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Competetive Strategy in Disrupted Taxi Markets

An Exploratory Case Study into New York City

Cameron P. Sheeler

Supervisor: Christine B. Meyer

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Abstract

Strategy has been all but regulated out of the taxi industry for the better part of the last century. While such far-reaching entry, pricing and quality regulation may have produced favourably uncompetitive and profitable markets for taxi firms in the past, today, they constrain the competitive response of traditional taxis to fast growing rideshare platforms. In a first step towards motivating compelling taxi strategy, this thesis aims to understand how the growth of rideshare platforms effects competition in established taxi markets. Nine years of taxi trip data and three years of rideshare trip data are retrieved from the New York City Taxi and Limousine Commission and employed using a log-log random effects regression model to estimate the elasticity of traditional taxis demand with respect to Uber. Demand elasticity estimates are reported at the market level, as well as across spatiotemporal axes. The findings from this analysis suggest that the value proposition of traditional taxis is strongest in densely populated urban areas, but not immune to erosion. The findings also suggested that without competitive response from traditional taxis, the rideshare substitution effects grows over time.

Preface

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"*Order and simplification are the first steps towards the mastery of a subjec*t"

–*Thomas Mann*

This thesis was written as part of the Master of Science in Economics and Business Administration program at the Norwegian School of Economics, within my major of Strategy and Management. Writing this thesis has been rewarding in equal measure to its challenge.

Acknowledgement and thanks are due to Dr. Christine B. Meyer who supervised this thesis and provided germane theoretical insights and an abundance of patience throughout the writing process. Without Dr. Meyer, this thesis would not hold the same quality.

I also owe a debt of gratitude to Dr. Roger Bivand who provided generous advice on the econometric portions of this thesis. To my colleague, Niko Virvillis, who was a shoulder to lean on, and of course, to my family.

Cameron P. Sheeler

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Definitions

This thesis uses the following term frequently as defined below:

rideshare an economic transaction where a passenger uses a smartphone application to order and pay for the service of a private, amateur driver, to taxi the passenger from point-to-point.

rideshare platform a technology firm that operates an intermediation service (smartphone application) to connect riders and driver in a rideshare network. Examples of rideshare platforms include *Uber*, Lyft, Juno, Didi, Yandex and Ola.

sharing economy also referred to as the **collaborative economy** generally acknowledges the phenomenon whereby individuals use an internet platform to convert traditionally underused assets into productive resources.

surge pricing Uber's dynamic pricing system used to equilibrate supply and demand in real time by increasing trip fares when demand exceeds supply.

taxi service a driver transporting a customer point-to-point using a car in exchange for a monetary fare paid by the customer.

taxi trip the unit of analysis of a single transaction where taxi service was provided.

taxi, **cab**, or **taxicab** a vehicle operated by driver which together have been licensed by some regulatory authority to perform taxi service in a given market.

TLC the New York City Taxi and Limousine Commission is the agency charged with regulating the city's taxi market.

traditional taxi or **medallion taxi** a *taxi*, *cab* or *taxicab,* characterized by legal authority to perform taxi service.

Uber the *rideshare platform* Uber Technologies Ltd., which provides rideshare intermediation service via a smartphone application.

1. Introduction

Seemingly overnight, the so-called "sharing economy" has disrupted traditional industries across the economy. This disruption has brought about mounting uncertainty among incumbents operating traditional business models. Uber is perhaps the most quintessential example of this phenomenon. Founded in San Francisco in 2011, the rideshare platform has since entered hundreds of markets around the world. As a mark of its perceived success, Uber hosted its initial public offering in March 2019 and fetched a roughly $67 billion valuation.[1] Shortly before that, Lyft, Uber's chief competitor, was publicly listed with a valuation of more than $24 billion.[2]

Rapid growth by rideshare platforms has not come without side-lining other market participants, however. Namely, traditional taxi firms have been besieged by the "Uber effect." Stark competition is something few taxi markets are privy to due to decades of pervasive government regulation that had prevented the entry, and diversification of taxi firms. Since Uber's entry, traditional taxis in many markets have faced depressed utilisation rates (Cramer and Krueger, 2016) - a metric directly responsible for profitability in the industry. Where entry is regulated, the value of taxi medallions has also fallen dramatically[3] - this signalling despondent confidence in the industry's earnings potential. The magnitude of these effects has materialised in large-scale protests by taxi drivers in major cities around the world[4].

Until now, incumbent taxis competitive response has been limited to two measures. First, taxi firms have exercised political muscle in order to impose more regulation on their ridesharing peers. Alternatively, some taxi markets have started to adopt e-hail applications that replicate the basic functions of rideshare applications. Aside from this, the taxi market has struggled to formulate and implement competitive strategy. Upon an initial review of the potential reasons for this, two have been identified

First, there hasn't been much of a need for strategy. This is because strategy has been all but regulated out of the taxi industry over the better part of the last century, through the use of entry, price, and standards. While regulation poses a vexing issue for most industries, traditional taxis who owe their enjoyment of idle completion and profits to it. The business

[1] https://www.wsj.com/articles/Uber-stumbles-in-trading-debut-11557503554
[2] https://www.wsj.com/articles/how-lyft-survived-a-cutthroat-money-raising-battle-with-Uber-11553776934
[3] https://www.wsj.com/articles/is-the-market-for-new-york-taxi-medallions-showing-signs-of-life-1516228199
[4] https://www.wsj.com/articles/londons-black-cab-drivers-protest-against-taxi-apps-1402499319

environment that has come as a result of this regulation has eliminated the possibility of achieving above average profitability, placing strategy at the wayside as a consequence.

The second factor effecting the strategic capabilities of taxi firms is concerned with who is responsible for formulating strategy, and how strategy be can implemented. Many taxi markets have tended to operate as fragmented networks of predominantly uncoordinated drivers. Disintegrated ownership, combined with far-reaching regulation has created a void in most markets with respect to who is responsible for formulating taxi strategy, and how actors can coordinate on whatever strategy is adopted.

Today, the need for competitive strategy in taxi firms is existential. The task is momentous as it requires most markets to pursue dramatic regulatory reforms, for ownership models to change, and for traditional taxi firms to ascend a corporate learning curve towards formulating and implementing a compelling competitive strategy. This thesis is an early attempt at evaluating the structural determinants of competition in taxi markets which have been disrupted by rideshare platforms, while also exploring the potential to improve the strategic positioning of traditional taxis in the broader taxi industry.

In addition to conventional management ambition to promote firm performance, there is also a compelling social case for establishing healthy taxi markets. Among the significant social benefits of a traditional taxi sectors has been its reliability as a solution to the last-mile problem of public transportation, even during periods of low demand. A second social benefit draws from the demographics of taxi drivers in many countries, especially western democracies, to be immigrants. In 2004, an estimated 84% of New York City taxi drivers were immigrants.[5] Ergo, it is convincing that the taxi industry also plays an essential role in society to integrate immigrant populations.

Prior to plunging into this thesis' analysis, it is important that certain assumptions about industry definitions and the strategic actors under consideration be clarified.

1.1.1 Industry Definiton

This study accepts a definition of the taxi service industry as being the offering of vehicle-for-hire service to the public without established schedules or routes. In other words, it is a point-to-point personalised ground transportation service administered by a driver using a road

[5] https://www.nytimes.com/2004/07/07/nyregion/study-of-taxi-drivers-finds-more-immigrants-at-wheel.html

vehicle. Both traditional taxis and the service that drivers of rideshare platforms provide can be considered as belonging to the taxi industry.

1.1.2 Strategic Actors

In order to improve the external validity of this thesis, I have adopted a simplified consideration of strategic actors in the taxi industry. This is also essential to managing the complexity of the industry since firm ownership models vary from one city to the next. In particular, it is not overly meaningful to discuss competitive strategy from the perspective of an individual taxi drivers who have narrow influence over the market.[6] Therefore, the units of strategic analysis in this thesis are traditional taxis (as if they operated as one firm) and individual rideshare platforms. Such simplification also works to levels the strategic playing field in terms of firm size and consequently, their potential to influence market outcomes.

1.2 Purpose

The purpose of any business school research is to reach conclusions that arm executives to improve the performance of their organisation. Such conclusions must be developed cumulatively from one study to the next in order to create a preponderance of evidence that supports their implementation (Ketchen, 2008). This thesis builds on earlier work by Wallesten (2015), Nie (2017) and Paik et al. (2018) with the ultimate objective of helping traditional taxi firms form a competitive response to rideshare platforms.

1.2.1 Research Question and Model

The factors that determine industry competition can and do change (Porter, 2008). Motivated by the entrance of novel ridesharing business models, the taxi industry in many parts of the world has changed dramatically over the last decade. Although some of the ways the industry has changed are quite clear, such as the increase in the number of drivers supplied to the market, others are less well-known. Therefore, this thesis seeks to answer the following research question:

How does the growth of rideshare platforms effect competition in established taxi markets?

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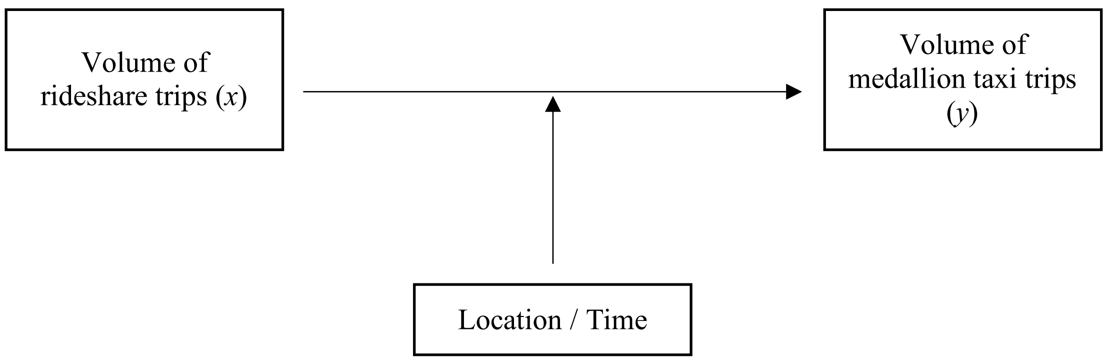
[6] See ….. () for a discussion of individual taxi driver ‘strategy’, discussing spatial positioning and earnings behaviour.

Studying the growth of competitors or, conversely, the decline for the purpose of strategic analysis calls unit volume of sales to action as a common sense measurement for performance (Porter, 2008). In the taxi industry, it can be assumed that one sale corresponds with one trip performed by a taxi driver for a customer. This is a safe assumption since taxis operate an on-demand service which typically ends with the customer paying a fare before exiting the vehicle at their destination. It follows then that the primary unit of analysis for this study is the unit volume of trips completed by both rideshare platforms and traditional taxis.

By adopting the volume of trips as a unit of strategic analysis, this thesis is able to draw empirical conclusions about the competitive effects of rideshare platforms on traditional taxis. Figure 1 represents this hypothetical relationship diagrammatically.

Figure 1: Research Model



1.2.2 Research Objectives

In order to set a clear direction of this study, the following objectives are established:

Objective 1: Characterize the correlative relationship between the volume of rideshare trips (x) and the volume of traditional taxi trips (y).

Objective 2: Estimate the strength of the relationship (β) shared by x and y in the form of elasticity of traditional taxi demand with respect to rideshare.

Objective 3: Explore how the elasticity of demand varies across geographic markets.

Objective 4: Explore how the elasticity of demand changes over time.

Fulfilling this set of research objectives will lead this thesis to contribute empirical conclusions about which pockets of the industry traditional taxis have the most resilient position. For example, a demand elasticity estimate that is location specific (*Objective 3)*, can help traditional taxis to identify the most attractive markets for their service. In an industry which has experienced such dramatic change, revisiting basic questions about where a firm should position itself in the market is an essential first-step towards seeing a way forward.

Together, the research model in Figure 1 and the research objectives above highlight an industry-level strategic analysis that is concerned two broad actors - traditional taxis and rideshare platforms. Although both traditional taxis and rideshare platforms operate more complex ownership models, in reality, the simplifying power of viewing competition as being between these two entities helps this study manage the complexity of the phenomenon at hand. Assuming that both these entities both provide 'taxi service' to the same market, means that this thesis is faced with studying oligopolistic competition.

