber crowded out yellow taxis from the central area of Manhattan. Yellow taxis either voluntarily responded or were non-voluntarily forced to serve customers outside of Manhattan. From enlarging geographical coverage and serving customers previously ignored, yellow taxis were able to retain their previous number of taxi trips and market share. Also, we find that yellow taxis responded by improving service quality to better serve customers' needs. Even though a precise counterfactual analysis is necessary in future studies, yellow taxi drivers would have experiences a drop in trip records as well as revenues without such a proactive response.

It might be yet premature to conclude whether Uber substituted yellow taxis or led to market creation. While modeling techniques need improvement, our results suggest that Uber clearly transformed the taxi industry in a positive direction by increasing customer's welfare. Yellow taxis enabled customers to get better access to taxis outside of Manhattan through improved customer service. These findings are consistent with previous literatures that incumbents actively respond to new threats of entry in order to survive.

We can finally conclude that the sharing economy and the existing economy can create positive value in our society through well-intentioned competition, complementing each other's weaknesses and strengths. We find that the sharing economy is in fact an extension of our existing economy and works as a catalyst that incentivizes incumbents to be more productive. Therefore, raising the entry barrier against the sharing economy by imposing regulations is not the answer. In combination with the incumbents' response, the sharing economy can influence the existing market in a welfare-enhancing way.

When a new type of disruptive entrant threatens the existing market, there has always been an opposing force that tries to secure its rent. As an example, healthcare providers argue that telemedicine is no substitute for hands-on care and labor unions are against the transition to smart-factory which might put their lives at stake. However, we find from our studies that incumbents do not merely succumb to threats but actively respond to acquire a new competitive advantage in the market.

This paper has several limitations. While we tried to control for various factors that might influence taxi trips, it might still be difficult to attribute changes exclusively to Uber's entry. For example, changes in regulations or prices may affect taxi trips for which our model does not fully account for. Moreover, rather than setting Uber's entry as a dummy, access to Uber's trip record data would present more accurate results on how Uber transformed the existing market.

REFERENCES

Aghion, P., Blundell, R., Griffith, R., Howitt, P., & Prantl, S. (2004). Entry and productivity growth: Evidence from micro-level panel data. *Journal of the European Economic Association, 2*(2-3), 265-276.

Aghion, P., & Howitt, P. (1990). *A model of growth through creative destruction* (Working Paper No. 3223). Cambridge, MA: National Bureau of Economic Research. Retrieved from http://www.nber.org/papers/w3223.pdf

Andersen, B., & Frenz, M. (2010). Don't blame the P2P file-sharers: The impact of free music downloads on the purchase of music CDs in Canada. *Journal of Evolutionary Economics, 20*(5), 715-740.

Azar, O. H. (2004). What sustains social norms and how they evolve?: The case of tipping. *Journal of Economic Behavior & Organization, 54*(1), 49-64.

Azar, O. H. (2005). Who do we tip and why? An empirical investigation. *Applied Economics, 37*(16), 1871-1879.

Ballús-Armet, I., Shaheen, S., Clonts, K., & Weinzimmer, D. (2014). Peer-to-peer carsharing: Exploring public perception and market characteristics in the San Francisco bay area, California. *Transportation Research Record: Journal of the Transportation Research Board*, (2416), 27-36.

Barker, G. R., & Maloney, T. J. (2012). The impact of free music downloads on the purchase of music CDs in Canada. *ANU College of Law Research Paper*, (4). 1-14.

Christensen, C. M., Suárez, F. F., & Utterback, J. M. (1998). Strategies for survival in fast-changing industries. *Management science, 44*(12-part-2), S207-S220.

Choi, K. H., Jung, J. H., Ryu, S. Y., Kim, D. S., & Yoon, S. M. (2015). The relationship between Airbnb and the hotel revenue: In the case of Korea. *Indian Journal of Science and Technology, 8*(26), 1-8. DOI: 10.17485/ijst/2015/v8i26/81013

Cohen, B., & Kietzmann, J. (2014). Ride on! Mobility business models for the sharing economy. *Organization & Environment, 27*(3), 279-296.

Fang, B., Ye, Q., & Law, R. (2015). Effect of the sharing economy on tourism industry employment. *Annals of Tourism Research, 57*(March), 264-267.

Geroski, P. A. (1995). What do we know about entry? *International Journal of Industrial Organization, 13*(4), 421-440.

Hall, J. V., & Krueger, A. B. (2015). *An analysis of the labor market for Uber's driver-partners in the United States*. Princeton University Industrial Relations Section (Working Paper, 587). Princeton, NJ: Princeton Univ., Industrial Relations Section

Hong, S. G., Kim, H. J., Choi, H. R., Lee, K., & Cho, M. J. (2012). In H. M. Srivastava, M. Bohner, I. G. Avramidi, M. Schechter, & M. Adelman (Eds.), *Critical Success Factors for The sharing economy among SMEs*. The proceedings of the 2014 International Conference on Applied Mathematics and Computational Methods in Engineering II & Economics and Business Administration II (pp. 70-75). Prague: Mathematical Methods in Engineering and Economics. Also available at http://www.inase.org/library/2014/prague/bypaper/AMCME-EBA/AMCME-EBA-11.pdf

Hong, S. H. (2007). The recent growth of the internet and changes in household-level demand for entertainment. *Information Economics and Policy, 19*(3), 304-318.

