

*The Economic Impact of the “Passenger Economy” on Real Estate:
An Analysis of Uber Growth and Parking Structure Sales*

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Abstract

This paper tests whether there is uncertainty in the parking property market, within the commercial real estate sector. This uncertainty can be characterized by a period of high ownership change of parking structures within ten of the top fifteen Metropolitan Statistical Areas (MSA's) in the United States. This paper uses Uber driver growth from introduction to 2018 as a predictor for parking property turnover on a geographic market level. The strength of Uber as an early showcase for the effects of the new mobility economy will be tested by using the INRIX score, a measure of what urban areas could have the greatest proportion of vehicle travel replaced by Autonomous Vehicles, which is weighted for intra-city travel, parking availability/restrictions, and demographics. Overall, an understanding of driverless cars impact on the cities of tomorrow is developed within this paper, with an emphasis on their effect on commercial real estate. Additionally, an exploration of current parking design and regulation literature highlights the problems faced by city developers and land owners, which gives context to the uncertainty in parking real estate ownership and strengthens the argument that driverless cars are primed to disrupt an already unstable market.

Introduction

Fifty years ago, the word “driverless car” would have been considered an oxymoron. However, today autonomous vehicles are expected to have the same sweeping, economic impact that railways had in the 19th century and that highways had in the 20th century. Cities that were near railways and highways thrived and grew, while those left off the beaten path faded away. In a sense, the same phenomenon is slated to affect all cities in the future with regards to driverless cars. A paradigmatic shift will be presented to community decision makers on whether they want to be on the frontier of this technology or whether they want to watch from the sidelines as others adopt and adapt.

While predictions of highly autonomous vehicle (HAV) implementation range from 15 to 40 years, it has become apparent that driverless cars are not an “if”, but a “when”. Some of the biggest names in tech and automotive are behind this push. Tesla, Google, Uber, Lyft, Ford, Audi, GM, Amazon, Microsoft, and Apple all have skin in the game, one that is predicted to yield \$7 trillion annually by 2050 (Lanctot, 2017). Even the U.S government has expressed interest with the former Obama administration proposing \$4 billion in funding for the testing of self-driving cars and the current administration pushing for a bill to ease testing by tech giants. Besides the enormous economic potential, the potential for HAVs to reduce traffic, pollution, and auto-accidents represents a vast civic and environmental opportunity.

Current literature agrees that those with the most to gain from driverless technologies are dense urban centers and suburban outskirts. As such, business owners, citizens, city decision makers, and land owners should be motivated by whatever economic shifts take place over the coming decades. Referenced in the title, “the ‘Passenger Economy’ represents the value of the products and services derived from the use of fully autonomous, pilotless vehicles, including the indirect savings in both time and resources generated by the use of pilotless vehicles” (Lanctot, 2017). The way the aforementioned groups anticipate and act, will determine their success in the Passenger Economy.

Due to the speculative nature of many of the changes predicted to happen as well as the unclear timeline of adoption, it will be difficult to anticipate the future successfully. For these reasons, governments, city regulators, and citizens may be slow or hesitant to act. However, for real estate owners the potential rewards for action are much greater. Real estate is built and bought to be held for long periods of time. Therefore, those who do not anticipate trends and shocks are often left with seriously underperforming assets.

This paper seeks to address the effect of mobility technology on each asset class in the industry. By using Uber proliferation as a precursor for driverless car adoption, this paper will specifically analyze the current level of uncertainty in parking property ownership. These types of real estate owners are more likely to be affected by the driverless future and will be acting now to capitalize on the coming “Passenger Economy”, therefore this paper will focus on parking property owners.

The most widely agreed type of real estate to be affected by HAVs are parking structures, spaces, and related properties. Car ownership is expected to drop significantly, and driverless cars are expected to perform a variety of duties most of the day (until returning to large, charging structures outside of the central business district) therefore making parking less and less a necessity. For much of commercial real estate’s history, parking has acted as a hefty, constricting

factor. Projects have hinged on how many parking spots are needed to accommodate people, thus making the cost of parking and the land associated a main driver in urban design. These constrictions have prevented both “smart development” and “a city’s ability to achieve [a] critical mass” (Levine, 2009). With the relaxation of such restrictions in tandem with driverless car adoption, owning a property dedicated to parking becomes a much riskier proposition.

Using CoStar database data and proprietary data from Uber, this paper will measure activity in parking structure sales. Through this economic analysis, this paper aims to determine if Uber (and by extension attitudes towards incoming driverless cars) can be traced to an uptick in parking structure sales since Uber’s introduction.