1.3 Structure

The chapters contained herein are intended to create a clear understanding of the problem at hand. Chapter 2 concludes that the formal strategic management literature has largely ignored the taxi industry, going on to evaluate relevant literature from neighbouring disciplines. Chapter 3 discusses the structural determinants of performance in the taxi industry as well as the traditional taxi profit model. Chapter 4 introduces the case study used in this thesis: New York City. Chapter 5 is devoted to the research methods employed by this thesis - design, data collection and analysis. Chapter 6 presents the results from the analysis. Chapter 7 discusses the results and their strategic implications for the taxi industry. Finally, Chapter 8 concludes. In sum, these chapters fulfil the specified set of research objectives and make a significant contribution to understanding competitive strategy in the taxi industry.

2. Related Work

Judging by the relatively scant supply of published articles relating to the strategic management of taxi firms, one could naïvely conclude that strategy is immaterial to the industry. Afterall, a simple search in the *Strategic Management Journal* reveals just two articles that study the taxi industry specifically (Rawley, 2009; Paik et. al., 2018).

Rawley (2009) uses data from U.S. taxi firms for the years 1992 and 1997 to study coordination costs when taxi fleets pursue horizontal differentiation into limousine service. Paik et. al. (2018) compares political competition across U.S. municipalities that either had or had not banned the operation of Uber. Paik (2018) offers some important insights into nonmarket strategy for rideshare platforms and offensive strategy for traditional taxis to block the entrance of ridesharing to their market.

Beyond the narrow field of research published directly to strategic management journals, work assembled from a range of other disciplines reassures the timeliness of strategy research to the taxi industry. Reviewing this previous work, I identified three aspects that are central to the issue at hand: the effects of rideshare entry on the taxi market, competition with taxis, and regulation.

2.1 Rideshare Entry Effects[7]

Consistent media attention since 2015 provides plenty of anecdotal evidence about the effects of rideshare in taxi markets, but the actual effects of rideshare platforms on taxi markets, grounded in empirical research, remains hazy. Given the relative newness of ridesharing and persisting instability of its market evolution, however, it is understandable that researchers have not been able to produce a substantial body of literature on the topic yet. Nevertheless, there have still been some significant contributions.

Cohen et al. (2016) estimates the total consumer surplus generated by UberX in the U.S. in 2015. They conclude that for each $1.00 a consumer spends on an Uber, they receive $1.60 in

[7] See also, Glöss and McGregor (2016) for the effects of rideshare taxi workforce skills; Angrist et al. (2017) study taxi drivers' preference between contract and commission income structures.

surplus. In the process of arriving at this figure, the author's also estimate Uber customers' elasticity to surge pricing.

Berger et al. (2018) study the income of taxi drivers in San Francisco after Uber's entry to the market. They generalise their findings to say that after Uber's entry into a new market, on average, the income of taxi drivers is depressed by 10%.

Hall et al. (2018.2) establish Uber as a compliment good to public transit, finding that the platform's entry into market results in a 3% increase in bus ridership and a 0.8% decrease in train ridership.

Each of these articles makes an important contribution to understanding how rideshare platforms effect the markets they enter into; however, their external validity tends to be undermined by the highly localised nature of the taxi industry. The majority of these studies have also only explored U.S. cities, making their application outside of the U.S. ambiguous.

2.2 Competition with Taxis

An impotent, and burgeoning steam of literature has begun to empirically investigate the dynamics of competition between traditional taxis firms and rideshare platforms. From these articles, the observation of higher utilisation rates among rideshare drivers than traditional taxis has emerged multiple times.

Nie (2017) makes perhaps the most closely related contribution in literature to this thesis by studying competition between Uber and traditional taxis in Shenzhen, China. Notably, he finds that that traditional taxis in Shenzhen have been more resilient to Uber's entrance than those in NYC. Hr attributes this to the fact that taxis in Shenzhen had adopted e-hailing before Uber's entrance, and that in the most densely populated areas of the city, the transactions costs are often higher to use Uber than a street-hail cab because Uber has a wait time, and drivers frequently have difficulty finding the passenger's location.

Wallesten (2015) studies of the relationship between the growth of Uber and the number of consumer complaints about taxis in New York and Chicago. He reveals that the number of complaints per taxi trip in NYC and Chicago declined alongside growth in the number of Uber trips - suggesting that taxis have responded to competition from Uber by improving quality.

Cramer and Krueger (2016) provide the study most closely related to firm performance in the taxi industry by comparing the capacity utilisation rates[8] of UberX drivers against traditional taxis in Boston, Los Angeles, New York, San Francisco and Seattle. They conclude that, on average, when compared to traditional taxi drivers, UberX drivers have 30% higher utilisation rates when measured by time, and 50% higher utilisation rates when measured by distance. They argue that the higher utilisation rates among UberX drivers may be attributable to more efficient matching technology, scale economies, inefficient taxi regulation, and network responsiveness to surge pricing

Jiang et al. (2018) explore competition between Uber, Lyft and taxis in terms of supply demand and price, all over temporal and special axes. Notably, they find differences in the intensity and distribution of surge pricing by Uber and Lyft. Whereas Uber tend to surge prices gradually over a large area, Lyft tends to concentrate surges on very specific neighbourhoods at more dramatic rates. This finding suggests a potential for interesting pricing competition between rideshare platforms that goes beyond a simple Bertrand race to the overall lowest prices. Jiang et al. also validate the findings of Cramer and Krueger (2016) that Uber and Lyft enjoy higher utilisation rates than traditional taxis.

With Nie (2017) and Wallesten's (2015) as an exception, the literature on competition in taxi markets as it relates to rideshare has mostly assumed the perspective of the rideshare platforms. This way of thinking about taxi markets implies a form of one-way competition wherein rideshare platforms compete with traditional taxis, but traditional taxis do not take measures to respond. As a result of this phenomenon in the literature, the contributions of this thesis become all the more significant.

2.3 Regulation

Literature concerning regulation in the taxi industry has come in two major waves. From 1970-1990, literature was heavily focused on whether the economics of the industry depended on regulation. In general, the proponents of regulation were motivated to protect consumer welfare. Many cited the risk of excess capacity and the presence of temporary monopoly

[8] Taxi utilisation rates are measured as the fraction of time or distance a taxicab is occupied by a customer over the time or distance it is vacant. Yang and Yang (2011) integrate utilisation rates in their taxi equilibrium model.

power[9] as unavoidable externalities that need be protected against. Others argue; however, that either the economic rationale for taxi regulation is not compelling and/or that there are certain social flaws in regulating taxis because, for example, higher prices harm low-income consumers who disproportionately comprise the taxi customer base (Frankena and Pautler, 1984; Dempsey, 1996)

More recently, a second wave or literature debating the use of regulation in the taxi industry has been concerned with rideshare platforms. Rogers (2016), Edelman et al. (2015) and Posen et al. (2015) all discuss the potential solutions for regulating rideshare platforms, they commonly cite safety and labour standards. Jiang et al. (2018) suggest that regulating rideshare platforms in order to compel them to serve all areas of cities equally. This argument also carries particular clout in less densely populated places where the government makes use of either regulation (stick) or subsidies (carrot) to ensure taxis provide service beyond city limits. In Norway, for example, where taxi service plays an important role in providing public transportation outside of cities, there is rightful concern that unregulated rideshare platforms would steal the city markets, which are profitable, and leave traditional taxis to only serve low-demand areas of the country, which less profitable and could put taxi firms out of business.

Lastly, the prototypical nature of the taxi industry has attracted extensive attention from economists since the 1960s (Douglas, 1972; De Vany, 1975; Manski and Wright, 1976; Cairns and Liston-Heyes, 1996; Flores-Guri, 2003; Yang and Yang, 2011). These authors have tended to focus on modelling taxi market equilibrium.[10] One major conclusion emerges from this literature as it relates to this study the taxi industry functions on an intervening supply and demand relationship - where an increase in supply decreases wait times and increases consumers' willingness to pay as a result.

2.4 Gaps in the Literature

Upon review of the extant literature related to competitive strategy in the taxi industry, three main shortcomings are apparent.

[9] When hailing a taxi off the street, customers are rarely faced with more than one taxicab to compete for their business, due to the high transactions costs of find a new taxi, and the inability for the consumer to compare price or quality, temporary monopoly dynamics emerges (Dempsey, 1996).

[10] See Salanova et al. (2011) for a full review of taxi equilibrium literature.

First, the majority of empirical studies have focused on U.S. cities. Since taxi markets are localised, generalising these findings outside of the U.S. demands delicate application. Part of the reason why there has been limited research outside of the U.S. is simply due to the availability of data and access to firms. The majority of articles which make empirical contributions to understanding the effects of rideshare platforms on taxi competition have done so either with publicly available data from New York City or San Francisco, or they have worked directly with the rideshare firms and been granted privileged access to data.

Second, with the exception of Jiang et al. (2018), the articles tend to focus only on Uber, despite most rideshare markets being oligopolies dominated by Uber and one other platform depending on which city you look to (Lyft, Didi, Ola, and Careem are all popular).

Third, and most significantly, the literature wholly lacks a discussion about the levers of competitive strategy from the perspective of traditional taxis firms.

Unfortunately, due to the scope of a master's thesis, I am not able to make meaningful contributions to overcoming the first two gaps in the literature, and so I point to them exclusively for the purpose of bringing to light the need for future research to do so. This thesis contributes to understanding the structural determinants of competition between rideshare platforms and traditional taxis, and the tenets around which traditional taxis firms may be able to begin to develop competitive strategy in response.

3. Theory

The strategic management discipline swings on a pendulum between investigating factors endogenous to the firm to explain performance, to investigating those exogenous (Guerras-Martin et al., 2014). Pervasive regulation in the taxi industry renders a purely inward facing strategic analysis of taxi firms incomplete. Such far-reaching price, quantity and quality regulation means that taxi firms are delegated little strategic discretion to improve their economic performance. As a result, the pursuit of average performance in the industry was broadly extinguished.

Since the growth of rideshare, however, the taxi industry has been invigorated with existential motivation to improve their economic performance. This is all to say, that whether it has been the result of regulation, new entrants, or both, performance in the taxi industry is inextricable from the environment it finds itself, and strategic analysis of the industry must reflect this.

Founded on the pioneering ideas of Bain (1956) and Mason (1939), Michael Porter popularized the contributions of industrial organization in strategic management. Porter's foundational argument is that economic performance is a product of two distinct causes: industry structure, and strategic position within the industry structure. This view of strategy conceives of a firm's operational activities a means to fulfilling strategy; however, Porter (1996) argues that operational effectiveness alone will not result is above average performance. Borrowing from this camp of strategic management, the remainder of this chapter will discuss some of the structural determinants to performance in the taxi industry as a method of understanding what drives performance in taxi firms. In pursuing this analysis, the central finding has been that there is asymmetry between traditional taxi firms and rideshare platforms across many of these factors of performance. This reality complicates the competitive strategy between taxi firms and rideshare platforms.

3.1 Barriers to Entry

Strategic barriers to entry in an industry include the structural characteristics of an industry that prevent free entry. Firms operating successfully in industries with high barriers to entry, tend to be well protected from the threat of new entrance. The central finding from anecdotal analysis of the taxi industry is that there is asymmetry in many of the barriers to entry. In other words, entry into the traditional taxi segment and entry into the rideshare market consititue different tasks, with correspondingly different barreirs to entry.

Entry restrictions have historically protected traditional taxi companies from new entrants. However, Uber's disruption of the market, by circumventing the industry's regulatory framework by position itself as a technology intermediary instead of a taxi firms enables its entry (albeit controversially) to the industry. In general, when analysing the barriers to entry in the taxi industry, there seems to be a clear distinction beetween the barriers to traditional taxi markets vs. rideshare markets.

3.1.1 Economies of Scale

The presence of economies of scale in the taxi industry is not symmetrical across actors. As an independent medallion taxi driver with constant marginal costs, economies are scale do not exist Yang and Yang (2011). For taxi leasing agents; however, Pagano and McKnight (1983) find that economies of scale exist up until a certain output level, at which point they vanish. As a result, their study concludes that medium sized leasing agents in the taxi industry have U-shaped average cost curves. As a potential entrant considering entry into the traditional taxi market, economies of scale therefore do not pose as a barrier to entry in terms of operating profitably at low output levels. That said, for entrants with scale aspirations, the absence of scale economies could certainly demotivate entry.

