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Incentive Regulation of Transportation Network Companies

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Incentive Regulation of Transportation Network Companies

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A Research Report from the National Center for Sustainable Transportation

Richard Arnott, University of California, Riverside

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16. Abstract

Transportation network companies (TNCs) like Uber and Lyft have revolutionized metropolitan transportation, surpassing traditional taxis in usage and rivaling bus ridership in the U.S. Despite their rapid growth, there has been limited analysis of appropriate policy responses. This project explored policy issues stemming from TNCs' "economies of density," where increased vehicle and customer density reduces wait and idle times, giving large TNCs a competitive advantage over smaller ones and taxis. This raises concerns about industry monopolization and regulatory disparities. The project's objective was to explore whether and how TNCs should be regulated, as evidenced by policy developments like New York City's cap on TNC vehicles and the establishment of a minimum wage for TNC drivers. These measures address traffic congestion and the economic challenges faced by taxi drivers, with other cities considering similar actions. Additionally, the project incorporated insights from a case study on the Los Angeles taxi industry, which highlighted regulatory inertia in response to TNC growth. The researcher later shifted focus to broader questions about TNCs' impact on metropolitan transportation, particularly their economies of density. Key research areas include TNCs' potential role in improving suburban-urban connectivity, integrating TNCs with mass transit to reverse declining ridership, and alleviating downtown parking challenges. These issues underscore the complexities of regulating a dynamic and rapidly evolving industry. This report summarizes the modeling approach developed and includes an unpublished case study, "The Taxi Industry and TNCs in Los Angeles," providing detailed analysis and recommendations for future research.

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Disclaimer

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Incentive Regulation of Transportation Network Companies

A National Center for Sustainable Transportation Research Report

April 2019

Richard Arnott, Distinguished Professor of Economics, University of California, Riverside

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EXECUTIVE SUMMARY

Transportation network companies (TNC's), such as Uber and Lyft, are changing the landscape of metropolitan transportation. In the US, the number of TNC trips now exceeds the number of taxi trips, and the number of TNC and taxi trips now exceeds the number of bus trips (Schaller, 2018).

This growth has stimulated considerable discussion in the popular press but has been so rapid that transportation scientists, engineers, and economists have had little time to consider appropriate policy response to the phenomenon. The aim of the seed grant project was to prepare a research grant proposal to the Civil Infrastructure Systems (CIS) program of the National Science Foundation that would address a selection of policy issues related to the growth of the TNC industry deriving from "economies of density".

Doubling a TNC's vehicle and customer density reduces a customer's waiting time for a vehicle and a driver's idle time. This "economy of density" gives larger TNC's a competitive advantage over smaller TNC's, which poses the threat of monopolization of the industry. At the same time, TNC's have a competitive advantage over the taxi industry since they are less heavily regulated. The goal of the seed grant was to develop a research program aimed at investigating the issue: Should TNC's be more heavily regulated, and, if they should, how best should they be regulated?

The topicality of the issue is evident from policy developments that occurred during the period of this seed grant. New York City decided to regulate TNCs. Citing the effects of TNC growth on traffic congestion in Manhattan, the City imposed a cap on the number of TNC vehicles. And citing the effects of TNC growth on the well-being of taxi drivers, the City imposed a minimum wage for TNC drivers. Other cities are now considering imposing similar regulations.

Many undergraduates are eager to gain research experience. By happenstance, one of the undergraduates who approached the PI last spring to gain research experience had intimate knowledge of the Los Angeles taxi industry since his father is a taxi driver. The PI hired him to write an essay on "The Taxi Industry and TNCs in Los Angeles". The well-researched case study documented the sclerotic response of taxis regulators in the City to the threat to the industry posed by TNCs. This case study, as well as the ongoing debate about net neutrality and more generally about the desirability of more tightly regulating the tech giants, such as Amazon, Google, and Facebook, changed the PI's views about the desirability of tighter regulations on TNCs. Tighter regulation would almost surely dampen the dynamism of the TNC industry. As well, technology is advancing so rapidly that regulations would become at the same time rapidly outdated and byzantine. Thus, the PI decided to the change the focus of this research effort to an examination of a broader range of issues related to TNCs and the metropolitan

transportation system, with particular attention to economies of density. For example, the following questions have been examined:

a. Continued dominance of auto travel in the suburbs combined with a diversion of public transportation funds away from highways and towards light rail in the metropolitan core is making travel between city centers and suburbs increasingly difficult. What role might TNCs play in addressing this problem?
b. Economies of density are important in both mass transit and the TNC industry. In many cities, growth of the TNC industry is causing a fall in mass transit ridership and a concomitant reduction in service quality. Can this downward spiral be reversed by providing integrated mass transit/TNC service?
c. To what extent is TNC growth relieving the downtown parking problem?

This final report outlines the modeling approach taken, and also provides in Appendix A: The Taxi Industry and TNCs in Los Angeles, an unpublished paper that resulted from this research.

1. Introduction

Less than a decade after Uber was founded in 2009, transportation network companies (TNCs) are changing the landscape of metropolitan transportation, not only in the US but around the world. In 2017, the number of TNC trips in the US was estimated by Schaller, 2018 to be 1.715 billion, or about 5.27 trips per person for every man, woman, and child in the United States. In the US, the number of TNC trips now exceeds the number of taxi trips, and by the end of the year the number of TNC and taxi trips combined is expected to exceed the number of bus trips (Schaller, 2018). To understand the explosive growth of Uber, Lyft, and other TNCs, which is very much in the news (e.g., Brink, 2018; Hawkins, 2018; Jamison, 2018; Johnson, 2018; PYMNTS, 2018), some background is useful.

Prior to computerized dispatching, taxi companies had dispatchers who manually matched idle taxis with customers who called in. Even two dispatchers working together had trouble coordinating their assignments, which resulted in many errors and frustrated customers. Thus, the technology of dispatching constrained the size of a taxi company. With each company able to handle only so many customers, and hence have only so many idle taxis, operating on a metropolitan-wide scale would have resulted in long expected wait times for customers and long expected journeys by taxis to pick them up. Thus, taxi companies naturally became localized, each having its own market area. Now, in contrast, computerized dispatching allows customers and idle vehicles (taxi or TNC) to be matched on a metropolitan basis, sharply increasing the efficient scale of the individual company.

Taxi travel has been regulated since its inception. Because taxi companies have been localized, each city has had its own taxi commission that decides on the city's taxi regulations. Most regulations were put in place in response to some perceived market failure. The most serious has been fare gouging. To prevent this, a city's regulated fare structure was built into its mechanical taxi meters, resulting in fare structures that varied only coarsely according to time of day, or day of the week, if at all. Taxi fare structures have remained rigid even though computerized dispatching, along with invention of the cell phone with apps, now allow the fare to be determined prior to the start of a trip, which largely overcomes the problem of fare gouging, and also permits flexible and demand-responsive fare structures. Taxi regulation has caused other inefficiencies too. City A allows only local taxis to pick up local passengers so that a taxi from city B that drops off a passenger in city A must return home empty. Also, taxi and medallion owners have had an incentive to restrict entry, which via regulatory capture of taxi commissions, has resulted in inefficiently small taxi fleets in most cities.

TNCs have consistently argued that they are not taxi companies and hence are not subject to taxi regulation, on the legal grounds that they provide a matching service much like a dating service not a taxi service. In those jurisdictions where this legal argument has been accepted, thanks to computerized dispatching TNCs have been able to operate on a metropolitan scale. As well, not being encumbered by taxi regulations, they have been able to offer superior service (at the least, a better combination of fare and wait time, and perhaps an improvement in other quality attributes as well) to taxis, which has substantially benefited consumers (Cohen et al., 2016). Furthermore, they have significantly expanded the opportunities for flexible, part-time employment, to the benefit of many workers. The taxi companies and taxi commissions can be excused for not anticipating the legal grounds on which the TNC's have been able to circumvent taxi regulations, but they should have understood the implications of the technological innovations underway and changed their regulations, technology, and business practices accordingly. The industry has paid a high price, in terms of a sharp loss in custom, for its rigidity and institutional inertia.

The technological advances that gave rise to the emergence of the TNC industry have the potential to considerably improve mobility within metropolitan areas. Will that potential be realized?

Recently (August 14, 2018), the New York City Council voted to impose a one-year moratorium on the number of "for-hire vehicles" (FHV vehicles are TNC vehicles, but not taxis) as well as to impose a minimum wage for FHV drivers. New York City's decision was based on a widespread perception, supported by abundant data[1] but little analysis, that rapid growth of TNC trips had increased traffic congestion, hurt taxi drivers, and undermined the quality of life.

Other cities are now debating whether they should follow New York City's lead (Laughlin, 2018; Speta, 2018). The time is now ripe to examine whether TNC's should be regulated and if so how. Not surprisingly, the academic literature on TNCs is growing rapidly[2]. Most of the papers are empirical, and most of the empirical papers examine the sources of TNC demand, the diversion from other modes as well as the generation of new trips. In contrast, the proposed research will be theoretical, examining TNCs from the perspective of urban transportation economic theory (Small and Verhoef, 2007) in five papers that together present a suite of four models. The research will start with two models of the TNC firm, then move to the TNC industry, with a focus on regulation, and finally consider two models of the TNC industry within the overall metropolitan transportation system. Rather than attempt to develop a comprehensive theory, the proposed research will focus on one facet—the role played by economies of density at the level of the individual TNC firm. When a customer contacts a particular TNC firm for a ride, her expected wait time is inversely proportional to that firm's density of idle taxis. By offering a lower expected wait time, a larger TNC firm has a competitive advantage over a smaller TNC firm. Thus, the TNC industry has the cost structure of a natural monopoly. At the level of metropolitan transportation system, economies of scale in TNC travel interact with other mode-specific sources of economies of scale, which may generate multiple equilibria and optima, greatly complicating the enlightened design and regulation of the metropolitan transportation system.

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[1] TNC trip data is proprietary, but TNC firms have granted academic researchers access to them on a selective basis.

[2] Angrist, Caldwell, and Hall, 2017; Brown, 2018; Bryan and Gans, 2018; Castillo, Knoepfle, and Weyl, 2017; Docherty, Marsden, and Anable, 2018; Hall and Krueger, 2018; Hall, Palsson, and Price, 2018; Rayle et al., 2016; Tirachini and G´omez-Lobo, 2018; Wang et al., 2016, Yang, Ke, and Ye, 2018, and Zha, Yin, and Du, 2017.

Examples of issues to which the research can be applied include the following:

- Schaller, 2017 argued that too high a proportion of TNC vehicles in Manhattan are idle, wasting valuable street space. Is there good reason to believe that the idle rate is indeed inefficiently high? If there is, what policies would be effective in reducing it?
- A concern expressed in several cities is that the growth in TNC travel has increased traffic congestion. A tax on TNC trips would be effective in reducing demand for TNC travel but would it increase social welfare?
- What are the effects of imposing a minimum wage for TNC drivers?
- Even though Uber dominated the TNC industry in the US for many years, Lyft has recently been increasing its market share (Jones, 2018). Is this a transitory phenomenon, stemming from problems that Uber is correcting, or does it provide a basis for optimism that the industry will not become monopolized?
- TNC's have argued that TNC travel is complementary to bus travel. Hall, Palsson, and Price, 2018find this to be the case for areas with high trip density but not for areas with low trip density, where bus service frequency is low. One policy response is to cut back on bus service in the suburbs. Another is to make bus and TNC travel more complementary in the suburbs by facilitating transfers. What determines which policy response is better?
- One goal of green metropolitan transportation policy is to decrease the drive-alone modal share of commuting trips from suburban residences to downtown worksites. What role do TNC's play in the portfolio of policies that would achieve this goal most effectively?

2. Criteria

2.1 Objectives

Transportation network companies have grown explosively since the founding of Uber in 2009. The broad aim of the proposed research is to extend the tools used to analyze the effects of transportation policies to include transportation network companies, especially the economic effects. One more specific aim is to construct a TNC module that can be incorporated into existing urban transportation economic models of the supply side of the metropolitan transportation system. This entails constructing a model of the TNC firm and from that foundation building a model of the TNC industry. Another more specific aim is to focus on economies of density at the level of the individual TNC firm, and their interaction with other sources of economies of scale in the metropolitan transportation system. The theoretical models will be used to construct simulation models of the metropolitan transportation system. Appropriately calibrated to individual metropolitan areas, these simulation models could be employed in first-pass analysis of a wide range of transportation policies, including policies to regulate TNCs. User-friendly versions of the models, aimed at transportation planning researchers, have been made available on the web. For illustrative purposes, the models were calibrated to one large, one medium-sized, and one small metropolitan area (perhaps the Los

Angeles CMSA, the San Diego MSA, and the Palm Springs MSA), and applied to simulate the effects of several sample policies.

2.2 Expected Significance

Only rarely does theoretical research influence contemporaneous policy. The aim of this research is to add to the kitbag of modeling tools that in the future will enable transportation policy analysts to provide sounder policy advice related to the TNC industry. The research should also inform data-driven empirical analysis of the TNC industry by itself and as a component of the metropolitan transportation system.

2.3 Relationship of Work to the Present State of Knowledge

To the PI's knowledge, this research is the first to develop an economic model of the TNC firm (though it does adapt existing models of the taxi industry) accounting for economies of density. It will also be among the first to incorporate TNCs into a medium-run (fixed road and subway network) economic model of a multi-modal metropolitan transportation system (Tirachini has started development of a model that is similar in conception but different in emphasis). Its treatment of the demand side will be conventional (discrete choice analysis extended to treat TNCs both as a simple mode and as a component of compound modes, such as bus-TNC). Its innovations will rather be on the supply side, in particular its focus on economies of density at the level of the individual TNC firm, and the interaction between this form of economies of scale and other "nonconvexities" within the metropolitan transportation system (which include economies of service frequency in bus and "subway" travel, economies of density in bus travel, and nonconvexities in auto-bus congestion interaction and in parking). It will also differ from existing work in its focus on the multiplicity of local optima and equilibria that nonconvexity may give rise to. The proposed work will not be seminal or transformative, but will rather extend existing work to a new and increasingly important policy context. The work should be of particular interest to urban transport economic theorists and transportation science theorists working on metropolitan transportation systems, but will in time hopefully be used in transportation planning practice.