Literature Review

Driverless Cars

Surprisingly, the idea of a driverless car has been around almost as long as the car itself. Driverless cars, or automated vehicles (AVs), were first envisioned in the 1920’s after Houdina Radio Control equipped a transmitting antennae to a 1926 Chandler (nicknamed the “Phantom Auto”) and controlled it via radio impulses from a car behind, up and down Broadway street in NY (The Milwaukee Sentinel, 1926). At the 1939 World’s Fair, General Motors sponsored an exhibit, “Futurama”, that showcased radio-controlled electric cars powered by electromagnetic fields placed within the roads beneath them. And as early as 1940, Bel Geddes promoted the removal of humans from the driving process in his book *Magic Highways* (Geddes, 1940).

For the next 60 years AVs were tested, redesigned, and researched further, however computing power and funding posed insurmountable obstacles for its widespread use and success. Yet, increasing government focus and rapid advances in artificial intelligence and related technologies have made AVs a near-future possibility today.

As of today, we are entering Level 3 automation, as coined by the National Highway Transportation Safety Administration. New cars have “automated features, but some circumstances require driver intervention” (Cox, 2018). Gradually, cars are becoming less reliant on humans each and every day. High-end cars park themselves and Autopilot, emergency braking, and lane guidance are already implemented on most luxury cars (Duranton, 2016). Transition to driverless cars (Level 4), in which drivers are not permitted to intervene” is on the horizon and full automation (Level 5) is an eventuality (Cox, 2018).

The changes and advancements that have precipitated the recent success of AV research have been accompanied by a “generational sea change in how consumers and business view transportation” (Lanctot, 2017). This transformation can be seen in the widespread consumer adoption of ride-hailing services like Uber and Lyft, as well as subscription-based services like Zipcar. As we move closer and closer to a truly automated driving experience a wide range of changes are expected to occur. The future of transportation will essentially be represented by being driven by intelligent, pilotless vehicles. The implications of this envisioned future are discussed below.

Passenger Economy

Emerging from the use of AVs will be an entirely new economy, nicknamed by Intel as the “Passenger Economy”. The Passenger Economy will represent “the value of products and services derived from the use of fully autonomous, pilotless vehicles, including the indirect savings in both time and resources generated by the use of pilotless vehicles” (Lanctot, 2017). This economy is predicted to generate \$7 trillion annually by 2050. Of this \$7 trillion, \$3.7 trillion will be generated from “consumer use of a range of Mobility-as-a-Service offerings” (Lanctot, 2017). Boston Consulting Group forecasts that 10% of global vehicle sales will be AVs by 2035 and Strategy Analytics predicts that once AVs gain widespread global use in 2050, that 50% of all vehicles sold will be AVs. Therefore, the evolution and mass adoption of mobility products by consumers is integral to the success of the Passenger Economy.

Currently, the types of mobility products offered can be categorized as vehicle-sharing or ride-hailing. Uber, Lyft, and a host of other ride-hailing companies offer on demand transit, while vehicle-sharing services like Zipcar, OFO (bikes), and Bird (electric scooters) allow subscribers to use transportation when they need it at a rate based on usage. Both these transportation approaches allow people to forgo car ownership for more efficient and cost-effective transportation options, hence “consumer and business use of Mobility-as-a-Service propositions are expected to deliver the greatest value since they involve shifts away from vehicle ownership” (Lanctot, 2017). Consumers and business users will be able to order mobility whenever and wherever to go from A to B, allowing for more dynamic business and travel opportunities.

Work commutes will be affected considerably. Consumers mobility orders will be “aggregated based on routing and timing, allowing users to schedule regular commutes and the network to drive scale by aggregating routes. Users can automatically receive discounts based on the number of rides, or they can pay in advance for miles or minutes or by mode (discounts available for longer-term commitments) to guarantee mobility needs” (Lanctot, 2017). Additional commute benefits attributable to mobility improvements will be discussed in later sections.

Businesses will be main drivers in the amount of AV sales, especially in the early stages of commercial development. Business models will change to more “usage based service revenues or to location based services where the service comes to the passenger rather than the passenger going to a specific vendor location” (Lanctot, 2017). Imagine a pilotless, intelligent bookstore coming to you, or even a barbershop on the go. Rather than building “new brick-and-mortar locations, land-restricted businesses like retail stores, hotels and restaurants will fuel another wave of business expansion by adding ‘mobile stores’ that deliver their goods and services directly to the consumer” (Lanctot, 2017). This type of shift will be accentuated by businesses that “have historically grown or scaled their business by increasing the number of locations: e.g., fast food (McDonalds, etc.), coffee shops (Starbucks, etc.), and convenience stores” (Lanctot, 2017). This shift from location based retail is already evident by the continued decline of shopping malls as destinations and by the rise of Amazon’s web-to-door style shopping.