In both aforementioned studies, the costs curves that were presented relied heavily on the presence of fleet maintenance costs (Beesley, 2013). However, this assumption does not hold for rideshare platforms, and as a result, economies of scale exists exists in this segment. As technology intermediaries between the driver and rider sides of the taxi market, rideshare platforms are not responsible for managing fleets. Instead, platforms have fixed costs associated with developing and operating their application, matching algorithms, etc., and revenue is collected as a percentage commission on each trip's fare. Rideshare platforms, most certainly have economies of scale.

Adjacent to economies of scale, rideshare platforms are subject to network economics and indirect network effects. In practice, this means that the attractiveness of a rideshare platform to both drivers and riders is dependent on the number of users on the opposite side of the network. In other words, more riders make the platform attractive for drivers because of earnings potential, which causes more drivers to join (Rysman, 2003; Evans 2003). More drivers make the platform more attractive for riders because of reduce wait times. Without critical mass on either side of the network, however, the platform cannot be successful (Caillaud and Jullien, 2003; Zhu and Iansiti, 2007; 2012). Therefore, while the promise of economies of scale may attract entry to the rideshare market, the necessity to reach a critical mass of users on both side of the network stand as a stark barrier that few firms can overcome. Moreover, the need for a large network in the rideshare industry means that there may be a efficient limit on the number of firms that can operate in the market before its fragmentation makes it impossible for any firm to be profitable. In other words, the rideshare business model may be one produces natural oligopolies (Kenneth et al. 2015; Sun and Tse, 2007).

3.1.2 Capital Requirements

Historically, the capital requirements to enter the taxi industry have been relatively flexible due to the industry employing a range of ownership models. For a single prospective taxi driver, it is possible to enter the market with a relatively small amount of capital. After becoming a licensed taxi driver, taxi leasing firms offer a point of access to a medallion taxi without the upfront investment in either a vehicle or a taxi medallion.

Taxi leasing companies on the other hand, have significant capital requirements. Entry into the taxi industry via this ownership model, allocates capital establishing a fleet. This mainly involves purchasing vehicles and retrofitting them according to regulators specifications, and appropriating taxi medallions, which depending on the city, and be as much as $1 million for a single medallion[11]. In addition, a property to store the vehicles when they are off-duty, maintain them, and operate a dispatch office are all necessary capital expenditures.

Entry into the taxi market as a rideshare platform comes with the most significant capital requirements. Although purchasing taxi medallions and taxicabs is not necessary, building a platform and network is. The costs associated with building a strong rideshare platform with novel algorithms is high; however, often the cost of building a network is much higher. Since the entrance of subsequent rideshare platforms after Uber, all platforms have been competing intensely using subsidies to incentivize both side of the network to participate and be loyal. This intense price competition between rideshare platforms undoubtably who are not able to subsidize their fares in the same way.

[11] https://www.washingtonpost.com/news/wonk/wp/2014/06/20/taxi-medallions-have-been-the-best-investment-in-america-for-years-now-Uber-may-be-changing-that/?utm_term=.664465cb74c1

3.1.3 Switching Costs

One of the only uniform characteristics of the taxi industry across both traditional taxis and rideshare platforms is the absence of switching costs for consumers. Without switching costs both traditional taxis and rideshare firms must win every single customer trip, without guarantee of future trips. The lack of switching costs in the industry fuels uncertainty because consumers can move from one network to another overnight, and there are rarely market signals to anticipate this shift.

Of course, in markets monopolized by traditional taxis, where rideshare platforms do not operate, switching costs have been largely unproblematic in the past. However, today, it seems that the mobility of consumers between traditional taxis and rideshare platforms, and from one rideshare platform to the next, fuels a constant competition - one that is particularly risky for rideshare platforms who depend on indirect network effects to deliver a strong value proposition. Srinivasan (2004) warn of the grow quick, decline quicker cycle, which sees platform companys grow quickly because of indirect network effects, but also decline quickly as users of the network will tend to all leave at one.

In addition to nearly zero switching costs for consumers, the drivers in ride hail networks also face small switching costs between platforms, and to multi-home. Multi-homing is a popular concept in network economics and refers to the ability for network participants to belong to more than one network (Liu et al.,2017). In the case of the rideshare industry, multi-homing is seen among drivers by joining two platforms (e.g. Uber and Lyft) and simultaneously running both applications to find passengers. Riders also often multi-home by having more than one rideshare application on their phone, which they can use to compare prices across platforms.

3.1.4 Government policy

Undoubtably, pervasive government regulation has historically served to be the most significant barrier to entry for the taxi industry. The most common form or regulation has been limited or even foreclosed entry into markets through the use of medallions and driver's licenses. While government may affect entry barriers through regulation, it can also affect the rivalry among competitors through the use of subsidies. In some taxi markets where taxi service is especially regarded as quasi-public good, governments may often subsidize taxi companies to compel them to provide service in places even where there is low-demand.

3.2 Modelling Taxi Profits

In accord with theory of the firm, this paper assumes that all strategic behaviour among taxi firms contends for profit maximization. Pursuant to this, firms are conventionally tasked with price and quantity decisions, which, when taken together, can maximize profit. While price and quantity decisions alone may overly simplify the strategic mandate of taxi firms, the exercise of modelling these decisions remains a compelling starting point towards understanding competitive strategy in the taxi industry.

The remainder of this chapter presents an economic analysis of price and quantity decisions in the taxi market, market equilibrium, and a subsequent set of industry-specific strategic decisions.

Cairns and Liston-Heyes (1996) bring to light two characteristics of the taxi industry that make it a prototypical specimen of economics analysis. First, it is subject to interrelatedness of supply and demand because: "one individual's ride will, at a margin, increase the waiting time of all other potential riders, a negative externality."

Second, there is a mismatch between the units of the cost of a trip, which is the industry's output, and the cost of operating a taxi, which is a constant cost per hour the taxi is in service.

Modelling the taxi industry has been subject to extensive literature - for a full review of it, see Salanova et al. (2011). The first contribution to this literature is the aggregate taxi demand model by Douglas (1972), where a generic market with regulated price, but free entry is considered. Douglas (1972) has been used as a standard of reference by all other authors of taxi industry models (Manski and Wright, 1976; Cairns and Liston-Heyes, 1996; Yang and Yang, 2011; etc.).

Due to the model's simplicity, this paper uses the Douglas (1972) model as a foundation for understanding profit in the taxi industry. Equation (3) represents the general aggregate profit model for the taxi industry and is supported by Equations (4) – (8), where Q denotes the quantity of taxi services demanded in the market, P is fare price, W is the mean wait time in the market for a customer to meet a taxicab, TC for total costs, and V is the total time that the market is spent "vacant" (without a paying customer).

Equation 1: General Model of Taxi Profit

$$\pi = (Q \cdot P) - (TC)$$

Special attention is owed to Equation (2), which models taxi service demand as a decreasing function of expected fare and expected wait time (a proxy for quality). In other words, consumers' demand for taxi services increases as either their journey's expected fare (4) or expected wait time (3), or both, decreases. This relationship between wait time, price, and demand, thereafter, is the basis of the intervening relationship between supply and demand in the taxi industry.

Equation 2: Taxi Demand Function

$$Q = f\,(P, W),\ \partial Q / \partial F < 0,\ \partial Q / \partial W < 0$$

Equation 3: Customer Wait Time

$$W = g\,(V),\ \partial T / \partial V < 0$$

Trip price, *P*, in Equation (4) is captured by the standard taxi fare charge per time unit duration for the trip. This is most commonly measured in the number of elapsed minutes from the instant the customer's trip begins to the instant the customer reaches their destination.

Equation 4: Taxi Price (Fare)

$$P = P \cdot (\text{time of trip})$$

A taxi firm's total cost function, *TC*, in Equation (5) is a constant cost multiplied by the amount of time the taxi is operating. In other words, the cost of operating a taxi is assumed to be independent of the proportion of time the taxi spends "occupied" or "vacant." (Orr 1969; Douglas, 1972, Yang and Yang, 2011) This assumption is intuitive, since the entire time that a taxicab is in service, regardless of it is completing a trip with a paying customer, or waiting for its next customer, it is accruing costs like consuming fuel with cruising in search of customers, and the vehicles useful mechanical life.

Equation 5: Taxi Total Cost Curve

$$TC = c\,(Q + V)$$

Thus, a constant *TC* function has important implications for the profitability of a taxi firm. First, this assumption means that the marginal costs for a taxicab accepting an additional customer is nil, aside from the opportunity costs of not being available for some other customer. Second, a constant *TC* means that the taxicab's utilisation, *U*, directly governs its profitability (Orr, 1969; Yang, 2002; Flores-Guri, 2003; Yang and Yang, 2011).

Yang and Yang (2011) have modelled taxi utilisation rates with Equation (7) as the fraction of time a taxicab is occupied by a customer over the time it is vacant. Let *I* denote the average taxi trip length as a fraction of an hour. Therefore, let *IQ* denote the total time the market is completing trips, over *N* number of taxicabs supplying the market, yielding *U*.

Equation 6: Taxi Utilisation Rates

$$U = IQ/N,\ 0 < U < 1$$

"The equilibrium quantity (total taxi-hours) supplied will be greater than the equilibrium quantity (occupied taxi-hours) demanded by a certain slack (vacant taxi- hours). This slack governs the average customer waiting time" (Yang and Yang, 2011).

Therefore, utilisation rates directly govern taxi profitability in two opposing ways. First, a high *U* will distribute constant *TC* over more units of *Q* (i.e. limiting the amount of time a taxicab spends in operation, accruing cost, but not generating revenue). Second, *U* influences the consumer demand for taxi service because *W* is a function of the number of vacant cab hours, *V*. Therefore, because an increasing *U* for the entire market necessarily forces *V* to decrease, consumers will be faced with longer wait times (Yang and Yang 2011). Based on Equation (4), longer wait times will depress demand for the taxi service. There is some debate on this concept, however. For example, De Vany (1975) supports the case for excess capacity in the taxi industry, citing that it affects the value and quality of service received by customers by reducing wait times and planned costs, subsequently increasing their demand for the service.

If taxi profitability is a function of *U*, where a high *U* is desirable to evenly absorb *TC* (economies of scale), but a high *U* may also reduce overall demand for taxi services due to long wait times, the equilibrium supply of taxicabs to the market, becomes critically important.

Lastly, because *W*, determined by (3), is the average wait time in a given market, and depends on the total number of vacant taxi hours, a single firm cannot offer customers an expected wait time that is different from any other firm in the market. Thus, in this model, wait time is not amenable to competitive differentiation (Douglas, 1972; Frankena and Pautler, 1984; Yang and Yang 2011).

4. Case Study: New York City (NYC)

4.1 Background

The history of New York City taxis shows evolution in the industry's business model and regulatory environment. The earliest recorded taxicabs arrived in the city in 1897 and were unregulated. Price and quantity became regulated in 1907 and 1937 respectively.[12] In August 2018 the TLC created a new license class: "High-Volume For-Hire Service (HVFHS). Included in this license class is any For-Hire Vehicle base that dispatches > 10,000 trips per day. The class was made with the express intention of regulating rideshare platforms.

NYC offers two varieties of taxicabs: Yellow and Green. Green taxicabs were introduced to supply New York's Outer Boroughs[13], which had historically been underserved by the Yellow taxicabs who concentrate themselves in the Manhattan below 110th street where search frictions to locate street-hail customers are minimized due to the area's high population density.

The remainder of this chapter discuss the different segments of the NYC taxi market, the market's regulator environment, and the firm ownership model.

4.2 Taxi Market Segments

Since taxis do not offer a single, homogenous good, it is helpful to disaggregate the market into the following five segments: (1) street hail (2) rank (3) dispatch (4) contract and (5) shared (Aarhaug and Skollerud, 2013). Table 1 sorts these segments against the engagement method used by customers to purchase the taxi service, where each segment is spatial located, their pricing model, and the customer-taxi relation at the point-of-purchase.

It is conceivable that the manner in which the taxi market has segmented itself has been a natural response to diverse consumer demands. To a large extent, these segments have also been reinforced with regulatory boundaries between them. One example of this is rather apparent from a quick glance at Table 1, where it can be seen that taxicabs serve all five market

[12] Taxi! A Social History of the New York City Cabdriver

[13] New York City is divided into five geographic "boroughs" (i.e. districts or territories) - Manhattan, Queen's, Brooklyn, Staten Island and the Bronx. Being the most densely populated borough, Manhattan is often divided further by "above" or "below 110th Street"

segments while rideshare platforms are limited to dispatch. This division exists because the street hail, rank and contract segments are more heavily regulated than dispatch.