2.4 Approach

The proposed research employs parsimonious microeconomic models to address practical economic issues. (In his research, the PI has been particularly influenced by Joseph Stiglitz, James Mirrlees, and William Vickrey.) Drawing on the seminal contributions of Beckmann, McGuire, and Winsten, 1956, Walters, 1961, Vickrey, 1969, and Mohring, 1972, this is still the mainstream approach in urban transportation economic theory, though it is currently out of fashion in many other fields of microeconomics, where most microeconomic research on public policy issues is data driven while most current theoretical work is more abstract. The proposed research also employs aggregative simulation modeling. Though a standard tool in macroeconomics, it has always encountered resistance from microeconomists. The proposed research will employ the MFD approach to traffic congestion, in contrast to both the disaggregated network approach common in transportation science and the "naïve flow congestion" approach (in which travel time is assumed to be inversely related to flow) common in urban transportation economics. Thus, the approach is in the spirit of the MFD approach to metropolitan transportation systems analysis.

2.5 Intellectual Merit

This research makes three principal contributions. The first is to provide a conceptualization of the place of TNCs within the overall metropolitan transportation system from the perspective of urban transportation economic theory. The second is to provide a workable economic model of the TNC firm incorporating economies of density in matching customers to TNC vehicles and equilibration via the idle rate, which can be applied to a wide range of policy issues related to TNCs, including prospective regulation. The third is to provide an integrated economic model of the metropolitan transportation system with TNCs that focuses on the interaction between nonconvexities in the system, which may lead to multiple equilibria and optima.

2.6 Broader Impacts

The technological advances that have given rise to the TNC industry—computerized dispatching along with smartphone apps—have the potential to considerably improve mobility within metropolitan areas. Debate has already begun on appropriate public policy to ensure that these potential benefits are realized. After New York City's decision to regulate the number of TNC vehicles, that debate will spread to city halls around the country and intensify. More regulation will reduce the danger of monopolization and will likely mitigate traffic congestion but at the cost of stifling technological and institutional innovation. Public debate has generally been focusing on the right issues but lacks an integrated conceptual and analytical framework to quantify the tradeoffs. By providing some of the elements of such a framework, the proposed research should aid wise policy design.

This research produces four user-friendly aggregative economic simulation models of the metropolitan transportation system, including TNC's, that are customizable to individual metropolitan areas. Designed for first-pass analysis of the effects of a wide variety of transportation policies, it is hoped that in due course such models will become a standard tool in the metropolitan transportation policy analyst's toolbox.

The proposed budget includes two items that should generate benefits beyond direct contributions to public policy:

- Hiring and mentoring a postdoctoral researcher skilled in computational mathematics, as well as training the two graduate students, should contribute to expertise in urban transportation economics, afield where the United States is relatively weak.
- Having one high school student and one undergraduate economics student work on the project should encourage them to pursue careers in either applied mathematics or transportation.

3. A More Detailed Research Description

3.1 A Model of the TNC Firm

This subsection presents a model of a representative TNC firm. The model could be a module of a larger model of a metropolitan transportation network industry that incorporates competition between TNC firms, which could in turn be part of a still larger model treating the entire metropolitan transportation system, allowing for modal choice on the demand side and congestion interaction on the supply side. To simplify, the model is steady state and assumes space to be isotropic. The subsection presents the first model variant that ignores traffic congestion. The model adapts the PI's model of the dispatch taxi industry (Arnott, 1996), which in turn adapted Beesley's model of the cruising taxi industry (Beesley, 1979; and Beesley and Glaister, 1983).[3]

A driver/vehicle is engaged if she (to accommodate political correctness without compromising grammar, the convention is adopted that drivers are female and passengers are male) is either en route, picking up or dropping off a passenger, or in transit, transporting a passenger/customer. Otherwise, the driver/vehicle is idle. Since the time it takes a driver to pick up a passenger is also the time the passenger waits for the driver, this time is referred to as wait time. The trip duration is the period of time between when a driver is assigned to pick up a passenger and the time the driver completes dropping off the passenger. Thus, trip duration equals wait time plus in-transit time plus pick-up and drop-off time.

The model has a conventional demand side, with risk-neutral customers (risk aversion can be accommodated by replacing the expectations of the fare and remuneration with their certainty-equivalents) deciding how frequently to take trips of fixed distance on the basis of the full price of a trip. The supply side is also conventional with the spatial density of TNC vehicles, assumed to be operated by competitive suppliers, increasing in net hourly remuneration. When both the fare and supply of drivers is held fixed, equilibration occurs via adjustment in wait time.

For the moment, the scenario is assumed of a representative TNC firm with a fixed fare, a fixed commission rate, and no regulation. Later this scenario will be modified.

The model is the same as a spatial model of dispatch taxi service presented in Arnott 1996, in all but one respect. There, the spatial density of taxis was assumed to be fixed, reflecting entry regulation in the taxi industry. Here, in contrast, since entry is not regulated, the spatial density of TNC vehicles is assumed to be increasing in the net hourly remuneration of drivers.

[3] The literature on taxicab regulation has progressed considerably since Beesley and Glaister, 1983: Cairns and Liston-Heyes, 1996; Yang et al., 2010; Buchholz, 2015; Wang et al., 2016; and Frechette, Lizzeri, and Salz, 2018.

The following notation is employed:

F	expected passenger full price of a trip	u	proportion of vehicle time idle
P	fare for a trip	z	expected trip duration
L	trip length	ρ	value of customer time
v	travel speed	k	vehicle operating cost per unit time
r	expected driver remuneration per unit time	T	vehicle density
θ	driver commission rate	$D(F)$	demand function for trips
$t(uT)$	expected passenger wait time function	τ	pick-up and drop-off time

The exogenous parameters are P, L, v, θ, ρ, k, and τ. $t(uT), T(r)$, and $D(F)$ are functions. And F, r, u, and z are the four endogenous variables, whose equilibrium values are determined in the four-equation system presented below.

3.1.1 The Four-Equation System

$$F - P - \rho z = 0 \quad (1)$$

$$r - \frac{\theta P(1-u)}{z} + k = 0 \quad (2)$$

$$z - t\big(uT(r)\big) - \frac{L}{v} - \tau = 0 \quad (3)$$

$$D(F) - \frac{T(r)(1-u)}{z} = 0 \quad (4)$$

Equation (1) states that the passenger expected full price of a trip, F, equals the fare, P, plus the passenger's time cost on a trip. The time cost equals the value of passenger time, ρ, times expected trip duration, z. The fare and the value of time are exogenous parameters. Expected trip duration is an endogenous variable.

Equation (2) states that the expected net remuneration of TNC drivers per unit time, r, equals the expected gross remuneration per unit time, minus operating cost per unit time, k. Expected gross remuneration per unit time is a weighted average of the expected gross remuneration per unit time when engaged, and the gross remuneration per unit time while idle, which is zero. The weights are the expected proportions of time engaged and idle, $1 - u$ and u respectively. Gross remuneration per unit time when engaged is a proportion θ of fare revenue. P, θ, k, and τ are exogenous parameters; r, u, and z are endogenous variables. The model can accommodate alternative remuneration schemes, such as providing an idling wage.

Equation (3) states that the expected duration of a trip equals expected passenger wait time, plus in-transit travel time, $\frac{L}{v}$, plus pick-up and drop-off time, τ. L, v, and τ are exogenous parameters. $T(r)$ is a function relating the expected number of TNC drivers per unit area to the expected net remuneration of TNC drivers per unit time, and is hence the supply function of TNC drivers. $t(uT)$ is a function relating expected wait time to the expected density of idle TNC vehicles, with $t'(uT) < 0$.

Equation (4) is the market-clearing condition, stating that the quantity of TNC trips demanded per unit time equals the expected quantity of TNC trips supplied per unit time. Under the assumption that passengers are risk neutral, the quantity of TNC trips demanded per unit time is negatively related to the expected full price of a trip; thus, $D(F)$ is the demand function for TNC trips. The expected quantity of TNC trips supplied per unit time equals the expected density of engaged TNC vehicles, divided by expected trip duration: $S(r,u,z) \equiv \frac{T(r)(1-u)}{z}$, which is the supply function of trips.

The function $D(F)$ and (1) together constitute the demand side of the model; equations (2) and (3) constitute the supply side of the model; and (4) is the market-clearing equation. The system of equations is a minimal set of equations to determine equilibrium for a TNC firm. There are many ways in which the model could be extended in the direction of realism.

A couple of comments are in order before proceeding to analyze the model's properties. First, the functional form of the wait time function is not arbitrary, but is derived from the physics of wait time. Specifically, it is assumed that trip origins are generated by a spatial Poisson process, that all destinations at distance *L* from an origin are equiprobable, and that drivers have no information on the trip destinations of other drivers' trips, so that it is natural to assume that idle drivers are distributed randomly over space. It is also assumed that the dispatching program assigns the closest idle driver to pick up a passenger. Together these assumptions imply that the distance between a dispatched driver and a passenger is generated by a spatial Poisson process with rate equal to the expected density of idle taxis. When travel distance is crow-line distance, the expected distance of the closest idle driver to a passenger is $\frac{(uT)^{-\frac{1}{2}}}{2v}$. But travel distance exceeds crow-line distance because of the geometry of the street network and the circuitousness of routes. To account for these considerations, it is assumed that the average distance traveled to pick up a passenger is double (Yang, Ke, and Ye, 2018 refer to this as the network detour ratio) the crow-line distance, so that

$$t(uT) = \frac{(uT)^{-\frac{1}{2}}}{v} \qquad (5)$$

Second, even though the model contains stochastic elements, it works with averages. Typically, this is inexact, but under the Poisson assumptions and with risk-neutral customers and drivers it is exact.

3.1.2 The Model's Properties and Behavior

The proposed research is designed on the principle that it is important to understand the properties and behavior of the stripped-down version of a model before extending the model in the direction of realism. There are two quite different forms of "understanding". One is understanding the mathematical structure of the model. The other is understanding the model's behavior at an intuitive level.

Even though each of the equations of the four-equation system is easy to understand, the behavior of the entire model is complex.

One immediate goal of this research is to undertake a thorough mathematical analysis of the above model. This entails examining the existence, uniqueness, and stability properties (defined with reference to an adjustment mechanism that needs to be specified) of equilibria in the model, and deriving the model's comparative static properties. This entails logarithmically differentiating the entire equation system, from which expressions for the comparative static elasticities can be readily obtained. Inserting values of the exogenous variables and of the endogenous variables, evaluated at a particular equilibrium, permits numerical calculation of the percentage change in the corresponding equilibrium value of an endogenous variable with respect to a percentage change in an exogenous variable. Such an exercise might for instance indicate that, in the neighborhood of a particular equilibrium, a percentage change in the fare, P, leads to a 0.517 percentage change in the full price of a trip, F.

Another immediate goal is to acquire an intuitive understanding of how the model works. The rest of this subsection reports on some preliminary work in this direction.

Starting with a simplified variant of the model in which the supply of drivers is fixed. Since intuition and empirical evidence (Hall and Krueger, 2018) suggest that the supply of TNC drivers is sensitive to net hourly remuneration, this assumption is not realistic, but is made to focus on how u, the idle rate of TNC drivers, adjusts to equilibrate the market.

The base-case parameters and functional forms are given below. Units are in hours and miles.

$P = \$12/trip$	$L = 3\ mls$	$v = 6\ mph$	$\rho = \$25/hr$
$\theta = 0.75$	$k = \$2/hr$	$\epsilon = 2$	$\underline{T} = 44.44/mi^2$
$\underline{D} = 40500\ trips/hr$	$D(F) = D_0 F^{-\epsilon}$	$T(r) = \underline{T}$	$t(uT) = \frac{(uT)^{-\frac{1}{2}}}{v}$

The specified parameters are typical for the downtown area of a medium-sized U.S metropolitan area. P is set to the current taxi fare for a three-mile trip in Los Angeles. The parameters $\underline{D}$, demand intensity, and $\underline{T}$, taxi density, are calibrated such that in the base-case equilibrium wait time is 0.05 hours (3 minutes) and the drivers are idle 25% of the time.

Let $\widehat{D}(u)$ denote the quantity of trips demanded as function of u, which will be referred to as the idle rate, and $\hat{S}(u)$ denote the corresponding quantity of trips supplied. $\widehat{D}(u)$ is calculated by substituting $z(u)$ from (3) into (1) to obtain $F(u)$ and then substituting $F(u)$ into $D(F)$. Figure 1 plots $\widehat{D_0}(u)$ and $\hat{S}(u)$against u for the example. Note that, since T is fixed at $\underline{T}$, lower values of u correspond to higher wait times.

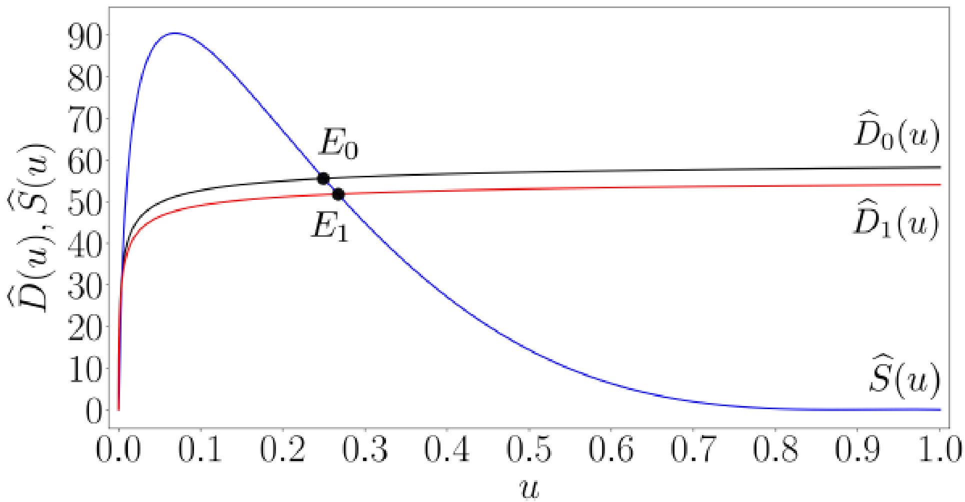

Figure 1. Demand and Supply versus *u*.

With the assumed demand function:

$$\widehat{D}(u) = D\left(P + \rho\left(\frac{(uT)^{-\frac{1}{2}}}{v} + \frac{L}{v} + \tau\right)\right) = \underline{D}\left(P + \rho\left(\frac{(uT)^{-\frac{1}{2}}}{v} + \frac{L}{v} + \tau\right)\right)^{-2} \quad (6)$$

is increasing in u. An increase in *u* causes the density of idle vehicles to increase, which in turn causes wait time and hence trip duration to decrease, which in turn reduces the full price of a trip, which in turn results in an increase in the quantity of trips demanded.