Hwang, S. (November, 2015). The sharing economy, welfare effects and policy implications: An economic perspective. *2015 International forum on service sector advancement – 'Dissemination of the sharing economy: Issues and solutions'*. Seminar held at the Korea Development Institute (KDI) in Seoul.

King, H. (2015, March 6). *Uber suspends UberX service in South Korea*. Retrieved from http://money.cnn.com/2015/03/06/technology/mobile/uber-suspends-uberx-in-south-korea/

Kosová, R., & Enz, C. A. (2012). The terrorist attacks of 9/11 and the financial crisis of 2008 the impact of external shocks on US hotel performance. *Cornell Hospitality Quarterly, 53*(4), 308-325.

Kerr, P. M., & Domazlicky, B. R. (2009). Tipping and service quality: results from a large database. *Applied Economics Letters, 16*(15), 1505-1510.

Lee, J. (2003). Innovation and strategic divergence: An empirical study of the US pharmaceutical industry from 1920 to 1960. *Management Science, 49*(2), 143-159.

Lessig, L. (2008). *Remix: Making art and commerce thrive in the hybrid economy*. N.Y.: Penguin.

Liebowitz, S. J. (2008). Research note-testing file sharing's impact on music album sales in cities. *Management Science, 54*(4), 852-859.

Levinsohn, J., & Petropoulos, W. (2001). *Creative destruction or just plain destruction?: The US textile and apparel industries since 1972* (NBER Working Paper No. 8348). Cambridge, MA: National bureau of economic research. Also available at http://www.nber.org/papers/w8348.pdf

Lynn, M., & Grassman, A. (1990). Restaurant tipping: An examination of three 'rational'explanations. *Journal of Economic Psychology, 11*(2), 169-181.

Lynn, M., & Graves, J. (1996). Tipping: An incentive/reward for service? *Journal of Hospitality & Tourism Research, 20*(1), 1-14.

Lynn, M., & McCall, M. (2000). Gratitude and gratuity: A meta-analysis of research on the service-tipping relationship. *The Journal of Socio-Economics, 29*(2), 203-214.

Macmillan, D. & Demos, T. (2015, July 31). Uber valued at more than $50 billion. *The Wall Street Journal*. Retrieved from http://www.wsj.com/articles/uber-valued-at-more-than-50-billion-1438367457

Organization for Economic Cooperation and Development (OECD). (2007). *Policy roundtable – taxi services: Competition and regulation* (DAF/COMP(2007)42). Retrieved from http://www.oecd.org/regreform/sectors/41472612.pdf

Prince, J. T., & Simon, D. H. (2014). Do incumbents improve service quality in response to entry? Evidence from airlines' on-time performance. *Management Science, 61*(2), 372-390.

Reynolds, P. D. (1999). CH 4: Creative destruction: source or symptom of economic growth. In J. J. Acs., B. Carlsson, & C. Karlsson (Eds.), *Entrepreneurship, small and medium-sized enterprises and the macroeconomy* (pp. 97-136). Cambridge: Cambridge University Press.

Reich, R. (2015, February 2). *The share-the-scrap economy* [Online post at personal website]. Retrieved from http://robertreich.org/post/109894095095

Ritzer, G., & Jurgenson, N. (2010). Production, consumption, presumption: The nature of capitalism in the age of the digital 'prosumer'. *Journal of consumer culture, 10*(1), 13-36.

Salnikov, V., Lambiotte, R., Noulas, A., & Mascolo, C. (2015). Open street cab: Exploiting taxi mobility patterns in New York city to reduce commuter costs. *arXiv preprint arXiv:1503.03021*. Retrieved from https://arxiv.org/pdf/1503.03021v1.pdf

Sampat, B. N., Mowery, D. C., & Ziedonis, A. A. (2003). Changes in university patent quality after the Bayh Dole act: A re-examination. *International Journal of Industrial Organization, 21*(9), 1371-1390.

Schumpeter, J. (2008). VII: Creative destruction. *Capitalism, socialism and democracy* (3rd ed.) (pp. 81-86). N.Y.: Harper Pe-rennial Modern Classics.

Seamans, R., & Zhu, F. (2013). Responses to entry in multi-sided markets: The impact of Craigslist on local newspapers. *Management Science, 60*(2), 476-493.

The New York Taxi & Limousine Commission. (2016). *Licensing*. Retrieved on 03 October 2016 from http://www.nyc.gov/html/tlc/html/industry/licenses_main.shtml

Uber Technologies Inc. (2015). *Uber: Find a city*. Retrieved on 24 February, 2015 from https://www.uber.com/cities/

Wallsten, S. (2015). *The competitive effects of the sharing economy: How is Uber changing taxis?* Washington D. C. : Technology Policy Institute. Retrieved from https://www.ftc.gov/system/files/ documents/public_comments/2015/06/01912-96334.pdf

Wooldridge, J. (2009). *Introductory econometrics: A modern approach* (4th Ed). New York: Macmillan.

Zervas, G., Proserpio, D., & Byers, J. (2015). *The rise of the sharing economy: Estimating the impact of Airbnb on the hotel industry* (Boston U. School of Management Research Paper No. 2013-16). Retrieved from http://cs-people.bu.edu/dproserp/papers/airbnb.pdf