From a strategic management perspective, this boundary creates an asymmetric relationship between taxicabs and rideshare because taxicabs can compete in the dispatch segment against rideshare; however, the rideshare platforms are unable to compete with taxicabs outside of this - leaving the remaining three segments monopolized by taxicabs. This asymmetry between taxicabs and rideshare underscores the importance of market structure when explaining performance differences between taxi firms.

Table 1: Taxi market segments

	Hail	**Rank**	**Pre-book**	**Contract**	**Shared**
	Street markets				
Contact	On the street	At taxi stands	Over the phone / smartphone app	Agreed in contract	On the street / over the phone
Location	Densely populated areas	Popular addresses with. stable demand (e.g. airports)	Nearly everywhere	Nearly everywhere	Nearly everywhere
Pricing	Regulated meter (distance and time)	Regulated meter Negotiated fare	Regulated meter - usually quoted at booking. Negotiated fare	Negotiated fare	Regulated meter, or negotiated fare
Customer-taxi relation	One customer, one taxi	One customer, one or more taxis	One customer, one or more taxi companies	Several customers, one or more taxi companies	Many customers, one taxi

4.2.1 Street hail / cruising

The street hail segment is profitable in densely populated areas of cities, such as Manhattan < 110th St, where taxicabs can cruise around and be matched with customers at random locations. In order to match, prospective customers must physically signal to passing taxicabs that they demand their service.

By nature, this process incorporates a large element of chance, which Equation (5) partly explains as expected wait time. This wait time can also be termed as transaction costs or search frictions. Buchholz (2017 and 2018) models the search process as a strategic game played by independent taxicabs that depends on the location and search behaviour of their competitors.

Search frictions make it highly unlikely that a customer be faced with two taxicabs competing for their business. Instead, faced with only one taxicab at a time, customers are unable to compare prices and quality across taxis, and a temporary monopoly emerges (Dempsey, 1996).

4.2.2 Rank / stand

Rank markets exist at a limited number of pre-established locations where taxicabs can organize themselves in a single file line and await customers. This segment tends to be profitable when located outside of popular destinations that have predictable demand. Airports and sporting events are good examples.

When a customer arrives at the rank, the presence of >1 taxicab creates a fundamentally different economic scenario from the street-hail segments. In this context, Bertrand competition is likely to emerge. This is supported by Equation (5), which highlights constant costs, and therefore, zero marginal cost for a taxicab to perform an additional trip. As a result, the

4.2.3 Dispatch / pre-book

Dispatch taxicabs are matched with customers via an intermediary. Once the intermediary has received a customer's request, it is immediately put out to the market to be fulfilled. While two-way radios were once the *sine qua nxon* of the dispatch segment, rideshare platforms have since established an advantage in this segment by offering smartphone applications that perform the dispatching task over telecommunication networks.

4.2.4 Contract

Companies operating taxi fleets often enter into short or long-term contracts with other companies to provide transportation for many customers. The taxi companies have to maintain large fleets in order to service the contract reliably, which can be interpreted as a significant barrier to entry to the segment. Moreover, once a contract has been signed, there is little residual competition within the segment for that business.

In addition to the previous four segments, some markets employ a fifth segment: shared taxis. Historically, shared taxis have been more common in emerging markets due to their power to harness economies of scale in order to drive fare prices down for individual customers. Since 2014[14], however, Uber and other rideshare companies have begun offering shared taxis also.

4.2.5 Shared / pool

Shared taxis function by collecting trip requests with roughly similar origins and destinations, then grouping them in a single vehicle (Aarhaug and Skollerud, 2014).

4.3 Regulatory Environment

The NYC Taxi and Limousine Commission (TLC) has been charged with regulating the city's taxi industry since 1971.

The supply of traditional taxis became regulated though the use of taxi medallions in 1937.[15] At first, the city issued 16,900 taxi medallions, which since been reduced to 13,587 - where it remained constant until August 2018 when 7,676 more medallions were issued for use by "Green" taxicabs.

In addition to expanding the total number of traditional taxicabs in the city, the Green taxicab service also introduced a layer of jurisdictional regulation. While, Yellow traditional taxicabs are able to accept trips anywhere in NYC and be engaged by any segment of the market (street hail, dispatch, etc.), Green traditional taxi cabs are restricted from accepting customers in Manhattan below 110th street and at either of the city's two airports. With intent, this regulation effectively limits service overlaps between Yellow and Green taxicabs, and with it, limits competition between the two also.

Unlike Green traditional taxicabs, drivers for rideshare platforms are permitted to pick-up customers anywhere in the city; however, they are instead regulated on acceptable terms of engagement with prospective customers. Whereas traditional taxicabs are authorized to engage with all segments of the taxi market (street-hail, rank, dispatch and contract), rideshare drivers may only accept a customer's trip if it has been dispatched through a legal base. Rideshare drivers are strictly prohibited from accepting street-hail trips.

[14] https://techcrunch.com/2014/09/02/Uberpool-launch-for-real/
[15] The Haas Act was signed by Mayor Fiorello H. La Guardia in 1937, regulating the supply of taxicabs in New York City.

Traditional taxis use a two-tier pricing model. The initial charge of taxi trip is 2.50 USD, plus .50 USD per 1/5 mile when traveling above 12 mph or per 60 seconds in slow traffic.[16] Beyond the requirement that drivers obtain a HVFHS licence, rideshare platforms are not regulated on price NYC.

4.4 Firm Ownership

Those with TLC driver's licences may operate a NYC Yellow or Green taxicab of their own (assuming they also own a TLC traditional), or they may choose to lease a taxicab and traditional from a fleet firm.

As of January 2019, there were 67 traditional agents operating fleets for lease to licenced TLC drivers. Those TLC drivers who are licenced but do not own a traditional may visit a traditional agent to rent a licenced taxicab for a short period. Typically, taxicabs are leased on a daily, or weekly basis. The drivers pay a flat rate for the lease, which is independent the number of trips they complete while operating the taxi (reflecting constant costs per Equation 5)

Rideshare platforms serve as an intermediary between drivers and riders and do not own taxi medallions or taxicabs. The first rideshare firm to enter the market was Uber in 2011. It was followed by Lyft, Inc. (Lyft) in 2014 and Juno in 2016. Since 2018 drivers for rideshare platforms have required a TLC driver's licence, similar to traditional taxi drivers; however, it wasn't until August 2018 that the number of licences was regulated - effectively freezing the number of rideshare licenses issued. Although all rideshare trips are mediated by one of the previously mentioned platforms, rideshare drivers are considered independent contractors. Drivers use their own vehicle and do not require a taxi traditional.

Lastly, rideshare platforms operate a commission regime which is absent of fixed costs for drivers and instead collects a portion of every trip fare. This commission serves as can be considered the price to access the rideshare platform's network of riders, which generate income for the drivers.

Angrist et al. (2017) point out that drivers who work long hours prefer leasing a taxicab at a fixed-costs because they are able to keep a higher proportion of their earnings. Drivers who

[16] https://www1.nyc.gov/site/tlc/passengers/taxi-fare.page

work a small number of hours prefer the commission regime because it negates the risk of them ever earning negative profits.

In summary, NYC's traditional taxi market operates with three main actors:[17]

1. Independent traditional taxi drivers
2. Fleet traditional taxi drivers
3. Independent HVFHS (rideshare) drivers

For the sake of simplicity, this research groups these three actors all under the broader umbrella of traditional taxis firms. As it relates to strategic management, all traditional taxi firms operating in the NYC taxi market with the intent to maximize individual profits. In addition, these competitive behaviour of these three actors is closely regulated by a fourth actor.

4. New York City Taxi and Limousine Commission

Finally, whereas the independent traditional taxi drivers and the fleet traditional taxi drivers engage in largely independent competitive games, the rideshare drivers are largely influenced by the platform with which they have membership. The following rideshare platforms operated in NYC at some point between 2011–2017:

5. Uber
6. Lyft
7. Juno
8. Gett

All of these rideshare platforms are responsible for maintaining applications and algorithms that match drivers and customers, route trips, and market their service.

[17] There are more actors than this, however this paper only considers these three.

5. Methodology

This chapter details the research methods employed by this thesis to explore the competitive effects of rideshare growth in established taxi markets. First, the research design is revealed, followed by an introduction to the collected data, and finally a description of the empirical model. Afterwards, the quality of the research design is critically reviewed in order to illuminate possible weak points and establish reliability and validity.

5.1 Research Design

Research design entails integrating components of this thesis in a coherent and logical way. In other words, the research design is the creation of an analytical framework that will systematically answer the research question by collecting and analysing data in a manner that produces significant results, reliably (Saunders et al., 2011). Good research design avoids drawing invalid inferences, while also proving to be creative about the use of accessible data.

This thesis uses a single case study of New York City's taxi market, involving three actors: Yellow Taxi, Green Taxi and Uber. Case studies tend to be successful as a research strategy because of the "real-world" applications that come from studying a phenomenon in its uncontrolled context (Saunders et al., 2011). Case studies are also widely considered to be a valid approach for strategic management research specifically (Larsson 1993; Hoskisson et al. 1999). In general, case studies are thought to be most applicable to research problems that are "a) broad and highly complex, b) when there is not a lot of theory available, and c) when 'context' is very important" (Dul and Hak, 2008). Therefore, the complex economics of the taxi industry, lack of theoretical knowledge about taxis in the strategic management discipline, and the influence of local regulation on the market, all lead to the conclusion that the use of a case study is highly appropriate for this thesis.

5.1.1 Research Approach

This study uses both deductive and inductive research approaches. Deductive research relies on existing literature to develop an understanding of a phenomenon, which is then tested with data (Saunders et al., 2011). Here, the literature on taxi profitability and the factors contributing to taxi demand is used.

While building on the existing literature has provided a strong foundation to examine how the growth of rideshare platforms effects competition in the taxi industry, the relative newness of the phenomenon also means that existing literature may struggle to provide an appropriate answer. As a result, this study retains some flexibility in its approach to answering the research question by using induction. Inductive research seeks to understand a phenomenon, particularly within its context, by exploring data in search for explanations not expected beforehand (Sauders et al. 2011).

Case studies have long been the backbone of strategic management research (Hoskisson et al., 1999). Perhaps this is because the discipline has focused predominantly on the performance of specific firms and industries which makes case studies appropriate, but also deeply entangles the discipline in the complexity of social environments, requiring induction to break through all the noise. In a sense, unpacking the complexity of real-world case studies is what makes the strategic management discipline so valuable, and interesting as a researcher.

Adopting both deductive and inductive approaches in this manner is appropriate for much of the same reason that using a case study strategy is. First, the overall objective of this thesis is to unearth new theories about the competitive effects of rideshare platforms. Second, deductive research has proven helpful in specifying this study's empirical model. Lastly, as an approach to understanding competitive dynamics between incumbent taxi firms and new rideshare platforms, the inductive research stands to contribute the most due to its open-mindedness when exploring this new phenomenon.

Given the newness of the competitive phenomenon between taxis and rideshare, and the resulting lack of existing research on the topic, an inductive approach came about naturally. It began with significant, and time consuming, exploratory research into and how existing literature serves to explain competition in the taxi market. Eventually, this process led to the emergence of a research question that is both interesting and makes a valid contribution to the discipline of strategic management.

5.1.2 Research Strategy

This is a quantitative study, which collects public data for inductive exploration. The combination of quantitative methods and a case study reflect the contemporary state of strategic management research (Ketchen et al. 2008; Martín et al., 2014). Quantitative data allows this thesis to develop a scientific characterization of the competitive effects of rideshare growth. This is also a longitudinal study, which follows Yellow Taxis, Green Taxis and Uber over a three-year period. Since Such a significant timescale allows the study to capture the dynamics of change in NYC's taxi industry.

This research examines the competitive effects of rideshare platforms on a single taxi market: New York City. Several factors were considered when choosing this case. First, New York City it is among the most established taxi markets in the world. Second, there exists an abundance of public data on individual transactions in the market. Third, Diversity across the city's five boroughs - in terms of both economic and social indicators, may produce findings that are generalisable to a range of urban contexts. Lastly, the rideshare platforms under study are based in the United States, so it is best to avoid studying foreign markets, where the 'foreignness" of a rideshare platform alone could affect its performance vis à vis traditional taxis.