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The supply of TNC trips equals the density of engaged TNC's divided by trip duration. Substituting out for *z(u)* from (3):

$$\hat{S}(u) = \frac{\underline{T}(1-u)}{\frac{(uT)^{-\frac{1}{2}}}{v} + \frac{L}{v} + \tau} \quad (7)$$

The quantity of trips supplied at $u = 0$ equals zero. Since there are no idle vehicles, wait time is infinite so that trip duration is infinite and the quantity of trips supplied equals zero. The quantity of trips supplied at $u = 1$ also equals zero. Now there are no engaged vehicles, and since trip duration is finite, the quantity of trips supplied equals zero.

$\widehat{D}(u)$ is the demand function with the base-case parameters and E_0 the corresponding equilibrium.

The behavior of the system when the vehicle idle rate is very low is complex. This corresponds to the complex adjustment dynamics Uber has reported when there is a large, localized, and unanticipated surge in demand (Castillo, Knoepfle, and Weyl, 2017; see also, Zha, Yin, and Du, 2017). Outside this range of u, however, the system's dynamics are easy to understand. When the idle rate is 0.1, below the equilibrium rate at E_0, 0.25, the quantity of vehicle trips supplied exceeds the quantity of vehicle trips demanded. Thus, the rate at which engaged vehicles terminate their trips (the rate at which engaged vehicles become idle) exceeds the rate at which idle vehicles are dispatched to passengers (the rate at which idle vehicles become engaged), resulting in an increase in the idle rate. In contrast, when the idle rate is above its level at the equilibrium E_0, there is excess demand for vehicle trips resulting in a decrease in the idle rate. Under these dynamics, the equilibrium E_0 is stable.

Figure 1 can be applied to examine the effects of parameter changes on equilibrium. Suppose that the system is at the equilibrium E_0 and the fare increases from \$12 to \$13. From (6) this causes the demand function to shift down from $\widehat{D_0}$ to $\widehat{D_1}$, but from (7) has no effect on the supply function. The equilibrium moves down the supply curve from E_0 to E_1, which corresponds to an increase in the equilibrium idle rate. The increase in the fare causes a temporary excess supply of trips. The rate at which trips are initiated falls short of the rate at which trips are terminated, causing the idle rate to rise until the new equilibrium is established.

When the supply of TNC drivers is sensitive to the net remuneration rate, the system's dynamics become more complex. Out of equilibrium the system adjusts not only through change in the idle rate but also through the entry and exit of TNC drivers.

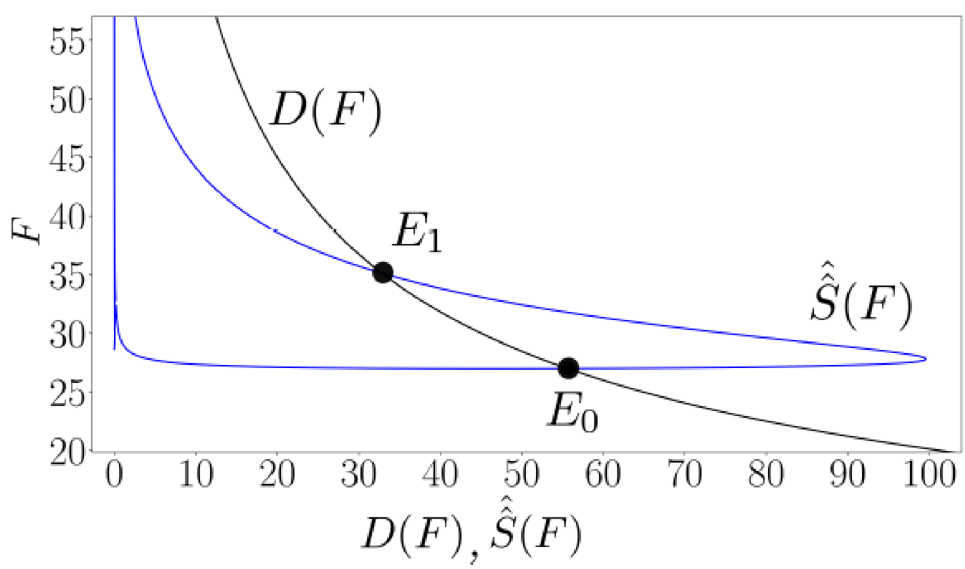

Figure 2. Conventional demand-supply diagram

Figure 2 displays the same equation system as Figure 1 but in the space of a conventional demand-supply or congestion pricing diagram. The x-axis is the quantity of trips and the y-axis is the full price of a trip. The quantity of trips demanded is related to the full price of a trip simply via the demand curve. The quantity of trips supplied is related to the full price of the trip by substituting out u using (3) and then substituting out z using (4), to obtain $\hat{\hat{S}}(F)$. Recasting the equation system in this space, it is evident that the equilibrium E_0 is analogous to the well-behaved or "congested" equilibrium from Walters, 1961 and that the other equilibria correspond to hypercongested equilibria. Whether the analogy is exact is an issue that will be taken up in the proposed research. If the analogy is exact, Walters' line of argument can be applied to determine an externality cost. But since traffic congestion is absent, what are the externalities?

This raises the more general issue of the efficiency of equilibrium. A central principle in the theory of market failure is that the market fails to achieve efficiency if externalities are not externalized. An externality is an effect of one economic agent's action on another's welfare that is not "mediated through the market". In the model, there are search-and-matching externalities (Mortensen and Pissarides, 1994). When initiating a trip, a passenger neglects that by withdrawing a TNC vehicle from the pool of idle TNC vehicles he causes the matching rate of other prospective passengers to fall. Similarly, when deciding whether to become a TNC driver or to engage in some other activity, an agent neglects that her entry causes the matching rate to increase. These externalities have been extensively examined in the search and matching literature (e.g., Hosios, 1990) but here are complicated by economies of scale in the matching process.

We now apply the equation system to examine the effects of imposing a minimum wage in a more complex scenario in which there is a monopoly TNC firm that chooses the fare and the driver commission rate of TNC drivers, so as to maximizes profit, π, considering that the supply of taxi drivers is given by $T(r) = mr2$ with m = 0.5194. The TNC firm exercises monopoly power in setting the fare and monopsony power in setting the commission rate. In choosing the fare and the commission rate, the firm considers equations (1) through (5). The second row of Table 1 records the values of variables for the monopoly equilibrium in the absence of any minimum wage. The profit-maximizing fare is \$29.32 and the profit-maximizing driver commission rate is 20.63%. The values of the other variables are obtained by solving (1) through (5) with this fare and commission rate. The full trip price is \$45.41; the net remuneration rate for TNC drivers is \$5.52/hr; the density of taxis is 15.80/ml^2; the idle rate is 20.00%; trip duration is 0.6438 hrs; and the firm's profit is \$457.0/ml^2-hr.

Table 1. The effects of a minimum wage on equilibrium with a monopoly TNC firm

	P	θ	F	r	T	u	z	π
no regulation	29.32	0.2063	45.41	5.52	15.80	0.2000	0.6438	457.00
$w^* = 10$	31.90	0.3035	48.18	10.00	14.08	0.1931	0.6511	387.67
$w^* = 12.50$	35.70	0.3300	52.23	12.50	12.06	0.1863	0.6612	355.10

The second-row reports on the "minimum wage" equilibrium when the minimum wage is set at \$10/hr. The wage is the net remuneration rate. The TNC firm does not choose the rate directly, but rather chooses the driver commission rate, the fare, and the number of drivers to hire so as to maximize profits, subject to the constraint (in addition to the other constraints) that the net remuneration rate is no less than \$10/hr. In the example, the firm does this by raising the fare from \$29.32 to \$31.90 per trip, increasing the commission rate from 20.63% to 30.35%, and decreasing the number of drivers it hires from 15.80/ml^2 to 14.08/ml^2. As it must when the minimum wage constraint binds, the minimum wage reduces the firm's profit. Since the minimum wage has little effect on trip duration, the rise in the fare causes an increase in the full price of a trip, which makes the firm's customers somewhat worse off. How the idle rate and trip duration adjust to establish the new equilibrium is complex; in the example, trip duration increases by slightly over 1% and the idle rate falls slightly more than 3%. The third-row reports on the minimum wage equilibrium when the minimum wage is increased further to \$12.50. All the variables respond to the minimum wage in the same way they did with a minimum wage of \$10.00/hr but more strongly.

The analysis of other policies would proceed in much the same way. One could apply it to examine the effects of changes in contract structure. For example, to encourage more of its drivers to work full-time rather than part-time, the firm might switch from a commission system to one in which each driver pays a fixed daily fee to be a TNC driver.

3.2 The TNC Industry

The previous subsection examined the behavior of an individual TNC firm. However, in order to consider how TNC's do, and should, fit into a metropolitan transportation system, it is necessary to consider the TNC industry as a whole. Recent industrial organization theory focuses on the strategic interaction between firms in the industry using formal game theory (Tirole, 1988). Traditional industrial organization theory, however, was structured around Joe Bain's conceptual framework of "structure, conduct, performance" (Bain, 1968).

From the perspective of traditional industrial organization theory, the central feature of the transportation network industry is decreasing costs at the level of the individual firm, deriving from economies of density in wait time. Consider two firms that compete in the same locale, and assume that one has twice the driver density of the other. The expected time it takes for the closest taxi to pick up a passenger, which is also the expected passenger wait time, is lower for the firm with double the idle driver density. The lower wait time increases that firm's profits in two ways. First, since its drivers spend less time enroute to pick up passengers, it does not need to pay them as much per ride. Second, since its customers have lower expected wait time, they are willing to pay a higher fare.

Decreasing costs at the level of the firm are the defining feature of natural monopoly. A firm that produces a higher level of output than another incurs lower production costs per unit. Thus, the firm that produces the highest level of output can force its rivals out of the market by setting its price below their average cost. The industry's cost structure therefore naturally leads to monopoly. Figure 3 displays the textbook analysis of natural monopoly, deriving from Hotelling, 1938. Price/cost per unit is on the y-axis and output on the x-axis, as in the standard supply-demand diagram. *AC* is a firm's average cost curve as a function of output and is downward-sloping reflecting decreasing costs. *MC* is the corresponding marginal cost curve, and lies everywhere below the average cost curve. If there is only one firm in the industry, the natural monopolist, it faces the market demand curve *D. MR* is the corresponding marginal revenue curve. A profit-maximizing natural monopolist chooses the level of output, *qm*, at which *MC* equals *MR*, and sets its price equal to the corresponding point on the demand curve, pm.

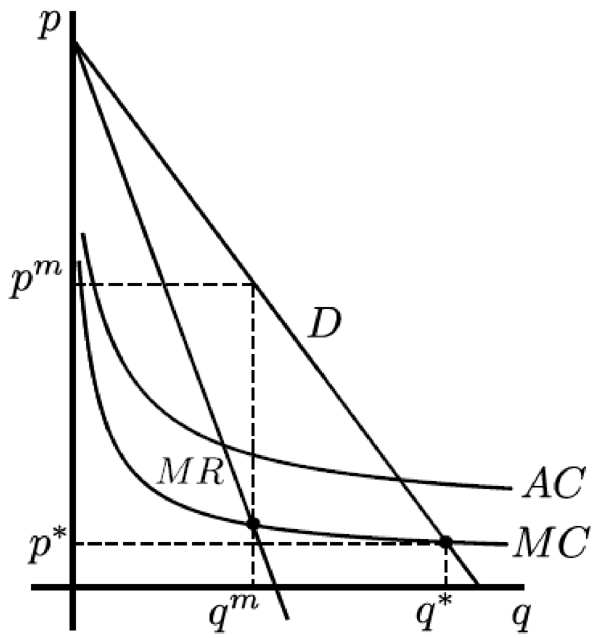

Figure 3. Walter's Diagram

A central result in microeconomic theory is that the efficient level of output is that for which marginal social benefit equals marginal social cost. When the marginal social benefit curve coincides with the demand curve, the efficient level of output is that for which *D* intersects *MC*, $q*$ in Figure 3. The market clears if price is set equal to marginal cost at this level of output, $p*$ in Figure 3. Since marginal cost is less than average cost, producing the efficient level of output and pricing to clear the market result in negative profit.

Thus, society faces a tradeoff in deciding how to deal with a decreasing cost industry. Left to its own devices, a natural monopolist is financially viable but this financial viability is achieved at the cost of its producing less than the efficient level of output and selling at a higher than efficient price. But organizing the industry in any way that results in its producing the socially optimal level of output requires subsidization. In the United States, the most common way society deals with this tradeoff is to regulate a private firm or public utility so that it produces more than the monopoly level of output but remains financially viable. There is a large and multi-faceted literature on the economics of regulation. One strand focuses on the political economy of regulation, dealing with such issues as lobbying, corruption, and "regulatory capture" (dealing so intimately with the regulated firm, the regulator becomes sympathetic to the concerns of the regulated firm). A newer branch of the literature deals with "incentive regulation" (Laffont and Tirole, 1986; 1993); the regulated firm knows more about its cost structure than does the regulator. To induce the firm to truthfully reveal its "private information" (a "truth revealing mechanism"), the firm must be provided with an incentive to do so in the form of "informational rents".

The traditional argument considers the long-run equilibrium of a decreasing cost industry. In the formative years of the industry, however, its constituent firms compete ferociously to increase market share so as to eventually become the industry's natural monopolist. Most of the "tech" industries are decreasing cost industries. So as not to stifle innovation, society via the government has for the most part chosen to stand on the sidelines, though this has been changing. Perhaps the threat of government intervention or a reformed and revitalized taxi industry will be sufficient to discourage TNC natural monopoly firms from abusing their market power. Of course, the structure, conduct, and performance of real-world decreasing cost industries is considerably more complex than the above discussion suggests. For example, most decreasing cost industries produce multiple products that are differentiated in many dimensions (Baumol, Panzar, and Willig, 1988; Laffont and Tirole, 1990). On one hand, this differentiation may lead the natural monopolist to price discriminate more effectively through market segmentation. On the other hand, in the transition to long-run equilibrium, it may permit secondary firms to achieve a dominant position in niche markets.

The third paper will discuss regulation of TNC's against the backdrop of the above discussion.

3.3 The TNC Industry in the Context of the Metropolitan Transportation System

What role should the TNC industry play in the metropolitan transportation system? To answer this question, a framework of analysis will be adopted that is standard in transportation economics[4]. It addresses the question from the perspective of a benevolent transportation planner who has only indirect control of the metropolitan transportation system via the policy instruments at her disposal, and considers the medium run, in which the "bolted-down" elements of the public transportation system (the road and subway network) are fixed, but rolling stock (subway trains and buses) and bus routes are policy variables.

There are five simple modes: walk, auto with parking, bus, subway, and TNCs[5]. In principle, there is a large number of compound modes, but only a subset will be considered. Parking needs to be considered since in its absence it is hard to explain the popularity of TNC's. Several scenarios are considered. In Scenario 1, space is isotropic and all trips are of the same length. In

[4] This framework ignores hypercongestion, but can be adapted to accommodate it by adding a macroscopic function relating flows to densities.

[5] 5The taxi industry might be added to this list. However, since most of those who continue to choose taxis either do not own a smart phone or receive subsidized service, over the medium-run analysis of this paper, it seems sound to assume that the taxi industry will at best continue to be viable only in niche markets.

Scenario 2, space is isotropic and trip lengths differ. In Scenario 3, space is anisotropic and trip lengths differ.

3.3.1 Scenario 1: Isotropic space, uniform trip length, "identical" individuals

This subsubsection draws on unpublished work by the PI and John Rowse (Arnott and Rowse, 2011), which solves numerically for the optimal metropolitan transportation system in the medium run with cars, parking, subway, and bus, but without TNC's. It also draws on Tirachini and Hensher (Tirachini and Hensher, 2012), which analyses equilibria and optima for ametropolitan transportation system in the medium run with cars, buses, and walking.

Space is isotropic is the sense that population density is uniform and the transportation system has a "spatial unit of replication". Individuals have identical tastes and budget constraints but differ in their walking distance to bus stops and subway stations. The planner's aim is to maximize (per unit area-time) social surplus, which is a dollar measure of total social benefit minus total social cost. Total social cost is a dollar measure of social resource costs associated with the entire transportation system, accounting for traffic congestion and crowding but ignoring traffic accidents and environmental externalities. Let q be a vector of the flow of trips taken by each mode, Ω be a vector of policy variables, $B(\cdot)$ be the benefit function and $C(\cdot)$ be the cost function. If the planner had direct control, she would face the following maximization problem: $\max_{q,\Omega} B(q) - C(q;\Omega)$.She would choose Ω to minimize the social resource cost associated with the optimal flow of trips taken by each mode. And she would choose q such that, for an interior optimum, the marginal social benefit of a trip by a particular mode equals the corresponding social cost. This is the first-best allocation. In a decentralized environment, for each mode individuals choose to travel up to the point where marginal private benefit equals the (full) price of that mode. If there are no consumption externalities, the marginal social benefit equals marginal private benefit. The planner can then decentralize the optimum by setting the (full) price of each mode equal to its marginal social cost, evaluated at the optimum, which is the *first-best pricing rule*. Thus, the planner does not need direct control to achieve the optimum. It is enough for her to indirectly control the optimal allocation by either setting prices directly or by imposing taxes and subsidies such that the optimal prices are determined through markets.

A first step in the analysis will be to solve for the first-best optimal metropolitan transportation system and the prices that decentralize it. In contrast to most of the previous literature, which focuses on first-order conditions, the focus will be on how nonconvexities inherent to the transportation system may lead to multiple local optima. The model incorporates five potential nonconvexities: i) economies of service density and service frequency for the bus system; ii) economies of service frequency for subways; iii) economies of density at the level of the individual TNC firm; iv) lateral economies of scale in garage parking construction (Arnott, 2006); and v) nonconvexities in the road congestion function. The last merits elaboration. The standard way of modeling congestion interaction between cars and buses is to assume that a bus is so many passenger-car equivalents (PCE's) in terms of the congestion it causes (Parry and Small, 2009). But when there are many cars on the road but few buses, a single bus causes more congestion than when there are many buses and only a few cars (Verhoef, Rouwendal, and Rietveld, 1999), and vice versa.

Often there are constraints other than technological and resource constraints that preclude decentralized attainment of the first best. In this case, the planner's objective is to maximize social surplus subject to these constraints. The optimal allocation subject to these constraints is termed the second-best allocation. In the context of the proposed research, four constraints are potentially particularly important: i) the underpricing of auto congestion; ii) the underpricing of curbside parking; iii) inefficiencies created by the private TNC industry; and iv) possible deficit constraints on the public transportation system. Constraints i) and iv) were first considered early in the development of the theory of the second best and have since been extensively considered[6], and constraint ii) was first considered in Arnott and Inci, 2006. The proposed research will focus on constraint iii). To illustrate how second-best constraints are dealt with, consider a situation where there are buses, cars, and TNC's and auto congestion is completely "unpriced". The full price of an auto trip would then be a driver's user cost, which would depend on travel speed, and hence on the flows of car, bus, and TNC vehicles: $^{uc}a(qa, qb, qc)$. Since individuals choose to travel on a particular mode up to the point where marginal private benefit equals marginal private cost, the constraint is $\frac{\partial B(q)}{\partial q_a} = uc_a(q_a, q_b, q_c)$, and the constrained second-best optimization problem is

$$\max_{q,\Omega} B(q) - C(q;\Omega) \ \ s.t. \frac{\partial B(q)}{\partial q_a} = uc_a(q_a, q_b, q_c) \tag{8}$$

The constraints imposed by TNCs are more complicated since not only does the density of TNC vehicles need to be incorporated, which depends on the equation system (1) through (4), but also it might be appropriate to endogenize the TNC fare and driver commission rate.

This research investigates the analytically the second-best optimization problem including only the TNC constraints. To treat the other constraints as well, the major tool will be numerical optimization calibrated to one small, one medium-sized, and one large metropolitan area. The numerical optimization will be need to be expertly done to deal with the nonconvexities inherent in the model. In earlier numerical work, John Rowse applied seven different optimizers to one problem considered in Arnott and Rowse (Arnott and Rowse, 2011), and each came up with a different solution! One outstanding issue is how to model the TNC industry, as distinct from the individual TNC firm, which was the subject of section 3.2.

One might argue that the proposed model is too rich. But it is hard to see what could be jettisoned, beyond the subway for the medium and small metropolitan variants, without compromising its ability to address the wide range of policy issues that have been raised in conjunction with the TNC industry and its regulation. For example, Schaller, 2017 argues: "The

[6] Lipsey and Lancaster, 1956; L´evy-Lambert, 1968; Vickrey, 1959; Baumol and Bradford, 1970; Mirrlees, 1971; Diamond and Mirrlees, 1971; Pickrell, 1985; Verhoef, Nijkamp, and Rietveld, 1996; Arnott and Yan, 2000; Kraus, 2003; Proost and Van Dender, 2008; Parry and Small, 2009.

most promising avenue [to deal with Manhattan's congestion problem] is to reduce the unoccupied time and mileage of taxis and TNC's." Also, to understand the extent to which the increased traffic congestion in Manhattan can be attributed to the growth of TNC's, a rich treatment of both transportation demand and transportation supply is needed. What simpler model could address these issues?

3.3.2 Scenario 2: Isotropic space, heterogeneous trip lengths, "identical" individuals

Treating heterogeneity in trip length is important since modal choice is sensitive to trip length. Treating this extension will be straightforward—trips are indexed by length as well as mode and trips and trip-miles are distinguished.

3.3.3 Scenario 3: Anisotropic space, "identical individuals"

In a classic book in transportation economics, Meyer, Kain, and Wohl, 1966 compared the social cost of different modes as a function of population density, and based on their findings argued that bus travel is not financially viable below a critical level of passenger density. Despite heavy subsidization (Parry and Small, 2009), bus services have indeed withered away in the outer suburbs. In recent years, partly as a result of a decline in revenue raised from the gasoline tax, and partly as a result of planners' advocacy of sustainable cities that has resulted in a substantial reallocation of transportation budgets from roads to mass transit, especially LRT's, highway congestion has been getting steadily worse. Suburbanites are becoming increasingly trapped in the suburbs. This is but one facet of a broad issue: How should an optimal transportation system be designed recognizing that population density declines with distance from the CBD? The proposed research will not concentrate on this question. But since the PI will have developed such a rich model of the metropolitan transportation system in an isotropic space, and since the issues are important, he would like to do some preliminary work extending the model of Scenario 2 to the monocentric city, focusing on the question: What role should TRC's play in transportation within suburbs and between the suburbs and central locations?

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Appendix A: The Taxi Industry and TNCs in Los Angeles

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09.27.18

1. Introduction

In the past near decade, Uber has become a natural monopoly of private ground transportation. With its market power and expansion, the company has disrupted taxi industries across the world, displacing those left unprotected by local regulations. Acknowledged as a network company, their provided network service connects passengers with drivers through ride-hail travel. Through this network, Uber can integrate mechanisms that create disparities between itself and other industries, in terms of technology and transit. For one, the company's legal representation as a transportation network company (TNC)[7] grants the ability to deflect legal obligations to follow regulations pertaining to taxicabs. Furthermore, in competing against taxi fares, Uber's pricing algorithm and its ability to surge price[8] establishes flexible fares that are more affordable than taxi fares. Additionally, consumer accessibility through app-based software and short wait times are convenient in relation to taxis, only requiring technological proficiency to a small degree. With its technological capabilities, freedom from certain legalities, and pricing power, Uber has uncovered a large source of demand for private transportation; however, exposing unprotected taxi companies to decline.

Taxis in Los Angeles are particularly disadvantaged. The presence of a systemic conservatism within the taxi industry has created complications in proposing policies to introduce change. A problem of jurisdiction also arises due to TNC compliance to state law rather than local law, inhibiting direct local action against TNCs and perpetuating unfair competition between taxis and Uber. Consequently, finding the optimal solution becomes a problem of whether LA taxis should secure their market segment or expand their market to compete against TNCs. The incapacity of the taxi industry to adapt hinders them unable to modernize, thus effectively compete. Thus, the purpose of this report is to explore aspects and events in order to provide information on the industry's decline, considering possible stances and policies that provides insight on this issue.

2. Information on Uber

Uber's primary objective has been to expand its market share, maximizing its revenue to dominate the market for private ground transportation. In doing so, Uber has accepted substantial losses, making large expenditures to assert global market dominance. In reporting their quarterly performance, there was consistent growth in revenue throughout 2017, and a

[7] Transportation Network Company – a company that provides a network for drivers to engage in ride-hail travel with passengers for fares.
[8] Surge pricing – setting prices based on real-time demand and supply, allowing price flexibility in the short run.

decrease in its reported losses in its earnings before interest, taxes, depreciation, and amortization (Figure 8). Unlike their losses in EBITDA, however, according to Uber's disclosed financial results, the company had total losses of $4.5 billion, a 61% increase from its 2016 losses of $2.8 billion.[9] It was also valued at $68 billion in 2017, whereas estimates indicate Uber's current valuation is $62 billion.[10] Although SoftBank made a substantial investment of $48 billion with their purchase of 15% of Uber's shares, Uber investors have receded from the company since 2017 for various reasons, causing a decrease in investor funds that comprise a majority of the company's valuation.[11]

On the other hand, Uber's user base is drastically increasing. In 2017, Uber disclosed its user base of 75 million, from a user base of 40 million in 2016.[12] The company also disclosed that it had 3 million total active drivers (defined as drivers that gave four or more rides a month). Moreover, the average no. of rides per user have increased, from 42 rides in 2016 to 53.3 rides in 2017, and 55 rides as of the second quarter of 2018.[13]

In terms of global market presence, the company operates in over 600 cities globally as of 2017. Among these cities, a majority of them have caused Uber to face obstruction from local regulations. In cities where Uber is banned from operating, Uber has sold its business operations to regional transportation businesses, particularly in China, Russia, and Southeast Asia, from which it has observed rare profit in the first quarter of 2018.[14] Meanwhile, in its ventures to avoid legalities imposed on transportation services, Uber has found difficulty in maintaining operations against local laws in Europe and Asia. Unlike its foreign counterparts, the United States have taken relatively little action to provide fair competition between taxis and ride-hailing vehicles. With Los Angeles being the focal point for analysis, this report provides context and reasoning in how LA taxi services were affected.

On a more precise scale, Uber comprises nearly all of TNC penetration in Los Angeles. According to a 2018 *Certify* press release, the world's largest travel and expense report management software company, Uber composed 89% of ground transportation expenses for business travelers in LA. In 2017, taxis' share of ground transportation expenses for business travelers in

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[9] Article found here.
[10] This information is based on several sources. These sources include Trefis, a company led by MIT engineers and Wall Street analysts; Techcrunch, a news outlet that majors in news on startups; Fortune magazine, and statista.com. This is information is as current as within the third quarter of 2018.
[11] Article for purchase of sales found here. Investors have left Uber in a series of lawsuits against Kalanick, blaming their recent scandals for investor losses. Being accused of several allegations, including fraud, and their record of unprofitability, brought a number of investors to leave the company, such as Benchmark, a previous major stockholder of 20% of Uber's shares. An article is provided for this event.
[12] Information on 2016 monthly users were disclosed by a source from Uber, and listed on Trefis. Information on 2017 monthly users were disclosed by Uber COO Barney Harford on Recode, a newsletter on technology and media. Estimates from Trefis expect a user base of 100 million by the end of 2018.
[13] Ibid.
[14] More information by *Bloomberg* can be found here

LA dropped to 8%.[15] Analyzing ground transport receipts and the ride-hailing market share between Uber and Lyft in the US, Uber's share has declined over the years (from 95% in 2016 to 90% in 2017 to 81% in 2018, in each of the first quarters), transferred to Lyft, which has viewed considerable growth (from 10% in 2017 to 19% in 2018, in each of the first quarters).[16] An infographic on the market shares between Uber and Lyft by city is provided by Quartz Media on *The Atlas* (Figure 9). Uber may be the largest ride-hailing company within the US by market share and consumer base, but its position is becoming more unstable due to startup competition and investors.

3. Taxi Authorities and Agents

This section will describe the agents within the taxi industry and their roles. The City Council is the municipal body that governs the city of Los Angeles, generally acting as the legislative body of the city. The Council confirms the Mayor's appointment and assignment of the Board of Taxicab Commissioners, to whom it places the burden of responsibility over taxi regulation. As such, regulation of taxicabs does not fall under its jurisdiction, and they only act to approve Board recommendations regarding taxis.

The Los Angeles Department of Transportation (LADOT) is the general transportation division under which the taxi industry operates. The department is tasked with collecting and analyzing data on the taxi industry, including collecting franchise performance, authorizing proposals made by the Board, and executing public planning/transportation/regulatory policies.

The Board of Taxicab Commissioners is a five-member advisory group that proposes legislation regarding taxis. They create policy recommendations pertaining to taxicabs, which are approved by City Council and LADOT. Additional duties include: observing cases on taxi drivers, determining franchise consequences,[17] and ensuring proper provisions of service. Lastly, they are responsible to plan the stabilization of the current taxi market and ensure fair competition between the taxi industry and TNCs; thus, they may act to represent and/or protect the private interests of taxicab franchises.