Demand elasticity has been another important matter related to the taxi industry, studied by economists De Vany (1975), Daniel (2003), and Yang et al. (2005). As noted earlier, in the context of rideshare, Cohen (2016), Wallesten (2017) and Jiang (2018) all incorporate demand elasticity into their investigation of Uber's entrance into either the NYC or San Francisco taxi market.

The general form of demand elasticity measures a change in demand for a good or service in relation to a one per cent change in some other economic variable. Equation (1) explains this relationship

Equation 7: Elasticity of Demand

$$e = \%\Delta y \;/\% \;\Delta \; x$$

With respect to demand elasticity in among taxis specifically, De Vany (1975) builds on the taxi model presented in Douglas (1972) to explore how market structure effects equilibrium. He considers monopoly, competitive, and traditional market structures. Of particular interest to this paper is his analysis of competitive equilibrium. Here, De Vany (1975) presents a demand elasticity model that features the volume of trips performed by firm j as its dependent variable, and the volume of trips performed by competing firm, *i,* as the independent variable. The result is a demand elasticity measure that expresses the percentage change in the volume of trips performed by firm j given a one percent change in the volume of trips performed by firm i. His model takes the following form.

Equation 8: De Vany Taxi Elasticity Model

$$e_i = 1 + (e - 1)\frac{h_i}{H} + (e - 1)\frac{h_i}{H}\sum_{j=0}^{n-1} \partial h_j/\partial h_i$$

Where $\partial h_j/\partial h_i$ is the change in the firm j trip volume induced by a change in cab i volume. De Vany (1975) concludes unit elasticity generates zero profit and elasticity > 1 generates negative profit. Therefore, demand elasticity must be < 1 for the industry to be profitable. Aside from De Vany (1975), Daniel (2003) obtained an inelastic relationship between vacant taxis and demand. And, Yang et al. (2002) prove that unitary elasticity produces the maximum competitive taxi fleet size.

5.2 Data Collection

This section explains the type of data used in this study, how it was collected, and how it was handled.

5.2.1 Type of Data

This study obtained longitudinal data on the daily volume of taxi trips completed by various taxi service firms in New York City. Therefore, the main unit of analysis for this study is a single taxi trip. There cannot be a portion of a taxi trip, so this data is considered as discrete datum (Saunders et al. 2011). Since a consumer's decision to use taxi service is typically a one-shot game that does not demand commitment for them to use the service more than once, the costs to switch between one taxi service provider and another is zero. As a result, each taxi trip represents a single consumer purchase decision.[18]

5.2.2 Data Sources

The data used by this study was originally collected and accessed through the NYC Taxi & Limousine Commission's (TLC).[19] The TLC has published detailed data on every transaction

[18] Consumer who use taxi service from the contract segment may not have made a "purchase decision." For example, if an employee uses a taxi because their employer has negotiated a contract for all employees to access taxi service late at night, that consumer will only be taking the taxi because their employer is paying for it.
[19] https://www1.nyc.gov/site/tlc/about/tlc-trip-record-data.page

by Yellow Taxis since January 2009[20], Green Taxis since August 2013 and For-Hire Vehicles since January 2015.[21] Transaction data on trips completed by rideshare platforms are included in the For-Hire Vehicle records.

Data from trips completed by either Yellow of Green Taxis is collected by the TLC themselves through telecommunication networks that are connected to each taxicab meter and payment terminal. The trip records include fields capturing the pick-up and drop-off dates/times, the pick-up and drop-offs locations, distance travelled, and more.

Data from trips completed by rideshare platforms are reported to the TLC by the platforms themselves. Such self-reporting techniques may introduce some concern about the credibility of the data; however, being that this data is reported under legal obligation, the risk of false reporting is minimal.

During the entire period the data was available (2009–2017) there were a total of 1.76 billion transactions - each one representing a single trip completed by either a Yellow Taxi, Green Taxi or Uber. The total file size of this dataset is more than 300 GB. Unfortunately, this meant that the raw dataset was too large for my computer to ingest. Thankfully, however, an initial analysis of the data was completed by Todd Schneider,[22] which aggregated the raw data from the transaction level into daily figures. This aggregate data set has a considerably smaller file size and was retrieved online through GitHub.

5.2.3 Summary of Data

The aggregate dataset used by this study was downloaded with 51,780 observations. This included the daily volume of trips performed by eight taxi service providers across five geographic regions of in NYC. The eight providers include Gett, Juno, Via, Lyft, Uber, Yellow taxis and Green taxis, and a blanket firm termed “non-app FHV” for limousine and black car services. The observation period is January 1, 2009–December 31, 2017; however, only the Yellow Taxis have recorded observations for that entire period. By using the aggregate daily trip records of Yellow taxi Green taxi, and Uber by pick-up location and date, I can merge

[20] The TLC actually has some records starting from 2008; however, it seems that the data was not being collected regularly until 2009.
[21] Each transaction in the dataset represents one trip.
[22] Todd Schneider is a graduate of Yale University in the U.S. and is a data scientist at Genius. Before using Todd’s dataset, I contacted him myself to gain a better understanding of how he handled the data. The data and code that Todd used to process the data was retrieved available on GitHub.

them to have matched records for all three taxi services. The total number of time points which are in relation to January 1, 2016, is 1096. The total number of location entities is 5.

For each entity, the daily number of trips is recorded as the total for all of NYC, as well as disaggregated by location. Each trip was assigned to one of four locations based on the trip's pick-up location: airport, Manhattan, Manhattan < 100th Street, or outer boroughs. Appendix I provides a summary of this data.

The main benefit of the data that has been collected is that it follows the number of daily trips across different locations in NYC over time. This characteristic of the data enables the use of a panel regression model to estimate the elasticity of demand for taxi trips with respect to Uber. Regression analysis has been a prominent analytical tool in strategic management research since the early 1990s, particularly out of a need to test the theories of Michael Porter, which were becoming increasingly influential at the time (Ketchen et al., 2008). Before running that analysis; however, the data required some preparation, which is detailed in section 5.3.1.

5.3 Data Analysis

The findings of this thesis rely on data analysis executed by Stata 15.1 SE. Being an exploratory study means that the data analysis was also conducted in an iterative way. This is quite a common process according to Kvale (1996) who characterizes data analysis as very much interrelated and interactive with the development of all other components of a research project. This section describes the steps that were taken when handling the data, and how the analysis was completed.

5.3.1 Data Preparation

After downloading the dataset, it underwent two phases of preparation. The first phase corresponded to the initial analysis if the NCY taxi market. In the first phase, the soul manipulation of the data was to omit all observations on non-app FHV transactions, which can be considered immaterial to this study. The non-app FHV segment has existed in NYC for many years and is regulated by the TLC such that does not directly compete with taxicabs. Since this thesis aims to study the competitive effect of rideshare platforms on traditional taxis, non-app FHV observations can confidently be excluded on the basis of immateriality. After this, n=47,516 observations remain in the dataset. The analysis of the remaining data is presented in section 6.1

The second phase of preparation pertains to focused analysis, which is presented in sections 6.2. To prepare the data for the focused analysis, two main actions were taken. First, observations for Gett, Juno, Via, and Lyft were all omitted from the data set. There are a variety of reasons for doing excluding these observations. In the case of Gett and Juno, the observations were only estimates based on extrapolation from monthly figures. As a result, the observations are of ambiguous quality, especially when compared to actual daily figures for Yellow taxis, Green taxis, Uber, Lyft and Via. In addition, non-app FHV observations were also eliminated because the segment is mature, and this study is not concerned with its effects on taxi demand.

While the observations collected for Via are actual and not estimates, these observations were also excluded. This was done for two reasons. First, the Via business model that has been significantly differentiated from both the other rideshare apps and the traditional taxis. Via exclusively provides scheduled shared / pool services for commuters. In effect, this operates somewhere between public transit that has both fixed schedules and fixed routes, and taxi services, which lack both of these qualities. While Uber, Lyft and traditional taxis certainly the commuter market to some extent (citation for NYC transport survey), it is reasonable to assume that Via competes more directly with rideshare platforms than it does with traditional taxis. Since this study is interested in the competitive effects of rideshare platforms on traditional taxis specifically, it is reasonable to exclude Via. Second, since Via is a relatively small firm in the overall rideshare market (5% market share in 2017, compared with Uber's 38.5% for the same period), the effect of excluding these observations is unlikely to reduce the quality of the research findings very much.

Lyft was excluded on the rationale that it the focused study could be made stronger if it measured the competitive effects of a single firm on traditional taxis, than if it measured, the impact of a sample of the rideshare platforms. In other words, a study that included Uber and Lyft, but not the other platforms could offer, at best, a partial analysis of industry competition.

All observations before January 15 were omitted. This is because January 2015 onwards is the period that we have data for Uber, and although we have data for Yellow and Green taxis from

2009 and 2013 respectively, we have excluded this data due to the concern of misrepresentation. This concern stems from the fact that while data on Uber transaction appears in the data set starting January 2015, the platform has been operating in the New York City since 2011, and their UberX service since 2012. Therefore, the dataset before 2015 can be considered incomplete since it fails to include a complete picture of all market activity before 2015.

Lastly, the data was transformed into a panel data set, such that it read like a cross section with location as the panel variable and date as the time variable. When collecting and arranging panel data, careful attention must be paid to ensure that the different time periods for the case cross sectional unit are easily linked (Wooldridge, 417). Appendix II displays how the panel data is stored in Stata.

This was done intentionally so that during the analysis of the data the elasticity of demand estimates could be determined for the individual locations in the city as well as over time. Panel data is the best way to study the dynamics of change and is often only limited by the ability to collect sufficient data. Luckily, this study is able to use panel data, making its insights all the more powerful. Locations are coded 1-5 (1. Total Sample; 2. Manhattan; 3. Manhattan < 110^{th} street; 4. Manhattan > 110^{th} street; 5. Outer Boroughs.) I added an additional binary coded variable to indicate whether a data is a weekday (Monday–Friday) or a weekend (Saturday and Sunday). The ability to tease out demand elasticity for these variables helps develop our understanding of the competitive dynamics and to at least, in part, capture some of the temporal variation of demand in the data.

The final product of this data cleaning is a set that includes n = 5480 observations on the total number of daily Yellow Taxi, Green Taxi, and Uber trips from January 1, 2015–December 31, 2017.

5.3.2 Initial Data Analysis

The intent of the initial data analysis is to explore trends in the data that may guide the subsequent, more focused, data analysis that follows. This analysis was completed in Microsoft Excel using daily trip volume for all market participants.

5.3.3 Focused Data Analysis

The main objective of the focused data analysis is to measure the competitive effects of Uber on traditional taxis, in terms of demand elasticity. Therefore, this section will estimate the elasticity of traditional taxi demand with respect to Uber in the NYC market. This can also be interpreted as the magnitude of Uber's substitution effect in the taxi market.

There is a vast literature that supports taxi demand exhibiting spatiotemporal variation in demand (Buchholz 2018). While some characteristics of demand variation can be attributed to measurable factors like population density, other factors may be unobservable. To account for spatial variation in demand for taxi service, and variation in demand over time, a panel model for the daily number of trips is used.

Equation 9: Panel Regression Model

$$\log(taxitrips_{it}) = \beta_0 + \beta_1 \log(Ubertrips_{it}) + \mathrm{u}_{\mathrm{it}}$$

Equation (9) is the panel regression model where $taxitrips_{it}$ denotes the daily volume of traditional taxi trips in NYC (Yellow + Green) and $Ubertrips_{it}$ is the equivalent measure for Uber trips. The panel variable, location of trip pick-up[23], is denoted by *i*. Denoting date is *t*.

Among the main features of a panel regression model is its ability to control for of time invariant unobservable effect (Wooldridge, 425). This is particularly helpful since NYC's boroughs are socially diverse, which could influence a customer's purchasing decision between taxi and Uber in unobservable ways.

Therefore, the main focus is to estimate the coefficient, β_1, which can be interpreted as the taxi elasticity of demand with respect to Uber. As is the case for all panel data, the interpretation of the beta coefficient is "for a given location, as *X* varies across time by one unit, *Y* increase or decreases by β units" (Bartels, Brandom, 2008). By using the log values of $taxitrips_{it}$ and $Ubertrips_{it}$, the impact propensity of Equation (9), denoted by β_1 expresses short-run elasticity (Wooldridge, 324). Appendix IX proves this relationship using calculus. As a short-run model, it represents the immediate impact of a percentage change in *taxitrips* given a one per cent change in *Ubertrips*.

[23] i = (1-5), where 1 = entire sample; 2 = Manhattan; 3 = Manhattan < 110th St.; 4 = Manhattan > 110th St.; 5 = outer boroughs

5.4 Research Quality

5.4.1 Model Specification

Bergh and Holbein (1997) argue that more than 90% of longitudinal studies in strategic management had type 1 bias because of insufficient attention to methodological assumptions. To avoid making the same mistake with this study, fulfilment of the regression model's assumptions is demonstrated in Appendix IV and V.

Jiang et al. (2018) tests the effect of a variety of socio-economic feature is on the demand for Uber and Lyft in NYC and San Francisco. They find demand decreased in geographic locations with a high number of family. No significant results were found about the relationship between race and demand. And finally, no significant results were found for the effect of income on Uber or Lyft demand.

5.4.2 Validity

Internal Validity

Internal validity concerns itself with whether the research that is being conducted establishes causality as intended. In contrast, research that lacks internal validity spuriously associates two variables (Ketchen 2008). In order to establish a causal relationship between variable, three conditions must be satisfied. First, the variables must be related. In other words, correlation must be observed. Section 6.2.1 provides proof that the volume of taxi trips and the volume of Uber trips are correlated.

Second, the temporal antecedence condition requires that the change in the independent variable happen *before* the change in the dependent variable. While establishing perfect temporal antecedences is difficult with the data used in this study, Figure 4 makes a compelling case by showing that the daily volume of taxi trips was relatively stable until Uber enters the market, at which point it begins to decrease.

Lastly, alternative explanations for the change in the volume of taxi trips must be ruled out. Thankfully, the longitudinal nature of this study makes it largely immune to a single event acting as a confounding variable. In other words, given that conclusions are drawn only after observing the variable over a long period of time, an irregular event that lasts a single day is unlikely to have a meaningful effect on the volume of taxi trip over time. Aside from special events, the demand for taxi service may be affected by the weather (Chen, 2017; Jaing 2018), the growing popularity in a substitute for taxi service outside of Uber (eg. Metro/Subway) or changing socioeconomics in a city.

External Validity

In most cases, the findings from research are more valuable if they can be generalised to a population beyond just that which has been tested. Concern of external validity primarily stems from experimental contexts where a small sample (treatment group) is tested in order to reach generalisable truths. In the context of this research, however, even if the results are generalisable only to the NYC taxi market, they are still worthwhile since NYC is among the largest taxi markets in the world. Work by Jiang et al. (2018) identifies several variables that had significant results in San Francisco, but not in NYC. Of course, San Francisco and NYC are very different cities; however, the fact that variation exists in factors affecting taxi and rideshare demand suggest that it may be difficult to generalise findings beyond a single city.

5.4.3 Reliability

The reliability of research examines whether the results can be produced consistently. (Saunders, 2011) Therefore, analysing the reliability of research involves answering three questions (Easterby-Smith et al. 2008). First, will the observed effect of the independent variable on the dependent variable be seen on alternative occasions. Second, would other research reach the same conclusions if they conducted the same analysis. Lastly, the handling of data made transparent and sensible. As sections 5.2.2 and 5.2.3 highlight, there is potential in this study to be subject or time errors due to daily trip volume figures for rideshare platforms being self-repotting to the TLC.

6. Results

This chapter presents the results of both the initial and the focused analysis. Together, they satisfy the research objectives outlined in Chapter 1.

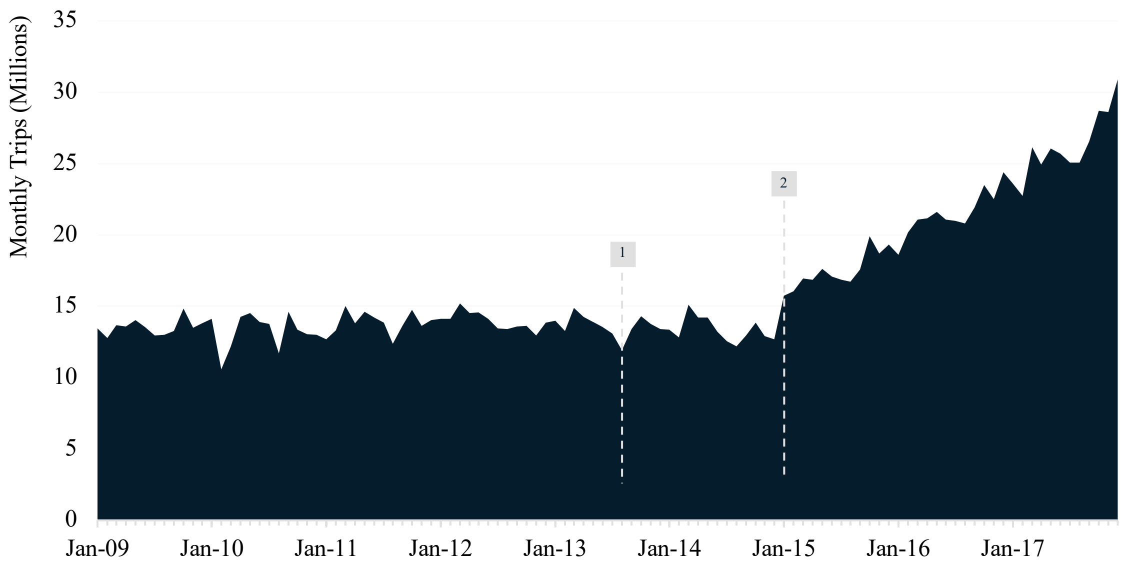
6.1 Initial Analysis Results

Over the full 9-year period this study collected data on for the NYC taxi market, the trend is clear. What was once an uncompetitive taxi market with modest growth, has become dramatically more competitive and is experiencing significant growth.

6.1.1 Market Growth and Segmentation

Porter (2008) argues that the most ubiquitous force leading structural change in an industry is the long run industry growth rate. As a starting point then, it is helpful to orient this study on the NYC taxi markets growth trajectory. Figure 3 reveals the monthly total number of taxi service trips in NYC from January 2009–December 2017. Since at least January 2015, the market has experienced explosive growth, this following many years of relative stability in the market's overall size and growth.

Figure 2: NYC Taxi Market by Total Monthly Trips



1. August 1, 2013: Taxi and Limousine Commission licences 7,676 Green taxis to serve NYC's Outer Boroughs
2. January 1, 2015: TLC begins collecting data taxi trips performed by rideshare platforms

Since the NYC taxi industry has regulated entry, and the number of medallions taxis in the city has remained relatively constant at ~13,500. One could simply conclude that this is the cause of such languid growth, however, Figure 3 also highlights two, more nuanced, trends in the taxi industry's performance. First, in August 2013, 7676 Green taxis were added to the market; however, there seems to not have been an increase in the total volume of monthly trips in the market after this. The addition of Green taxis increases the supply of taxicabs to the market by more than 50%, yet the volume of trips in the market remained relatively constant. This means that one of three things.

First, Green taxis may have performed very few trips, therefore, not growing the overall size of the market. Second, most of the trips completed by Green taxis came from stealing Yellow taxi market share. Therefore, the market did not expand after Green taxis entered, and instead competition between the taxis was focused on capturing/defending market shares in a mature industry. Lastly, the Yellow taxis may have been in decline already and the Green taxis made up for these losses by expanding the market into a new segment. In either case, Figure 3 also indicates that before January 2015 at least, taxicab utilisation rates were falling - this is because the overall volume of trips remained stable, but the number of taxicabs on the streets increased.

From January 2015 onward, the NYC taxi market experienced an immense amount of growth in terms of the total number of trips. On a whole, during the period January 2015–January 2017, the NYC taxi market grew 49.9%, from 209,389,885 annual taxi trips 313,981,158.

Figure 3: NYC Taxi Market Share by Rideshare and Traditional Taxi

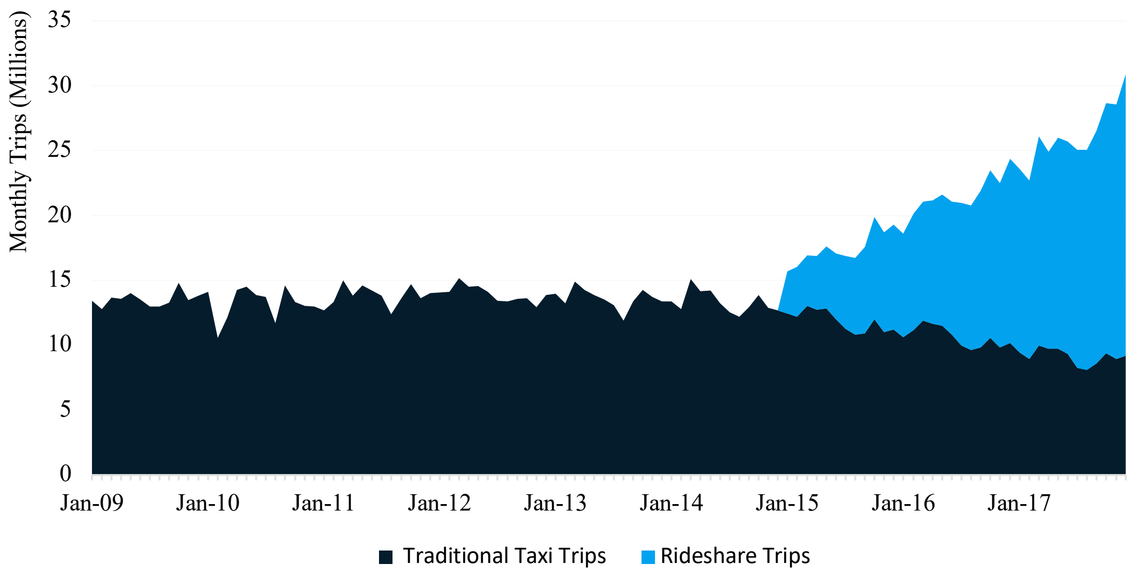


Figure 4 shows all of the growth in the NYC taxi market from January 2015–December 2017 belongs to rideshare platforms. In addition to capturing the market's expansion, the rideshare platforms have also eaten into the market share of traditional taxis. This leads the conclusion that the dramatic change in the long-run growth rate of the NYC taxi market is likely driven by a change in the relative position of substitutes.

Figure 5 attributes the majority of growth captured by rideshare platforms to the expansion of service to the city's outer boroughs. These customers have historically been underserved by traditional taxis, who prefer to position themselves in Manhattan where the street-hail market is profitable. Therefore, it could be argued that the change in the long-run growth rate of the NYC taxi market is attributable to the increasing penetration to new customers. (Porter, 2008) Interestingly, the Green taxi service, which the TLC created in August 2013 for the express purpose of serving the city's outer boroughs, has largely been unsuccessful. Especially over the period, January 2015–December 2017 traditional taxi service market share in the NYC's outer boroughs has eroded. In December 2017, just 1.6% of trips in the NYC taxi market were completed by traditional taxis in the outer boroughs.