There are nine taxi franchises in the City of Los Angeles authorized by the Board and LADOT. Operating under a complex system, they are granted a number of authorized vehicles by the city of Los Angeles, dedicated for the taxi fleet and taxicab services (See "Taxi Operations", page 12).[18] All taxicab franchises comply with sets of ordinances that may pertain to their respective franchise. These ordinances define taxi services and create requirements for their services, such

[15] A business traveler is a consumer who make trips on behalf of her company with trip expenses covered by the company. *Certify* is a software program that manages company travel and expense reports, downloaded by companies across the world. As such, it records, compiles, and analyzes data to provide information on ride-hailing market shares based on company expense reports.
[16] Press Release by Certify can be found here
[17] This is referring to the continuation, extension, probation, suspension, and expulsion of a franchise
[18] The number of permits and vehicles do not necessarily correspond, as due to the state of the industry in the current economy, the labor supply of taxi drivers are scarce compared to the vehicles granted.

as technological progress, environment-friendly regulations, compliance with LADOT regulations, etc.[19] The nine authorized franchises are Bell Cab, Beverly Hills Cab, Los Angeles Checker Cab, Independent Taxi, United Checker Cab, United Independent Taxi, City Cab, United Taxi of San Fernando Valley, and Yellow Cab. Taxi drivers are self-employed agents that perform taxicab services, summarized as loading, transporting, and unloading passengers under sets of rules and ordinances (More details on "Information on Los Angeles Taxis", page 6-9).

4. Information On Los Angeles Taxis

After the Great Recession of 2008, LA taxis experienced a decline in demand for their services. Taxicab demand rose slightly in 2011-2012, then dropped again after the second quarter of 2013, during when TNCs became popularized in Los Angeles (Figure 4). Consequently, the total number of drivers began to drop, as driver counts went from 4100 in 2012-2013 to 3200 by November 2016. Dispatch taxi services[20] found a steady drop in quality (measured by the percentage of trips having response times within 15 minutes), decreasing from roughly 88% in 2008 to 85% in 2015 (Figure 5).[21] Wait times would increase with less idle taxi drivers[22] available to respond to the call.[23] Hailing taxi services have especially declined since 2012, when Los Angeles reportedly became the city with the worst traffic in the United States.[24] This drastic decrease is attributed by how taxi drivers are typically not in active search for passengers, due to severe traffic congestion (currently an average of 45% delays in travel time),[25] urban population density, the vast size of the city, and low demand for taxis.[26] Moreover, traffic laws legally prevent taxis from loading passengers via hailing in most of Los Angeles. Public ignorance of how these laws pertain to taxis, have prompted the Board and LADOT to encourage hailing services with the "Hail-a-Taxi Program", an attempt to increase public awareness of hailing taxis, yet to little or no avail.

Proceeding to describe the driver agents in the industry, a taxi driver is sponsored by any individual franchise, in which he operates an authorized vehicle issued by that franchise. He is considered to possess his own business, earning commission income by providing taxi services,

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[19] Individual ordinances are generally the same aside from technical or trivial differences. For those who are interested in the differences between ordinances, individual ordinances can be found on under 'Taxicab Ordinances'

[20] Dispatching a taxi – ordering a taxi by calling a taxi company, who connects the call to a dispatcher, processing the request so that a nearby taxi driver can pick up the passenger.

[21] Los Angeles Taxicab Performance Review and Annual Report 2014-2015, p. 22-23.

[22] Idle taxi – or vacant taxi; an employed vehicle without a paying passenger.

[23] Michael E. Beesley and Stephen Glaister's model of cruising taxis states that the number of vacant taxis are inversely proportional to waiting times. The Los Angeles Taxicab Performance Review and Annual Report 2014-2015 has also reported this to have occurred.

[24] Reported on a INRIX report, a company that specializes in analyzing car services and transportation. Article on this information can be found here.

[25] Reported on the TomTom Traffic Index as of Aug 2018. Information can be found here.

[26] This generalization was reported on *The New Yorker*: Article can be found here

under a company-contractor relationship with his sponsor. As such, he is self-employed, and makes the following general payments:

1) Vehicle lease – if the driver is not the owner of the vehicle, he may lease the vehicle on a weekly or shiftly basis, by his choosing; leasing rates are paid to the vehicle owner, a separate, but affiliated agent; leasing drivers are permitted to use their vehicle as they desire, so long as it follows the rules and regulations provided by the City.[27] As of September 2016, 2,277 out of 3,328 (68%) drivers were reported as leasing drivers.[28]
2) Insurance premiums – if the driver owns the vehicle, he must pay auto insurance for his vehicle, which can be sponsored by the franchise or from an independent third party; if the driver is leasing the vehicle, the vehicle owner may charge the leasing driver so that he can cover his cost of insurance.
3) Membership fees – the taxi driver pays the franchise a fee to cover the cost of sponsorship; this includes the use of dispatching and/or app network services, assessment fees, etc.
4) Vehicle expenses – i.e., cost of gas, cost of repairs, cleaning the vehicle, etc.; some of these expenses should fall to vehicle owners, but they may charge repair and maintenance costs to taxi drivers if they wish.

If the taxi driver is a vehicle owner with company affiliation, he is, effectively, a shareholder of that company, in part of the embedded shadow medallion system described previously. All drivers are registered under the Employer Pull-Notice system, where the Department of Motor Vehicles inspects driver records to promote driver safety and ensure their 'employers,' or their sponsoring companies, are properly represented. Taxi vehicles are inspected on a weekly basis by taxicab franchises/owners and an annual basis by the officials from the LADOT. Inspection criteria is provided (Table 3 and Table 4).

LADOT reported demographics in 2016 that out of 3,328 taxi drivers in Los Angeles, 3,140 (94%) taxi drivers are from a country of origin outside of the United States; the remainder are from the United States, which may include Americans of (≥)second-generation. Taking this information into consideration, the population of drivers of US origin has grown since 2015, from 159 (4%, out of 4,169; 2015) to 188 (6%, out of 3,328; 2016). Lastly, as of 2016, taxicab drivers in Los Angeles are reported to average 52.1 years of age.[29]

The majority of taxi drivers continue their services under poor working conditions and having little disposable income. Most work full-time, restricted to this profession due to age, little professional experience in the United States, inadequate education, unable to take time to

[27] Leases on a shift basis offer lower lease rates, but less freedom to operate the vehicle. Drivers are open to choose leasing options, which creates variability in the number of reported hours worked within a time period. This point is of importance for the number of reported driver hours, found on page 9 of this report.
[28] Los Angeles Taxicab Review and Annual Performance Report 2014-2015, pp. 68.
[29] Los Angeles Taxicab Review and Annual Performance Report 2014-2015, pp. 66-67.

search for different employment, inadequate English skills (as only adequate English comprehension is required), and/or other factors that reflect the employment limitations of first-generation Americans in the United States. It is important to consider that the California Vehicle Code mandates that "drivers are restricted to no more than 10 straight hours of driving (without a break), and no more than 10 hours over any 15-hour period. An eight-hour break is also stipulated in the Code."[30]

The failure of this Code, however, is that drivers are restricted to *reportedly* operate no more than the hours stipulated by the code, so there would be potentially fallible information on the number of reported hours. To specify, consider: a taxi driver may report that he took a break during the time that he was idle, incentivized to earn enough to meet personal "quotas" (e.g., membership fees, due leasing payments, rent); or, a taxi driver may accept a personal engagement for privately set fares agreed by both parties (at discounted, regulated, higher fares). Assuming that the taxi driver is a rational being acting in his self-interest, it is only necessary to consider that he may take actions that cannot be properly regulated or monitored, in order to fulfill his needs. Therefore, rules and regulations exist, but can be insignificant in that they cannot be monitored or properly enforced.

5. Comparative Regulations on Taxi Drivers and TNC-Based Drivers

Overall, the taxi industry has faced long-lasting regulations, leaving a certain conservative persistence to maintain these regulations. It is justified, however, as these regulations have provided security, in and of, passengers, drivers, and the industry. For example, taxi drivers must possess a permit, which they receive after they pass a series of tests (driver's test, background checks, drug tests, fingerprint check, etc.) with a company sponsorship. This permit authorizes drivers to engage in transportation services, enabling the loading of, unloading of, and charging mandated fares to passengers. The permit acts as a regulator of consumer safety, to the degree in which drivers can be monitored. Contrarily, with their rating mechanism, TNC drivers are not necessarily required by state law to possess a license, as they are regulated to the extent consumers can observe/control driver behavior. In spite of this, they are mandated by city law to possess a license in order to pick up passengers at the Los Angeles International Airport (LAX). This mandate has been enforced since 2016, after TNC drivers were prohibited from loading/unloading passengers at the LAX. As LAX trips comprise a substantial share of taxi drivers' income, this rule provides taxis a means to secure their consumers (See Table 3 to view growth of airport trips from 2012 to 2015).[31] Ergo, the solutions of securing the market segment or competing against TNCs may converge in some aspects, but they also diverge in others. Another notable rule is that taxi vehicles must undergo procedures and retrofitting to be permissible for use. Taxis must possess a taximeter, a toplight, a shield between passengers and drivers, a radio transmitter/receiver system, an identifiable number, a security camera for consumer and driver protection, and a painted design according to the franchise sponsorship.

[30] Los Angeles Taxicab Review and Annual Performance Report 2014-2015, pp. 65.

[31] Rights to operate at airports are so highly valued that taxi franchises are privileged to operate on a turn-by-turn basis.

As such, capital costs come at high costs for taxi companies. In comparison, TNCs use drivers' personal vehicles for ride-hailing services, thus avoiding the cost of retrofitting and vehicles. Taxi vehicles are also required to remain within the ninth anniversary of the model year.[32] It is important to note that it is irrelevant that the vehicle was produced after the model year; it must comply with the time restriction after the model itself was introduced. Uber age limits for private vehicles are much more lenient, at a requirement of fifteen years or less.

It is also mandatory conduct for taxi drivers to be dressed in a specific fashion, "consisting of black dress pants (no jeans of any type), white dress shirt or polo type shirt (polo shirt must be embroidered with company name and/or logo), tie acceptable but not required, and black shoes with socks, with black skirts allowed for female drivers".[33]

Infamously known as the "Sock Regulation," it reinforces the contractor-sponsor relationship that places taxi drivers under self-employment and grants companies unaccountability for drivers (e.g., unaccounted for driver expenses, insurance, etc.). Attempts to remove this policy was met with opposition by franchises because companies would be required to enforce passenger-experience rules, and treating drivers more as employees than independent contractors.[34]

In part of their securing their market segment, there are those that exist to promote the greater good. For the pollution issue in Los Angeles, LADOT enforces that taxi vehicles meet a production standard of low emissions. The Greening Program the displacement of vehicles that produce higher emissions and replacing them with fuel-efficient vehicles of four levels that meet a minimum standard of Tier 2 SULEV (Super Ultra Low Emissions Vehicle) pollution emission standards, from Level 1 being the lowest and Level 4 being the highest.[35] Vehicles used in TNC operations are not bound by or necessarily meet these standards. LADOT and the taxi industry also strictly make their services accessible and fair to the disabled and senior population by complying with the Americans with Disabilities Act (ADA). In 2011, 228 vehicles out of 2361 total vehicles in the fleet became dedicated to the ADA, charging equal or subsidized (from the CityRide program)[36] fares. Uber also has wheelchair-accessible services, namely UberWAV (abbr. Wheelchair Accessible Vehicles), but contain issues with price and availability. To specify, UberWAV is claimed to cost ten times more than its UberX services and has failed to meet WAV demand in many instances. Finally, restrictions on the number of permits also exist to reduce the level of traffic. Therefore, taxis are positioned in a great

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[32] This was reported in the Los Angeles Taxicab Review and Annual Performance Report 2014-2015, which was released in January 2017, but deregulation may have shifted this requirement to eight rather than nine years. The source of this information is from a taxi driver.
[33] Taxicab Rules, page 7. Taxicab Rules found here.
[34] Interview with President of the Board of Taxicab Commissioners Eric Spiegelman on the *New Yorker.* Interview can be found here.
[35] Los Angeles Taxicab Review and Annual Performance Report 2014-2015, p.77.
[36] LA CityRide is a program dedicated to seniors and individuals with disabilities, funded by Proposition A, Local Transit Assistance (PALTA) funds. This program is executed by the LADOT with the Los Angeles Department of Aging.

disadvantage due to these limitations, exchanging the cost of higher wait times for lower traffic congestion. In a report from Schaller Consults, it states, “Private ride TNC services (UberX, Lyft) put 2.8 new TNC vehicle miles on the road for each mile of personal driving removed, for an overall 180 percent increase in driving on city streets” (6).[37] This is a significant point to consider, as this would indicate lower productivity on ground transportation, and potentially higher auto emissions. Although traffic congestion is an issue, an absent consideration from this report is the *quality of the miles* that are contributed by TNC services. With ride-hailing, consumers take affordable trips that otherwise would not have taken, had they had their own private transport or taxis (e.g., one-way direct transport, immediate transit). When these trips are now possible, one must account for the level of overall productivity from these trips (i.e., added transportation of businesses, time saved for taking trip, etc.).

6. Taxi Operations

The permit system is comprised of a sponsorship of the permit and an authority that issues the permit; a complicated institution that contains an underlying shadow medallion system, where permits partially behave as a share of the company. The number of permits granted in the taxi industry is determined by Public Convenience and Necessity Indicators (PC&N) of Los Angeles, and issued by the LADOT. These indicators are determined by:

> “Changes in the number of total reported trips, counts of ‘requests for’ and ‘completion of’ dispatch service trips, both passenger and taxicab trip volume at the Los Angeles International Airport, hotel occupancy levels and population statistics are all indicators of changes in service demand.”[38]

An infographic provides the statistics of these indicators (Figure 6).

The taxi franchises have areas within Los Angeles in which they are responsible for, known as primary service zones, or areas where drivers of a particular franchise primarily operate. There are five zones, which are defined from “Zone A… E”. In a general description of each zone, Zone A refers to the San Fernando Valley area, Zone B refers to West Los Angeles area, Zone C refers to Central LA, Downtown LA, and the Hollywood areas, Zone D refers to mid-Southern LA (beginning from Central LA), and Zone E refers to the southernmost area of LA (from San Pedro to the Harbor).[39] Taxi drivers are not restricted in loading passengers from other zones, merely that they generally concentrate their operations within their franchise’s responsible zone(s). Franchises may be responsible for up to three zones. A chart displaying vehicle distribution is provided (Table 2 and Table 3).