Figure 5: NYC Taxi Market Shares Segmented by Trip Pick-Up Location

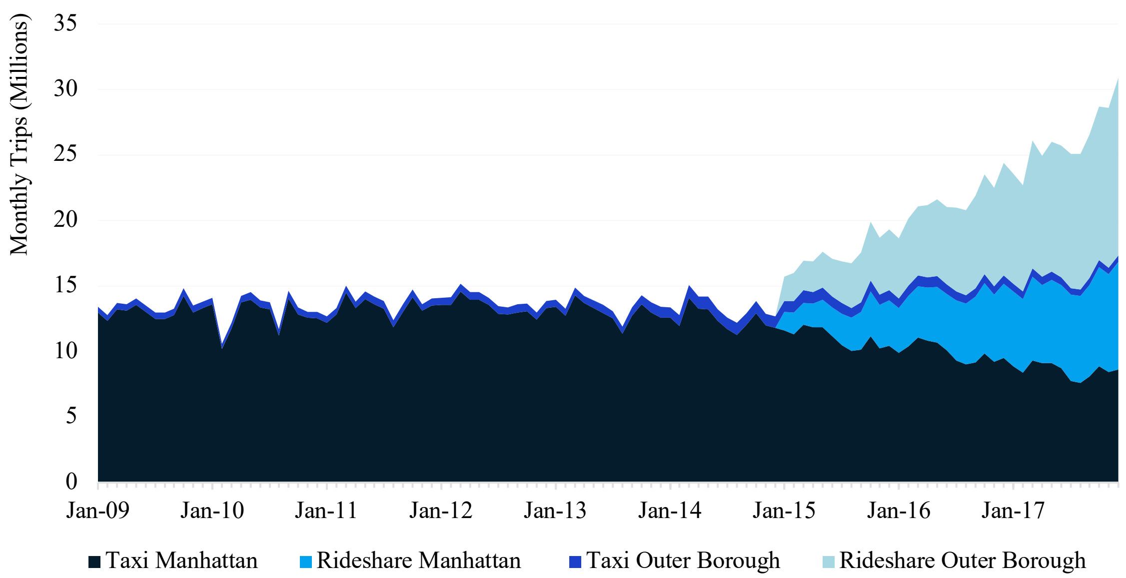


Figure 5 also communicates an interesting tension between two common phases of the traditional product life cycle concept (See Appendix X for a diagrammatical explanation of product life cycles). If we consider traditional taxis and rideshare as separate industries for a moment, it can be seen that traditional taxis are in in an industry of decline, and rideshare platforms exist in an industry of growth. According to Porter (2008) these distinct phases of market evolution carry with them the need for different strategy. While the growth and decline phases of an industry's evolution appear at first to have opposite characteristics, they share in being chiefly characterized by uncertainty.

In industries of growth, uncertainty flows there being no proven strategy for success. As a result, firms experiment with different approaches to product/market positioning, marketing, service, and so on (Porter, 2008)

Players in industries of decline, speculate whether an industry will continue to decline, or it can be revitalized. Firms of industry's in decline who have an optimistic perspective of future demand may also experiment with positioning, marketing etc. to try and find what profit pools remain.

6.1.2 Market Concentration

The Herfindahl-Hirschman Index (HHI)[24] is a commonly accepted measure of market concentration (DOJ) and competitiveness. The index ranges from 0-10,000; where a higher HHI indicates more concentration, and a low HHI indicates the opposite. Conceptually, the HHI is grounded in the theoretical notion in economics that if industry output is concentrated among a smaller number of firms (a high HHI) that competition among the firms is likely to be anemic. Conversely, if industry output is distributed over a large number of firms (a low HHI) than competition will tend to be vigorous (Rhoades, 1993). The U.S. Department of Justice often uses the HHI as early-stage tool to analyse the competitive effects of horizontal mergers. This makes the index also appropriate tool for measuring increasing fragmentation, or "anti-merger" effects.

The HHI is calculated by summing the squared market shares of each competitor in a market. Equation 10 denotes this process where MS represents the market share of firm i.

Equation 10: Herfindahl-Hirschman Index

$$HHI = \sum_{i=1}^{n}(MS_i)^2$$

The U.S. Department of Justice generally considers markets with an HHI < 1,500 as competitive, 1500-2500 to be moderately competitive, and an HHI in excess of 2500 to be

[24] The HHI was developed by economist A.O. Hirshman in 1945 and O.C. Herfindahl in 1950.

highly concentrated (DOJ).[25] In markets with pervasive scale economies (decreasing average costs), it may be more socially optimal for the market to be dominated by fewer firms, or even a monopoly. As a result, what can be considered an acceptable HHI varies across industries. Table 3 presents the NYC taxi market HHI on a quarterly basis from Q1 2015 (January–April) until Q4 2017. The HHI has not been extended all the back until Q1 2009 because during the period of Q2 2012–Q4 2014, some rideshare platforms were operating in NYC, but not yet reporting daily volume figures to the TLC. As a result, calculating the HHI for this period, without those observations would prove substantially biased.

Table 2: NYC Taxi Market Herfindahl-Hirschman Index[1]

Quarter	No. Firms	All of NYC	Manhattan	Outer Boroughs[2]
Q1 2015	3[3]	6279	7400	5383
Q2 2015	5	5850	7048	5705
Q3 2015	5	5140	6384	6535
Q4 2015	5	4728	5863	6737
Q1 2016	6	4443	6506	5786
Q2 2016	6	4030	5677	6088
Q3 2016	6	3709	5303	6043
Q4 2016	6	3635	5177	6068
Q1 2017	6	3377	5216	5955
Q2 2017	6	3296	4491	6540
Q3 2017	6	3095	4322	6448
Q4 2017	6	3163	3735	6590

1.HHI calculated with volume figures for Yellow and Green Taxi, Uber, Lyft. Juno and Via.

2.Outer Boroughs includes Queens, Brooklyn, Bronx, and Staten Island

3. Technically, there are > 1 firms operating Yellow taxis in NYC; however, due to regulation, they operate homogenous services, and alone, they do not have the ability to influence the market.

A quick glance at Figure 3 shows that, on the whole, the NYC taxi market became significantly more competitive between Q1 2015 and Q4 2017. Based on the nature of the HHI calculation, lower HHI scores correspond with less concentrated markets- more firms with less market share each. Perhaps most interesting; however, is that the outer boroughs have become relatively less competitive, or more concentrated. Based on the data used by this study to calculate HHI, this trend is the product of explosive growth by Uber in the outer boroughs, which saw their market rise to 80.5% in Q4 2017.

[25] https://www.justice.gov/atr/herfindahl-hirschman-index

The HHI provides an easy to interpret measure of market concentration, and by extension, competition. However, it is not without limitation. Chiefly, limits in the HHI's usefulness mainly stem from its simplicity as a measure. First, the measure simply captures the distribution of sales or output in a given market, without detailing any of the more complex characteristics of competition like demand elasticity. As a result, the index cannot explain what would happen if the output of one firm were reduced. One could assume that if the output of one firm in the market decreased that the other firms would compete for the output; however, this may not always be the case. Especially in markets that are compatible with differentiation, even if one firm reduces output, the other firms in the market may not be able to replace that supply due to cost, capacity or transmission constraints (Borenstein et al., 1999).

In effect, this means that the HHI fails to capture dynamic competition in a market where differentiation exists. In the NYC taxi market, this may particularly be the case for some portion of trips in the outer boroughs, where rideshare has expanded the market, or for some portion of Manhattan, where taxis still own most of the market.

6.2 Focused Analysis Results

The focused analysis seeks to fulfil the four research objectives of this study. It does this by estimating the overall elasticity of demand for taxi trips with respect to Uber in the NYC market, and by subsequently attaining location and time specific estimates that capture spatial variation in demand, and the evolution of demand elasticity as rideshare platforms grow. The results of this analysis present three main findings. First, in all instances, the elasticity estimate indicates that Uber is a substitute for traditional taxis. Second, elasticity estimates vary across locations, with the outer boroughs and Manhattan > 110th St. being most elastic. Lastly, taxis have become *more* elastic as Uber grows.

6.2.1 Objective 1: Idenfity Correlation

To fulfil *Objective 1,* the correlation coefficient of y and x was estimated. To do this, Pearson's product-moment (PPMCC) correlation coefficient was used. PPMCC is a measure of linear dependence between two random variables (Wooldridge 758). As a cross-validation measure, the correlation was estimated twice. First using the actual daily trip values, and second using the log transformed values. In both cases, the coefficient was estimated with at a 1% confidence interval, making all results statistically significant.

When comparing Uber to taxis a negative correlation was identified for the overall Uber/Taxi relationship (Pearson r = -0.4195* for Uber/Taxi), as well as for the disaggregated Uber/Yellow taxi (Pearson r = -0.3920* for Uber/Yellow taxi) and Uber/Green taxi (Pearson r = -0.4984* for Uber/Green taxi). These coefficients represent the strength and direction of the relationship between the number of Uber trips and the number of taxi trips. In all cases, the variables are negatively correlated with strength <1 and >0. In instances where correlation is equal to +1 or -1, it can be said that the variables are perfectly correlated. In other words, when there is a change in one variable, there is a perfectly consistent change in the other.

A negative PPMCC indicates high values of the number of Uber trips are associated with relatively lower values of taxi trips. This does not establish causation between Uber and rideshare; however, to does suggest the growth in Uber trips my cause a decrease in taxi trips. This result corresponds appropriately to the trends displayed in Figures 4 and 5.

6.2.2 Objective 2: Estimate Taxi Elasticity of Demand

While correlation is used to characterize the relationship between the values of two variables, regression is used as a predictive tool to estimate the effect of one variable on another. In other words, regression is used to establish causal effect by predicting future values of the dependent variable based on the historical relationship it has shared with the independent variable. The panel regression model (Equation 9) is used to identify the overall strength of the effect of the number of Uber trips effect on the number of taxi trips. Appendix VI contains the Stata code for this analysis. The result of this analysis is displayed in Table 3. As established in section 5.3.3, because this model uses the log values for its variables, the coefficient estimates can be interpreted as demand elasticity. Therefore, the results of this regression indicate that a 1% change in daily number of Uber trips cause a 15.4% decline in the daily number of taxi trips.

Table 3 also indicates a P-value of 0.000, which establishes the results as statistically significant. Lastly, the overall R-sq for the model is 0.94. This can be interpreted as the amount of variation in the daily volume of taxi trips that can be explained by the model.

Therefore, the panel regression Equation (9) can be represented in its full form as:

Equation 11: Elasticity of Taxi Demand with Respect to Uber

$$\log(taxitrips_{it}) = 13.7 - .154\log(ubertrips_{it}) + 0.21$$

Table 3: Random Effects Regression Results

log(taxitrips)	Coef.	Std. Err.	z	P >| z |	[95% Conf. Interval]	
log(ubertrips)	-.1542939	.0100945	-15.28	0.000	-.1741006	-.1344872
Location						
Manhattan	-.1088777	.0136604	-7.97	0.000	-.1356812	-.0820743
Manhattan < 110th St.	-.0980949	.0143814	-6.82	0.000	-.1263131	-.0698766
Manhattan > 110th St.	-.1121689	.0129299	-8.68	0.000	-.1375392	-.0867987
Outer Boroughs	-.199275	.0105909	-18.82	0.000	-.2200557	-.1784943
Year						
2016	-.1950003	.0079085	-24.66	0.000	-.2105007	-.1794998
2017	-.4266712	.0104341	-40.89	0.000	-.4471216	-.4062208
_cons	13.74292	.0590859	232.59	0.000	13.62709	13.85875
sigma_e	.2085721					
R-sq (w, b, o)	0.1377, 1.000, 0.9425					

6.2.3 Objective 3: Estimate Taxi Elasticity of Demand by Location

In order to provide additional richness, the findings of this thesis, taxi elasticity of demand with respect to Uber has also been estimated for each location entity in the panel.

> "Technological substitution is threatening to industry profits because increasing substitution usually depresses industry profits at the same time that it cuts into sales. The negative effect on profits is mitigated if there are pockets of demand in the industry that are immune or resistant to the substitute and have favourable characteristics (Porter, 2008).

The results of this regression are presented in Table 3.

The results presented in Table 3 indicate that the demand elasticity traditional taxis with respect to Uber is highest in the Outer Boroughs (-19.9%). In other words, Uber is most strongly a substitute for taxi service in this geographic market. Conversely, traditional taxis have the most defeasible market position in Manhattan < 110th St, where the elasticity taxi demand is 9.8%. Presumably, the resilience of traditional taxis in competing with Uber in this market is their monopoly on the street hail market, which is booming in Manhattan < 110th St (lower Manhattan)

6.2.4 Objective 4: Estimate Taxi Elasticty of Demand by Year

Lastly, the elasticity measures are estimated for each of the three years in the panel. This estimation captures the dynamics of change in the competition between taxis and Uber. Table 6 presents these results, which indicate that taxi demand with respect to Uber has become more elastic year-over-year. This means that Uber is becoming a stronger substitute traditional taxi. In 2017, the elasticity of traditional taxi decade with respect to Uber jumped to 43.6% 19% the previous year.

Although this study is not able to conclude the cause for the growing elasticity estimate from 2016 to 2017, this phenomenon may be because of positive indirect network effects for Uber (Rysman, 2004). In short, as the size one side of the Uber network grows, its service becomes more valuable to the other side and vis versa. Therefore, it can be speculated that as the Uber's network grows, using the number of trips as a proxy for this growth, its value relative to competitors also increases.

7. Discussion

Among the most interesting trends captured by this thesis' analysis is the dichotomous stages of market evolution that rideshare platforms and traditional taxis are experience simultaneous to one another. Figure 5 shows this best. While rideshare platforms enjoy the characteristics of an emerging market for e-hail, and high-tech personal mobility, traditional taxis exist in a declining industry.