On a spatial plane where vehicles are distributed, in Zone A, there are 200 vehicles in an area of 260 square miles; in Zone B, there are 560 vehicles in an area of 101.28 square miles; in Zone C,

[37] The report is linked here .
[38] Los Angeles Taxicab Review and Annual Performance Report 2014-2015, pp. 90.
[39] A map is provided for better illustration of the defined zones (Figure 7).

there are 1035 vehicles in an area of 93.3 square miles; in Zone D, there are 488 vehicles in an area of 16 square miles; in Zone E, there are 75 vehicles in an area of 18.84 square miles.[40]

The mandated Los Angeles taxi fares are currently established as follows:[41]

- $2.85 Flag drop (first 1/9th mile)
- $0.30 For each additional 1/9th mile ($2.70 per mile).
- $0.30 For each 37 seconds waiting/delay ($29.19 per hour).
- $46.50 Flat fare for trips between LAX and Downtown area bounded by Alameda St., Santa Monica Fwy., Harbor Fwy., Cesar E. Chavez, Union Station and Chinatown.
- $4.00 Surcharge for all trips originating at LAX.
- $15.00 Minimum fare for trips originating at LAX (In addition to the $4.00 surcharge)

7. Competing Against TNCs in Los Angeles

Among the industry's reactive responses, their most accomplished actions to compete against TNCs in Los Angeles have been their progression towards modernization. By integrating GPS and app-based systems, new features were introduced, as well as abolishing inefficient conventions of service. This included: eliminating paper waybills, a system where drivers devoted time to record trip details; GPS systems to improve navigation; GPS-based smart taximeters (preventing fare fraud, creating electronic waybills); use of third-party apps to optimize the convention of hailing a taxi, also providing electronic means of payment; removing credit card processors; etc.

In "How L.A.'s Taxi Boss Plans to Take On Uber" from *The New Yorker*,[42] Eric Spiegelman, the President of the Board of Taxicab Commissioners, drafted a proposal for the taxi industry to approach a fair competitive market through an app system. This draft created the e-hailing prototype to allow consumers to order taxi services, optimizing the efficiency of hailing a taxi.[43] Spiegelman mentions that the app would be contracted by private app companies rather than by the city, "placing most of the direct regulatory burden for everything from fare controls to providing a system for commenting on driver courtesies on app providers, rather than on government or taxi companies, could insure higher ride quality while still preserving fair access and insurance-coverage rules". The app system has been integrated and operates as he describes: a single app establishes a market network where all drivers are registered; then, multiple third-party apps connect to that network, where they are used by different franchises

[40] These are rough approximations, based on the area that the Primary Zones cover.
[41] Standard as of 2018.
[42] Article can be found here.
[43] Hailing – ordering a private transport vehicle by signaling the vehicle while it is operating on the road; signaling a stop gesture on the road was the norm to hail a cab in the past (in Los Angeles), but electronic-signals have become the primary, modern norm.

(e.g., LA City Cab primarily uses Curb, Bell Cab primarily uses Taxi.us, etc.). The apps do not have to be specific to e-hail, as long as they are connected to the network.

In another interview with Spiegelman, the majority of franchises (seven out of nine) largely rejected the proposal for Assembly Bill 650 made by Assemblyman Evan Low, a deregulatory proposal that includes removing fare regulations, relieving driver codes, and easing taxi drivers to enter the industry. Relieving the strict requirements of becoming a taxi driver was an action to prevent the decline of taxi drivers. However, taxi companies met the bill with opposition, for many reasons, such as: consumer safety, liability of service discrimination towards racial and disabled groups, and the liability of unfair price discrimination.[44] These companies have opposed changes to retain taxi drivers' statuses as independent contractors rather than employees, which would make companies liable to salary wages.[45]

Fare controls were also rejected by these companies, which were proposed by Spiegelman, introducing a reduction of fare prices to stimulate the demand of services. It may be that by decreasing fare prices to increase the demand for services may increase the number of unserviced dispatch/e-hailing orders (given the low supply of drivers), thus potentially endangering each franchise's performance reviews and continuation to operate. Furthermore, decreasing fares to stimulate demand would also suggest that taxis would gain less income per ride, assuming average rides per driver remain the same in the short run, until they adjust in the long run. At the same time, taxi drivers would likely discontinue operating at low fares if demand expands at a gradual rate. As quoted from Spiegelman, "Ironically, we may be preserving competition through regulation."[46] One could conclude that the primary incentive of these companies are to maintain their level of business, rather than directly capturing the demand uncovered by TNCs and properly contest them.

8. Comparative Data on LA Taxis and TNC Drivers

Taxi drivers in Los Angeles earn a median annual income of $39,299, as of July 31, 2018.[47] Uber drivers in Los Angeles earn an average annual income of $49,349, as of May 26, 2018.[48] In both jobs, independent contractors must pay a share of their income to intermediary parties, which I will refer as "sponsors" or "service providers."

Taxi drivers pay flat-rate fees independent of their commission income to their sponsor. These flat-rate fees consist of several costs (See "Information on Los Angeles Taxis", page 7). These fees can vary depending on the model and expenses of the car. For example, insurance premiums can vary depending on the car model, if the insurance is sponsored by the company,

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[44] Article can be found here. Information about the opposition to AB 650 can be found here.
[45] Commission income rewards drivers for being engaged, from which they earn fares. Salary income would reward drivers for the time they are idle, producing inefficient losses from the company and incentive effects where drivers may not perform at optimal productivity.
[46] Article can be found here.
[47] According to salary.com.
[48] According to Glassdoor.

if the insurance is from a third party, or depending on the vehicle owner who charges the taxi driver to cover his costs. Service fees (i.e., for dispatching services, app networks, etc.), sponsorship fees, (and any other fees the company deems they can charge) may vary depending on the franchise. Uber drivers, on the other hand, pay a percentage fee of their commission income to Uber. The standard percentage varies from 20% to 25%, depending on when one became their contractor. This fee consists of the price of sponsorship and the service cost of using their network to find passengers.

In a hypothetical scenario, let us assume a taxi driver works with Bell Cab, driving a 2011 Toyota Prius on a lease. In this case, he pays Bell Cab and an affiliated taxi owner a total of $500 per week.[49] Assuming the median income as his, he pays $24,000 a year in fees, which qualifies as tax deductibles. Therefore, he lives off approx. $15,299 in Los Angeles, without accounting for his tips or his other expenses. On the other hand, let us now assume an Uber driver earns the average income and pays a 25% service fee, which qualifies as tax deductibles. Then, he would live off approx. $37,012 in Los Angeles, without accounting for the tips (which Uber may or may not pocket themselves) or his other expenses.

Another considerable aspect in the potential regulation of Uber is the number of drivers. As both TNC and taxi drivers are considered to be self-employed and possess their own business, they face competition in a unit level. The industry has speculated that regulations maintaining the number of taxi drivers protected the average number of rides per driver. Reflectively, with the growing number of Uber drivers in Los Angeles, would observe a decrease in average output of services provided, assuming all other things equal. To add to this issue, more employed drivers would entail greater traffic congestion, thus decreasing the productivity. After New York City announced it would implement restrictions on the number of Uber drivers, Los Angeles may be considering to implement the same restrictions to reduce traffic congestion. Recent cases indicate that vehicle-for-hires generally advocate restricting the level of competition among themselves.[50] Discovering the social optimum for the number of drivers is exhaustive to include in this report, but is prospective research to develop public policy for traffic and market regulations.

9. Cases Against TNCs

In observing these cases, I will observe cases regarding TNCs, unrestricted to Los Angeles, as characterizing the general public towards TNCs should not be limited to local cases. Cases in 2018 have shown ride-hailing consumers to be victims of vomit fraud, where riders are accused of causing a leak of fluids, that lead to charges from $80 to $150, if they were found to be bodily fluids.

In 2017, the Equal Rights Center in Washington DC charged Uber with a lawsuit that accused the company of violating the ADA and denying wheelchair accessible services to consumers.

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[49] This situation is closely derived from a case.
[50] Article can be found here.

Another case in 2018 found that Uber and Lyft collectively failed to provide over 70% of WAV service requests in New York. Uber was found to have a 55% (27 of 49 attempts) success rate in locating a WAV, and Lyft was found to have a 5% (3 of 65 attempts) success rate in locating a WAV. In addition to low success rates, large disparities in wait times between WAV services and regular services were found. The New York Taxi and Limousine Commission has issued a mandate for 25% of TNC drivers to be wheelchair accessible by 2023, which has been met with opposition from the three major TNCs, with claims this mandate is "arbitrary and capricious" that places high and unreasonable burdens on the companies, who claim their lack of liability to accommodate seniors and individuals with disabilities. Their lack of liability is derived from the use of privately-owned vehicles for transportation, rather than capital, thus making accommodations difficult.

Under Travis Kalanick's leadership, cases of corporate toxicity were brought to light, including the workplace culture environment, sexism, the reinforcement of unrestrained meritocracy, inappropriate behavior, and more. Numerous sexual assault allegations were made against Uber drivers over the years, discrediting the general safety of TNC ride-hailing.[51] Kalanick and several executives were found to invalidate the occurrences of these cases, claiming these allegations were a ploy made by competitors to disgrace Uber's public image. As a result of these cases, they were legally required to remove "safe travel" from their slogans, as false advertising.

Lichten & Liss-Riordan, a law firm devoted to vindicating employment rights, filed a class-action lawsuit against Uber which accused the misclassification of employees, refusal to reimburse driver expenses, rejecting/stealing gratuity payments, and wage violations. This lawsuit was formed in state courts in California and Massachusetts.

Uber concealed a hacking incident in 2016, where information from 57 million users was stolen. The company paid the hackers $100,000 to dispose of the information. This data breach was disclosed to the public in 2017, and generated public distrust that Uber could not account for consumer safety and user protection.

In the beginning of 2018, Uber faced a lawsuit by Google for the theft of trade secrets regarding autonomous cars, which has been settled.

Most of these cases pertain to Uber under former-CEO Travis Kalanick, but has still brought a negative public opinion of the company. Since the 2017 transition from Kalanick to Dara Khosrowshahi, executives and employees who were liabilities were removed and replaced.

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[51] These sexual allegations are overwhelming to list and describe in this report, but by no means are irrelevant or insignificant. The purpose of this case is not to provide statistics (as the relative number of Uber drivers who are sex offenders to the Uber driver population is too small to reliably state the overall safety of Uber services), but to develop perspective on how the public's trust of Uber has diminished over time.

10.General Public

The general public reflects a preference toward TNC services over taxi services. This can be induced from the fact that nearly all of private ground consumption is comprised of TNC services among business travelers (See "Information on Uber", page 3). Features of taxi services that do not exist in TNC services seem to be irrelevant if it does not affect consumers directly. The absence of ADA compliant vehicles in TNC services are not regarded by consumers that are not involved with the ADA. Consumers also do not seem to be discouraged to use TNC services even if it is not environmentally friendly, and increases traffic congestion (See "Comparative Regulations on Taxi Drivers and TNC-Based Drivers", page 12). It may be that these features have not attracted public attention to effectively to promote taxi use. Otherwise, it can be generally assumed that consumers will prioritize a pragmatic means of transport to serve their private interests, rather than sympathy for a declining industry, company scandals, etc.

Even during a period of toxic leadership, Kalanick's actions as Uber CEO does not appear to have negatively affected its user base significantly, hence, the growth of their user base. According to *Los Angeles Times*, one user, Tiffany Seeley, was one of 200 outraged consumers who uninstalled her Uber app in 2017 because of Kalanick's association with President Donald Trump. She reinstalled it after a week because she found the convenience of ride-hailing as necessary.[52]

Seeley is one of many examples who defaulted in their backlash against Uber. Though, that is not to say Uber's scandals have not caused major consequences. It has been observed that Uber's market share of private ground transportation has been displaced by Lyft. From a previously referred *Certify* report, Lyft has realized major growth in its share of ground transportation expenses by business travelers.[53] Lyft's replacement over Uber as the dominant ride-hailing company may be realized over time, as shown by a growing inclination of popularity towards Lyft services.

Although TNCs such as Uber might have its history of scandals, the taxi industry of Los Angeles has its own reputation among Los Angelenos. Having a long history of operations, taxi drivers are typically associated with a stigma for lateness and rude behavior. With the number of TNC drivers available on the streets, wait times are comparably lower, and cutting-edge TNC technology allows customers to monitor their ride's arrival and traffic issues, as well as driver locations. A close evaluation system also incentivizes TNC drivers to act on their best behavior, whereas passengers must undergo a process to submit grievances against taxi drivers. Moreover, problems of regulatory capture make this report system fairly lenient against taxi drivers, where franchise owners act to protect drivers and their interests, especially when the labor supply of taxi drivers is scarce. As a result, bad behavior often goes left unpunished

[52] Article can be found here.
[53] Report can be found here.

among taxis.[54] Issues of overcharging and driver fraud have also been prevalent well before the emergence of TNCs. Taxi franchises, the Board, and LADOT have addressed these issues with preventative measures. Despite their best efforts, it is still unclear how well these measures have prevented them, and how well it has been conveyed to the public.[55]

Recent research from UCLA graduate, Anne Brown, has also uncovered discrepancies between service provided by TNCs and taxis to ethnic communities. Indications of racial and gender discrimination were found by LA taxicabs, which took place through the prolonging of wait times and avoidance of/poor service towards low-income communities, generating concerns of inequity. Rather, TNCs (Lyft, in particular) was found to service low-income communities more equitably than taxis, thus making a protective stance for taxis more questionable.[56] Her research was received coverage by the media and attracted public attention within Los Angeles, stirring influence among policymakers and the public.[57]

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[54] Acceptable" bad behavior would be defined as anything short of behavior prohibited by the Code or misdemeanors. Taxi drivers are also able to appeal for cases, where they can justify their actions before the Board.

[55] Los Angeles Taxicab Review and Annual Performance Report 2014-2015, pp. 56. To summarize, fraud prevention has been taken in the form of rules, safety measures, records, technological advancements, etc. These include: changes in the taxicode, installation of security cameras and smart taximeters, rules to deter manipulation of the taximeter.

[56] Upon interviewing the Director of Transportation, Eric Bruins, from Council 11 of the City Council of Los Angeles, it became clear that the continuation of a protective stance towards LA taxis became questionable, when it became known that they did not service these communities as they were intended to. As such, it was found that taxi regulations for the provision of fair services were obsolete relative to equity from TNC services.

[57] Brown, Anne E. 2018. "Ridehail Revolution: Ridehail Travel and Equity in Los Angeles." *UCLA Doctoral Dissertation*.