Rideshare platforms have been experiencing explosive growth in NYC since 2015. This growth has come from two sources. First, by stealing market share from traditional taxis, and second, by expanding the total market - specifically into the outer boroughs. The result of this process is declining in market share among traditional taxis, and emergent market share by rideshare platforms. Moreover, considering that the majority of trips in traditional taxi trips Manhattan are derived from the street-hail segment - of which traditional taxis have a monopoly, the fact that rideshare has made such steep inroad into stealing this market share with their e-hail (pre-book) technology, signals that the street hail market is in decline.

Like most declining industries, incumbents are uncertain about the extent to which their market will continue to shrink. It is hard to expect that ridesharing platforms will render street markets (hail and rank) completely obsolete in densely populated areas of cities where the transaction costs of ride hail still exceed traditional taxis. As a result, traditional taxis will likely continue to supply the market in hope that street markets are revitalized or that a profitable share remains.

In generally traditional taxis must being to make strategic trade-offs about which pockets of the market to serve. While some may suggest that e-hail is the solution to traditional taxis problem, I would argue that basic e-hail has become a matter of operational effectiveness in the taxi industry. As a consequence, while incumbent traditional taxis can implement e-hail (in many markets they have), it is unlikely to produce superior performance. Furthermore, market leaders in e-hail (Uber and Lyft) are more than willing to invest exceptional amounts of resources into defending their position from traditional taxis. In short, fighting rideshare platforms on what they do best is sure to be a failing strategy.

7.1 Managerial Implications

I conclude that traditional taxi firms ought to embrace the following set of actions, pursuant to competitive strategy before ridesharing platforms enter, and after:

Pre-Rideshare Entry:

1. Get up to speed on the basic technology requirements of the modern taxi industry. Namely, this means implementing basic e-hail services and scaling back on costly dispatch centres. This action has been proven to soften the effects of rideshare entrance. [26]

2. Work with regulators to organise for strategy formulation and implementation. Exiting regulation on price, quantity, and quality have removed strategic discretion from taxi firms, while fragmented ownership models raise coordination costs above what is possible to implement strategy. Without addressing these issues, taxi firms have little to no capacity to be competitive actors.

3. Revisit the basic questions about their value proposition: who their customers are, what their customers what, and how much their customers are willing to pay, in order to make strategic trade-offs to serve them better.

Post-Rideshare Entry:

4. Mobilizing political muscle and work with regulators and rideshare platforms to create a legal framework conducive to healthy competition. Namely this means circumventing unfair Bertrand pricing competition, and congestion externalities.

5. Evaluate in which pockets of the market traditional taxis have the most resilient value proposition. This means pursing a niche strategy and making trade-offs about which segments of the market to serve.

6. Pursue novel methods of increasing switching costs to insulate from rideshare platforms, reduce uncertainty among incumbents, and create fresh barriers to future market share capture by new entrants.

[26] Nie, Y. M. (2017). How can the taxi industry survive the tide of ridesourcing? Evidence from Shenzhen, China. Transportation Research Part C: Emerging Technologies, 79, 242-256.

7.2 Future Research

In the process of writing this thesis, several areas of future research were surfaced.

First, the coordination problem among taxi firms has presented itself as a clear barrier to implementing competitive strategy in the traditional taxi industry. Future research should investigate the relationship between taxi ownership models and the costs of coordinating on competitive strategy. Rideshare platforms currently operate highly coordinated networks which optimize for customer wait times, directly undermining the traditional taxi value proposition in many markets.

In addition to the purely economic performance of traditional taxis, an investigation into how traditional taxis create shared value would represent a highly contemporary contribution to strategic management literature, and an important contribution to informing the ongoing debate among municipal government regarding regulatory reform in the taxi industry.

Another promising avenue of research is to model the relationship between the growth of rideshare platforms and the exiting of traditional taxi drivers. This phenomenon presents a specific limitation to the empirical study in this thesis because the rate of decline in the traditional taxi market is partly a function of traditional taxi drivers exiting the market, which my model does not control for. Since industries of decline are commonly susceptible to accelerated contraction due to firms exiting instead of direct competitive effects. Understanding how taxi drivers respond to competition in terms of exit would be a germane contribution to the discipline.

Lastly, the study of competition in the taxi market, from the perspective of taxi firms, or antitrust litigators, would benefit from a broader theoretical body of work debating the extent to which rideshare platforms and traditional taxis belong to the same industry. From the basic analysis presented in this thesis, there are clue that the structural determinants of performance may be substantially different between traditional taxis and rideshare platforms. As a result, a reasonably case could likely be made that the two entities occupy separate industries. In the event that the academic debate reaches the conclusion that traditional taxis and rideshare platforms are in fact in different industry, the work on substitution effects presented in this thesis will remain relevant.

8. Conclusion

This thesis has presented an early attempt at strategic analysis of a disrupted taxi industry. From the data collected for this study, there is no doubt that the growth of rideshare platforms have had sweeping effects in NYC's established taxi industry.

For one, the entry of rideshare has created asymmetries in the structural determinant of performance in the taxi industry. For example, where as traditional taxis exhibit a U-shaped average cost curve with vanishing returns to scale, rideshare platforms enjoy significant economies of scale. This thesis also made a significant contribution to understanding the effects of rideshare entry into established taxi markets by estimating the elasticity of traditional taxi demand with respect to Uber - in other words, the Uber substitution effect. I find that the traditional taxi value proposition is most resilient in Manhattan < 110^{th} St. where medallion taxis have a monopoly on the street-hail market. In this geographic market, however, traditional taxis still exhibit a nearly 10% elasticity of demand with respect to Uber, suggesting that not even their dominance in the street-hail market is immune to competition from rideshare platforms.

While traditional taxis may not have needed competitive strategy in the past, their business is under siege from rideshare platforms who offer novel business models and highly coordinated networks. While it has become clear through this thesis that traditional taxis need strategy, what has also become clear is that traditional taxi ownership models and regulations are not set up for strategy formulation and implementation. Answers to the questions of who is responsible for strategy formulation, and how can all actors coordinate on a single strategy, are an important first step towards creating a new sustainable competitive advantage for traditional taxi firms.

While taxis may not have needed strategy in the past, this study has made abundantly clear that increasing completion, and evolving structural determinants of performance have made strategy essential to the preservation of traditional taxi firms. This thesis has made a novel first step towards understanding the effects of rideshare entrance to established taxi industries, and the appropriate managerial responses. Further, it has identified several areas of future research that will prove invaluable in designing winning strategy for traditional taxi firms to achieve superior performance in the disrupted taxi industry.

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10. Appendix

10.1 Appendix I: Summary Statistics

Daily # of Yellow Taxi Trips					
	Obs.	Mean	Std. Dev.	Min	Max
Total	1096	561615	97306.82	130760	838499
Manhattan > 110th Street	"	323585	55535.09	70059	477508
Manhattan < 110th Street	"	227715	39786.81	54671	340846
Outer Boroughs	"	10316	3758.77	4239	29886
JFK and LGA	"	16987	3314.21	687	27425
Daily # Green Taxi Trips					
	Obs.	Mean	Std. Dev.	Min	Max
Total	1096	43106	11896.77	7587	81376
Manhattan > 110th Street	"	12766	2753.48	1583	20233
Manhattan < 110th Street	"	3	7.36	0	44
Outer Boroughs	"	30336	9571.37	5975	61141
JFK and LGA	"	17	7.82	1	48
Daily # of Uber Trips					
	Obs.	Mean	Std. Dev.	Min	Max
Total	1096	275229	119843.25	38378	725088
Manhattan > 110th Street	"	112742	41496.73	18857	279463
Manhattan < 110th Street	"	84637	29912.46	13870	206004
Outer Boroughs	"	77850	51997.97	5651	257301
JFK and LGA	"	7053	3241.73	325	18893

10.2 Appendix II: Sample Panel Data Storage Stata

	ob	location	date	year	quarter	month	day	wdwe	y	g	yg	x	logy	logx
1091	5475	1	21179	2017	4	12	3	0	199795	20209	220004	258995	12.20505	12.46456
1092	5476	1	21180	2017	4	12	4	0	231011	23489	254500	298729	12.35022	12.60729
1093	5477	1	21181	2017	4	12	5	0	253752	26362	280114	345239	12.44411	12.75199
1094	5478	1	21182	2017	4	12	6	0	253749	28870	282619	380628	12.4441	12.84958
1095	5479	1	21183	2017	4	12	7	1	225532	26326	251858	379561	12.32622	12.84677
1096	5480	1	21184	2017	4	12	1	1	226502	29879	256381	447837	12.33051	13.01218
1097	1	2	20089	2015	1	1	5	0	329581	13404	342985	36506	12.70558	10.50523
1098	2	2	20090	2015	1	1	6	0	312449	12686	325135	26629	12.6522	10.18976
1099	3	2	20091	2015	1	1	7	1	369664	13244	382908	40571	12.82035	10.61081
1100	4	2	20092	2015	1	1	1	1	289729	10110	299839	25108	12.5767	10.13094
1101	5	2	20093	2015	1	1	2	0	323818	13240	337058	29753	12.68794	10.30068
1102	6	2	20094	2015	1	1	3	0	349461	13300	362761	39889	12.76415	10.59386

10.3 Appendix III: List of Variables

No.	Label	Variable Name	Coding
1	*ob*	observation	1–5480
2	*location*	location	1–5 based on trip pick-up location
3	*date*	date	20089–21184
4	*wdwe*	weekday or weekend	0–1 (dummy variable), 1 if weekend
5	*y*	daily volume of Yellow taxi trips	n/a
6	*g*	daily volume of Green taxi trips	n/a
7	*yg*	combined daily volume of taxi trips	n/a
8	*x*	daily volume of Uber trips	n/a
9	*logy*	natural log of *y*	n/a
10	*logyg*	natural log of *yg*	n/a
11	*logx*	natural log of *x*	n/a

10.4 Appendix IV: Breusch and Pagan Test for Random Effects

```
. xttest0

Breusch and Pagan Lagrangian multiplier test for random effects

        logy[location,t] = Xb + u[location] + e[location,t]

        Estimated results:
                         |       Var     sd = sqrt(Var)
                ---------+-----------------------------
                    logy |     1.8985       1.377861
                       e |   .0502726       .2242155
                       u |   3.303367       1.817517

        Test:   Var(u) = 0
                             chibar2(01) =   2.1e+06
                          Prob > chibar2 =    0.0000
```

10.5 Appendix V: Hausman Test

```
. hausman fixed random

                 ---- Coefficients ----
             |      (b)          (B)            (b-B)     sqrt(diag(V_b-V_B))
             |     fixed        random       Difference          S.E.
-------------+----------------------------------------------------------------
        logx |   -.1380402    -.1380272        -.000013         .0000823
------------------------------------------------------------------------------
                           b = consistent under Ho and Ha; obtained from xtreg
            B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(1) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        0.03
                Prob>chi2 =      0.8743
```

10.6 Appendix VI: Stata Code

```
** Set model as panel **
use NYC Taxi Volume Data
xtset location date
              panel variable  : location (strongly balanced)
               time variable  : date, 20089 to 21184
                       delta  : 1 unit
** Correlation between log(taxitrips) and log(x) **
pwcorr logyg logx, star (0.01)
pwcorr logy logx, star (0.01)
pwcorr logg logx, star (0.01)
xtline logyg
xtline logx
** Panel regression of log(taxitrips) and log(Ubertrips) **
xtreg logyg logx i.location i.year, re robust
** Hausman Test for fixed effects **
xtreg logyg logx, fe
estimates store fixed
xtreg logyg logx, re
estimates store random
hausman fixed random
** Breusch and Pagan Lagrangian Multiplier Test **
xtreg logyg logx, re
xttest0
```

10.7 Appendix VII: Taxi Log Trend by Location

10.8 Appendix VIII: Uber Log Trend by Location

10.9 **Appendix IX: Log-Log Model Elasticity Proof**

(1) $\ln(taxitrips) = = \beta_0 + \beta_1 \ln(Ubertrips)$

Differentiate the equation to obtain:

(2) $\frac{\delta taxitrips}{taxitrips} = \beta_1 \frac{\delta taxitrips}{taxitrips}$

10.10 **Appendix X: Stages of the Life Cycle**