Chart 8.AQ Graph of Taxicab Trip Type Changes from 2012 through 2015

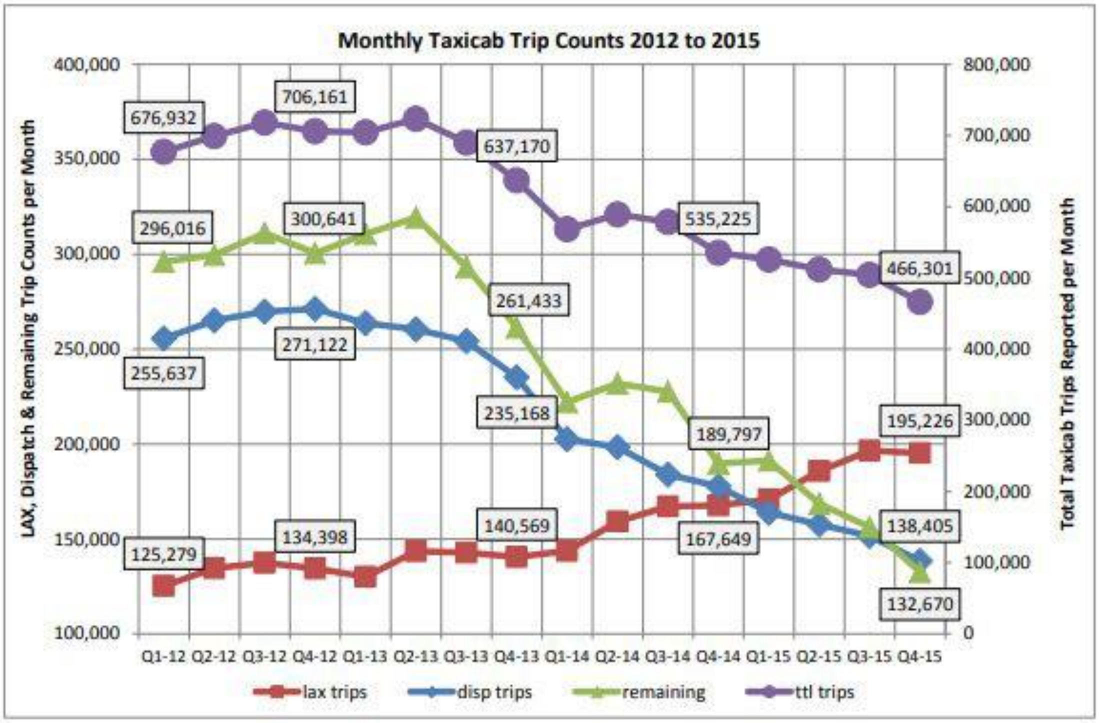

Figure 4. Graph of Taxicab Trip Type Changes from 2012 through 2015

Chart 4.H Service Zone Performance History 2002 through 2015

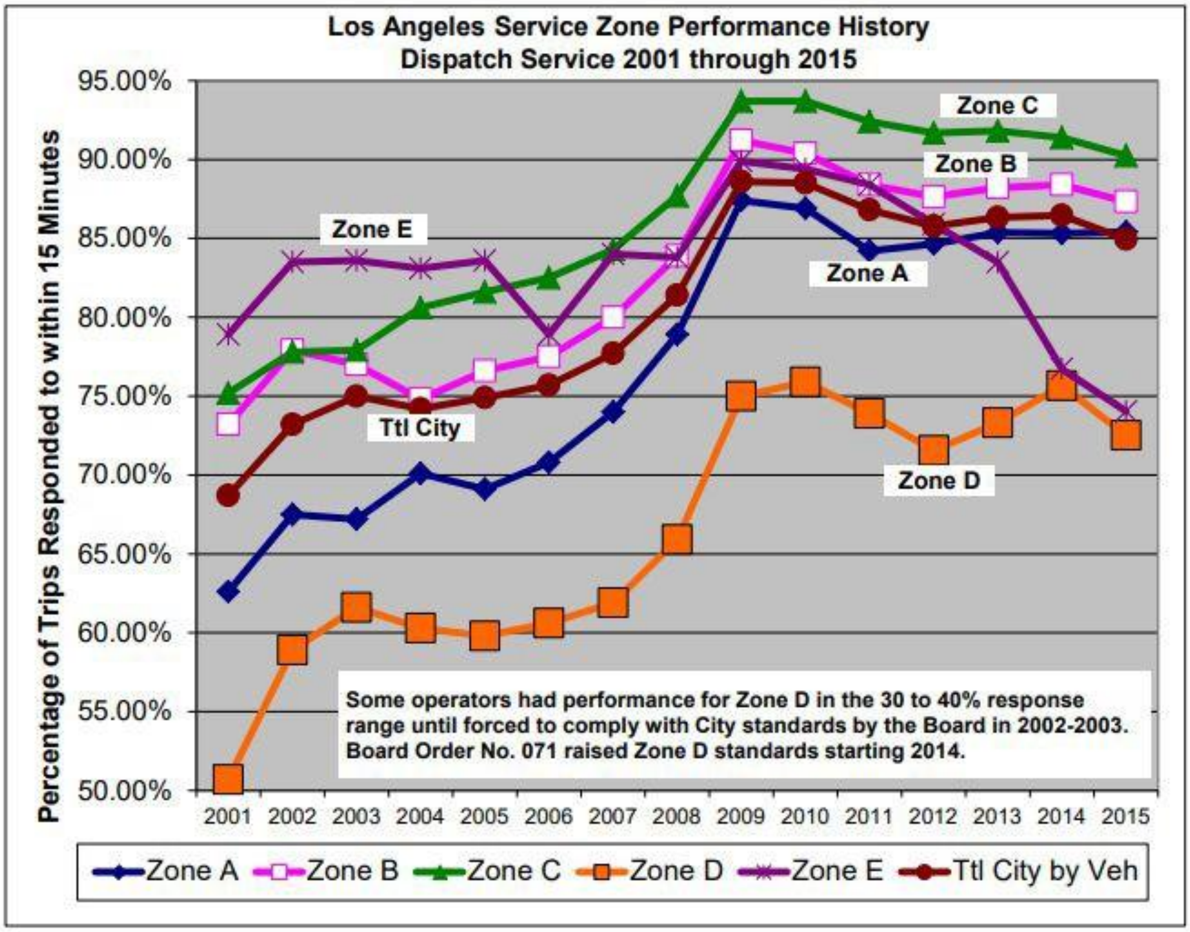

Figure 5. Service Zone Performance History 2002 through 2015.

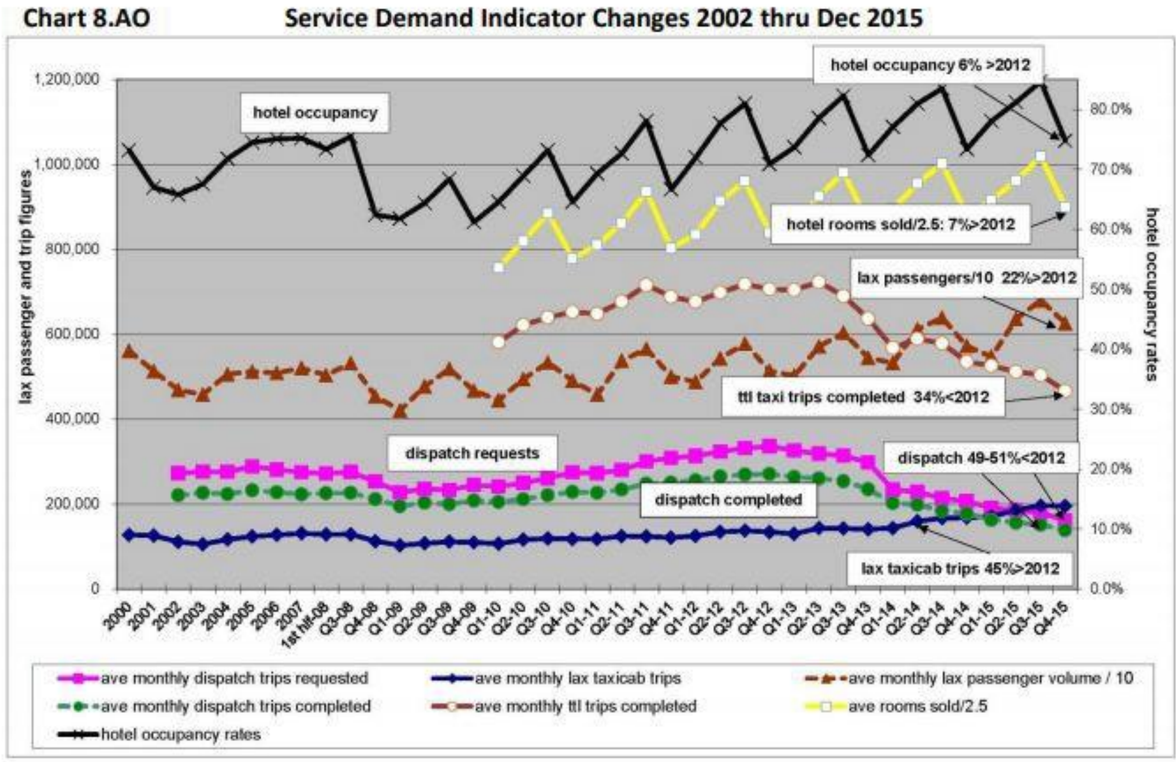

Figure 6. Service Demand Indicator Changes 2002 through December 2015.

Chart 2.C **Taxicab Service Zone Map**

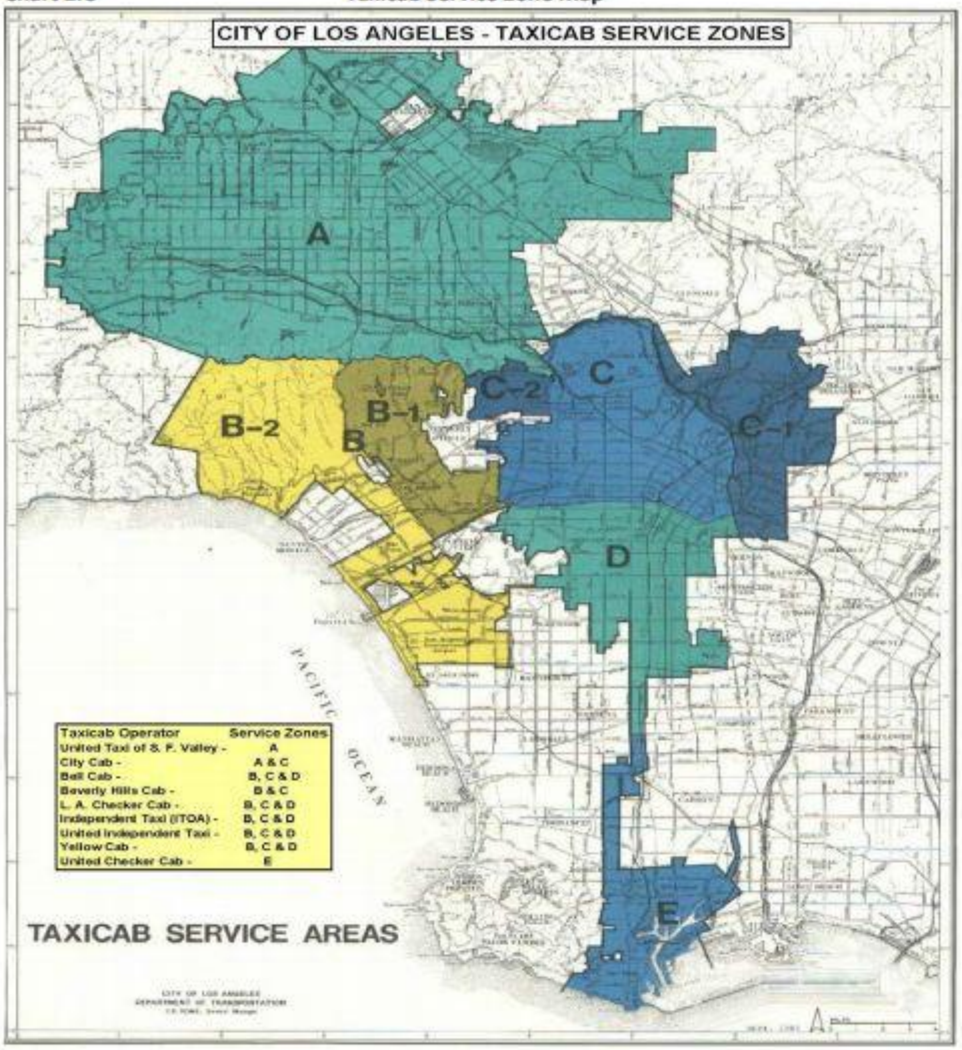

Figure 7. Taxicab Service Zone Map

Table 2. Vehicle Distribution by Franchise over Primary Service Areas

Taxi Franchise	No. of Vehicles over Primary Service Area(s)[58]
Bell Cab	273 vehicles over Zones B, C, D
Beverly Hills Cab Co.	167 vehicles over Zones B, C
Independent Taxi	252 vehicles over Zones B, C, D
LA Checker Cab	269 vehicles over Zones B, C, D
United Checker Cab Co.	75 vehicles over Zone E
United Independent Taxi	294 vehicles over Zones B, C, D
City Cab	170 vehicles over Zones A, C
United Taxi of S.F. Valley	102 vehicles over Zone A
Yellow Cab Co.	759 vehicles over B, C, D

Table 3. Distribution of taxis from each franchise per zone

Primary Zone	Number of Cabs from Each Franchise[59]
Zone A	City Cab: 98 United Taxi of S.F. Valley: 102
Zone B	Yellow Cab: 164 Beverly Hills Cab Co.: 95 Bell Cab: 73 United Independent Taxi: 90 Independent Taxi: 74 LA Checker Cab Co.: 67
Zone C	Yellow Cab: 380 Bell Cab: 132 LA Checker Cab: 134 City Cab: 72 Beverly Hills Cab Co.: 72 Independent Taxi: 113 United Independent Taxi: 132
Zone D	Yellow Cab: 215 United Independent Taxi: 72 Bell Cab: 68 Independent Taxi Co.: 65 Los Angeles Checker Cab Co.: 68
Zone E	United Checker Cab Co.: 75

[58] This information is updated as far as 2014-2015, on the Los Angeles Taxicab Review and Annual Performance Report 2014-2015.
[59] This information is updated as far as 2014-2015, on the Los Angeles Taxicab Review and Annual Performance Report 2014-2015.

Table 4. Taxicab Total Trips and Performance Ratings by Franchise in 2015-2016[60]

Zone	Franchise	Total Trips and Performance Ratings
Zone A	City Cab	129,904 (excellent performance)
	United Taxi of S.F. Valley	151,582 (good performance)
Zone B	Yellow Cab	118,652 (excellent performance)
	Beverly Hills Cab Co	98,082 (excellent performance)
	Bell Cab Co.	48,133 (good performance)
	United Independent Taxi	120,438 (good performance)
	Independent Taxi	34,284 (satisfactory performance)
	LA Checker Cab Co.	16,911 (unsatisfactory performance)
Zone C	Yellow Cab	432,084 (excellent performance)
	Bell Cab Co.	161,454 (excellent performance)
	LA Checker Cab Co.	125,033 (excellent performance)
	City Cab	25,834 (excellent performance)
	Beverly Hills Cab Co.	35,323 (good performance)
	Independent Taxi	123,950 (good performance)
	United Independent Taxi	118,691 (satisfactory performance)
Zone D	Yellow Cab	124,001 (good performance)
	United Independent Taxi	27,408 (good performance)
	Bell Cab Co.	10,553 (satisfactory performance)
	Independent Taxi	7,795 (satisfactory performance)
	LA Checker Cab	6,113 (unsatisfactory performance)
Zone E	United Checker Cab Co.	100,086 (satisfactory performance)

[60] 54 Formatted by Zone, franchise, total of number of trips in Zone, and performance rating as measured by the city of Los Angeles. Performance Ratings are measured by dispatch service response times within a 15 minute period.
Thus, the percentage of trips responded within 15 minutes out of the total number of trips determines the Performance Rating. A complete description of the performance ratings is provided on the Los Angeles Taxicab Review and Performance Report 2014-2015, page 17-18.

Table 5. TaxiCab Trip Counts – Monthly Averages per Quarter 2012 to 2015

Quarter & Year	Total Trips Completed	Dispatch Trips Reqstd	Dispatch Trips Completed	LAX Taxicab Trips	Other Trips Flags, Hotels, Personals
1st Q 2012	676,932	313,647	255,637	125,279	296,016
2nd Q 2012	699,311	323,990	265,172	134,565	299,574
3rd Q 2012	718,237	331,482	269,744	137,465	311,027
4th Q 2012	706,161	326,287	271,122	134,398	300,641
Total 2012	8,401,922	3,915,446	3,185,024	1,595,121	3,621,777
1st Q 2013	704,455	325,911	263,740	130,113	310,602
2nd Q 2013	723,274	318,620	260,381	143,512	319,380
3rd Q 2013	690,273	314,178	254,177	142,795	293,301
4th Q 2013	637,170	297,749	235,168	140,569	261,433
Total 2013	8,265,515	3,769,375	3,040,400	1,670,967	3,554,148
1st Q 2014	568,359	233,890	202,550	143,720	222,089
2nd Q 2014	589,353	228,436	198,380	159,135	231,838
3rd Q 2014	578,669	213,835	184,010	167,063	227,596
4th Q 2014	535,225	207,074	177,779	167,949	189,797
Total 2014	6,814,816	2,649,705	2,288,154	1,912,701	2,613,961
1st Q 2015	525,945	188,526	161,701	170,846	193,398
2nd Q 2015	511,965	183,594	155,037	185,757	171,172
3rd Q 2015	504,252	177,399	149,013	196,465	158,774
4th Q 2015	466,301 (-34%)	163,431 (-50%)	135,866 (-50%)	195,226 (+45%)	135,208 (-55%)
Total 2015	6,025,391 -28% from '12	2,138,847 -45% from '12	1,804,852 -43% from '12	2,244,880 +41% from '12	1,975,659 -45% from '12

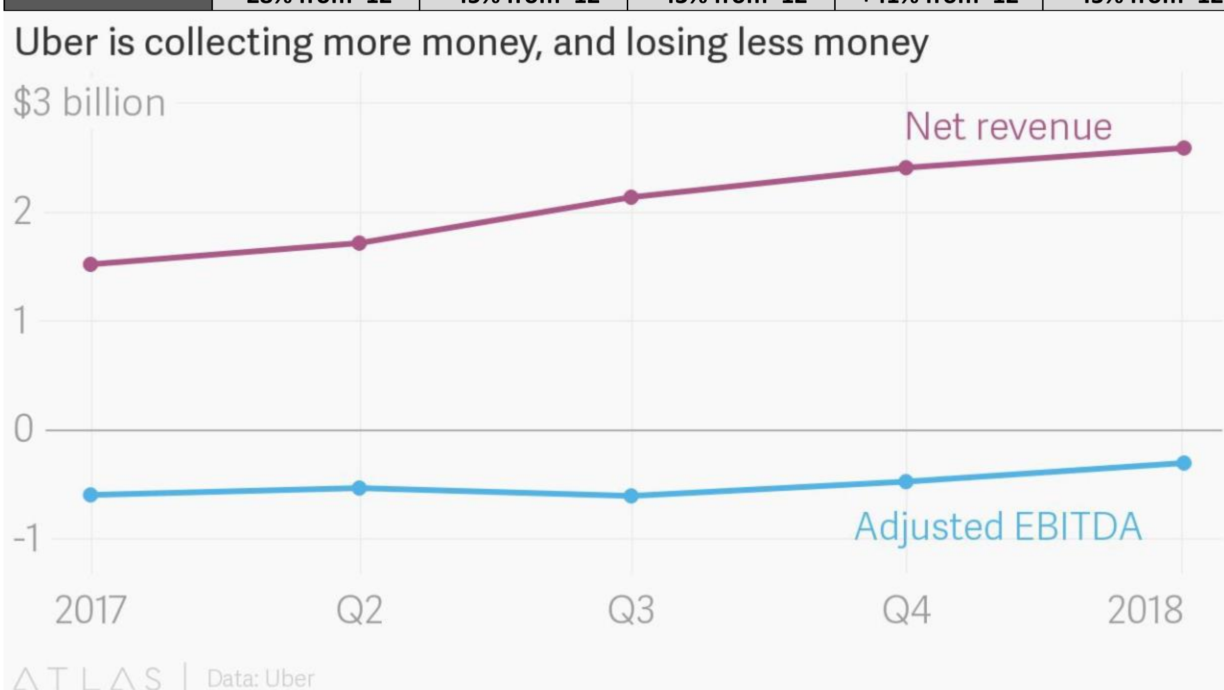

Figure 8. Uber's reported earnings and losses in 2017.

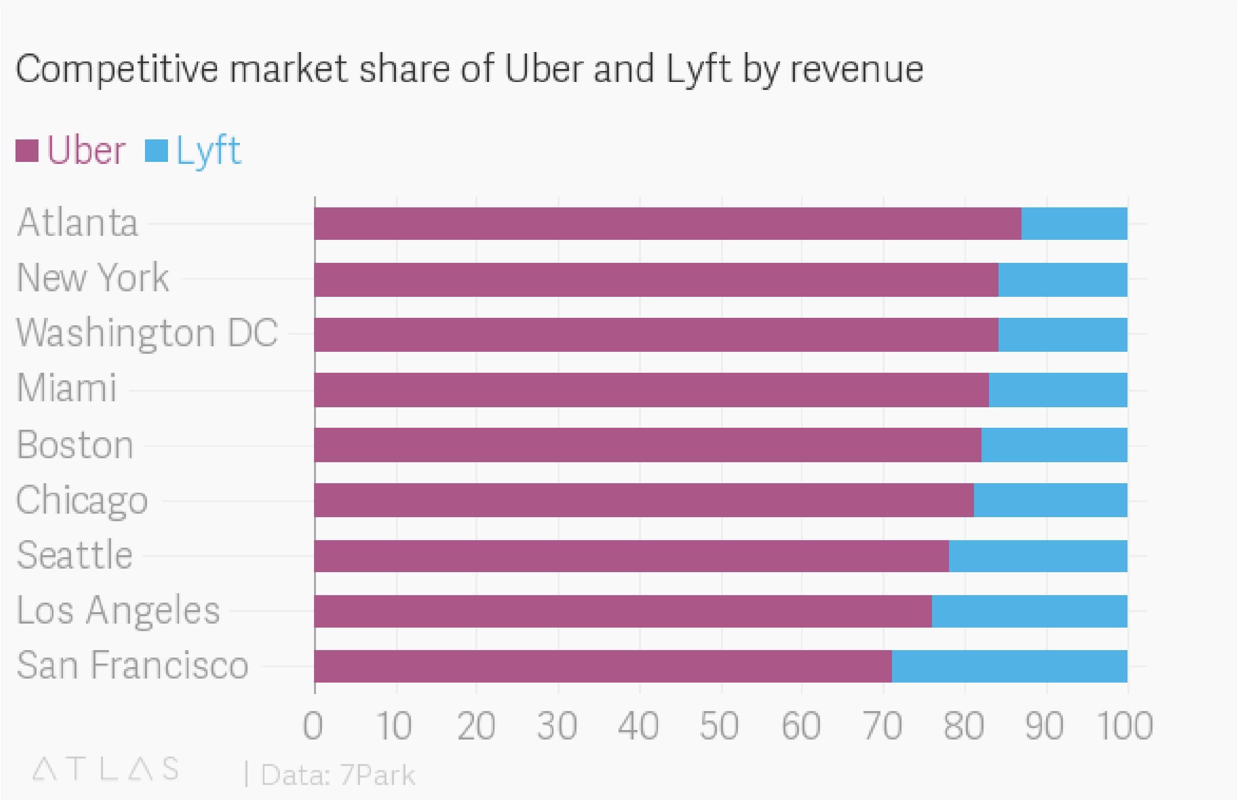

Figure 9. Market shares between Uber and Lyft by city.

Chart 7.AE

DEPARTMENT (DOT) ANNUAL PHYSICAL INSPECTION

Taxicab Vehicle Inspection Items – Initial and Annual Inspection Criteria

Vehicles must meet and comply with all requirements specified in the taxi rule book, municipal and vehicle codes, franchise ordinances, and any other state or federal regulatory requirement. Some of the items reviewed during entry and annual DOT taxicab vehicle inspections include the following items:

General Vehicle Inspection Items	Rule/Reference
1. Vehicle Color Scheme & Identification	LAMC 71.16 & 71.20; Rule 422, 423
2. Unsightly Paint Defacement or Body Dents	437
3. Tires ____ Hubcaps ____	440, 454
4. Glass _____ Mirrors _____ Windows _____	434, 435
5. Lamps: Head ____ Tail ____ Stop ____	434, 454
6. Lamps: Directional _____ Flasher _____	434, 454
7. Dome/Top Light	403, 454
8. Back-up Lights	434, 454
9. Robbery Light	416, 454
10. License Plate Lamp	434, 454
11. Odometer	n/a
12. DMV Registration	Ordinance 4.3.c
13. Meter Number: ________________	402, 420, 461
14. Weights & Measures Certificate	402
15. Radio (two-way)	404
16. Wipers ____ A/C ____ Htr ____ Defrost ____ Horn ____	454
17. Steering Mechanism	454
18. Check Engine Light	460
19. Safety Shield _____ Camera _____ Camera Signs _____	407
20. Exhaust System & Emission Status	401
21. Brakes: Service _____ Emergency _____	454
22. Trunk Unlock Device	417
23. Seats _____ Upholstery _____ Projections _____	433, 436, 438
24. Seatbelts _____ Door Locks _____	435, 441, 442
25. Floor Covering _____ Head Liner _____	433, 436
26. I. D. Card Holder	418
27. Lettering: Size _____ Sign Locations _____	
28. Rate Postings (w/ $5 change, all ride for price of one, credit cards accepted, driver provides printed receipt)	405, 410, 413, 459, 462
29. $5.00 Change Sign (vehicle ext & rate sign)	411
30. All Passengers Ride for Price of One Sign (veh ext & rate sign)	413
31. Braille Sign	455
32. Customer Service/Comment Sign	458
33. Other Req'd Signs	439, 459, 462
34. Wheelchair Securement Straps	401.d

Figure 10. Taxicab Vehicle Inspection Items – Initial and Annual Inspection Criteria

Chart 7.AF Annual ASE Mechanical Inspection Criteria (Age 5+)

Annual ASE Certifed Mechanical Inspection Criteria

City of Los Angeles Taxicab Safety Inspection Program

Satisfactory / Unsatisfactory	S	U	Satisfactory / Unsatisfactory	S	U
GENERAL INSPECTION			**TIRES – WHEELS**		
Windshield Wipers L- R			Wheels – Cracked		
Windshield Washer Fluid			Tire Wear Even/Uneven		
Horns			Tread Depth		
Mirrors			RF - LF - RR - LR		
Air Filter			/32 /32 /32 /32		
Front and Rear Window Defogger			Comments:		
Window Integrity Open – Close					
Comments:			**BRAKES**		
			Brake Fluid		
LIGHTS			Brake Pads		
Headlight HI – Low			Discs/Drums – Cracked		
Parking Lights			Parking Brake		
Turn Signal L – R			Comments:		
Tail Lights					
Stop Lights			**SUSPENSION**		
License – Back – Up – Lights			Alignment		
Side-Lights RF – LF – RR – LR			Steering Wheel Play		
Emergency Flashers			Bushings and Ball Joints		
Indicator Lights (Instrumental Panel)			Shock Absorbers – McPherson Struts		
Comments			Wheel Bearings		
			Comments:		
BELTS – HOSES					
Belt Air – P/S – Gen/Alt – AC			**EXHAUST SYSTEM**		
Pulley – Water Pump			Catalytic Converter		
Hoses Heater By Pass			Muffler		
Hoses Collant – Upper/Lower			Manifold		
Vacuum Lines			Pipes		
Fuel Hoses / Fuel Filter			Comments:		
Comments:					
			BODY		
LUBRICANT – FLUIDS			Doors, Hood & Trunk Align & Close		
Engine Oil – Level – Low – Dirty			Rust		
Trans Level – Low – Overfull – Burnt			Collision Damage		
P/Steering – Level/Hoses			Comments:		
Coolant Level – Rusty –Low					
Radiator Cap Condition			**TRANSMISSION**		
Comments:			Shifts Smoothly		
			Holds Park Position		
BATTERY			Comments:		
Carrier/Hold – Down/Cables					
Water Level – Low			**FUEL SYSTEM PERFORMANCE**		
Battery Test			Smog Check Certificate		
Comments:			Comments:		

Taxicab Company________________________ Taxicab No.__________ Hybrid ☐Yes ☐No

License Plate No.____________ VIN No.____________ Work Invoice No.__________(attached)

I Certify that I have inspected this taxicab and that it is safe to operate at time of inspection. I have no affiliation with any taxicab company.

By:____ Date:____________

Signature (Garage Mechanic)

DOT AAA Inspection Form

★Attach original mechanic/shop work order/invoice and checklist.★

Figure 11. Annual ASE Mechanical Inspection Criteria