Beyond retail, food, and services, other types of businesses will change their value proposition to include transportation related amenities. Places like office buildings, apartments, college campuses, and hotel chains might have “specialized pilotless vehicles as amenities for added convenience” and “some employees will have transportation services as a part of their compensation package” (Lanctot, 2017).

Some business lines might have to shift considerably more than others. As vehicle ownership declines, Auto-makers will have to transition to “transportation network operators” as “carmakers may ultimately vie to operate particular networks of vehicles for particular cities – not unlike cities in China today where local taxi franchises are assigned to particular carmakers” (Lanctot, 2017). Carmakers, ultimately, could become fleet operators and managers. General Motors invested \$500 million in ride-hailing service Lyft last year and have announced “ambitious plans to deploy a centralized fleet of shared, electric, autonomous vehicles as early as 2018”, while Lyft predicts AVs will “provide the majority of its rides by 2020” (Lanctot, 2017). Both GM and Volkswagen have indicated that “they are moving from an ‘ownership model’ to a ‘mobility-on-demand model,’ which may presage private ownership as a subscription-based service” (Spencer & Henderson, 2016).

If Uber and Lyft achieve their own pilotless fleets, their service will become even cheaper for consumers by cutting labor costs. Likewise, “conversion of the automobile from private ownership to ownership by corporate mobility providers will result in lower costs” due to effectiveness through scale. Mobility service companies are predicted to “use vehicles more efficiently, reducing purchase costs and passing the savings on to consumers, assuming a fully competitive market” (Cox, 2018).

As consumer preferences change and business roll out these new strategies, city officials will need to adapt and rebalance priorities. Seeing the importance of a robust and innovative transportation network, “public officials and city planners will treat transportation in the same manner as they treat real estate – allocating transportation resources for commercial and personal applications varying by type and time of day and dynamically allocating those resources to suit varying requirements. Some cities may choose to own the vehicle networks not unlike existing public transportation” (Lanctot, 2017).

On a national level, there will need to be greater support for AV initiatives before full adoption can be realized. In 2016, the Obama administration proposed \$4 billion in the 2017 budget be allocated over the next 10 years to fund the “testing of self-driving cars because of their potential to reduce pollution, traffic and accidents” (Risen, 2016). The funds for the 2017 fiscal year are meant to assist pilot programs and their testing of computerized driving vehicles throughout the country, however financing is not the biggest obstacle for AVs as regulation poses the biggest threat to growth. Secretary of Transportation, Anthony Foxx, pledged in early 2018 “that the National Highway Traffic Safety Administration will work with companies and states within the next six months to start developing these regulations”. Both policymakers and automakers like Nissan have said it “will take until at least 2020 for technology and regulation to enable self-driving cars to operate safely on most American roads” (Risen, 2016).

In 2018, U.S lawmakers pushed a bill in the house titled the Self-Drive Act, which won “swift, broad approval from House Democrats and Republicans alike” (Romm, 2018). This bill would give tech giants and automakers special exemptions for safety standards that apply to older cars, allowing more test driving of experimental vehicles around the country. Unfortunately, the bill has stalled in the Senate, as a few senior party lawmakers fear “that these computer-driven vehicles aren’t yet ready for major roadways or might be susceptible to cyber attacks” (Romm, 2018). The most vocal opponent has been Sen. Diane Feinstein, “whose state of California is a home base and critical testing ground for companies like Uber, Tesla and Google” (Romm, 2018).

While a multitude of society transforming changes are said to accompany the driverless car future, none of these changes will materialize if some large obstacles cannot be overcome. The track record of restrictive licensing of taxis and some of the recent “hostility toward ride-hailing services like Uber and Lyft suggest that we should anticipate” that obstacles could impede the development that would lead to the hefty benefits being touted by pro-driverless parties (Fuller, 2016). These obstacles and purported-benefits will be described below.

Benefits and Obstacles

Some of the most widely advertised benefits of driverless cars boil down to safety, congestion, and productivity. Hyper connectivity between cars will allow communication and the formation of fleets. These fleets will drive much closer together and will autocorrect much faster than humans because computers can react orders of magnitude quicker than humans. These facets, reaction time and communication, allow for higher safety on highways and roads which will reduce traffic fatalities and auto damage. Additionally, cars will be much less prone to erratic, angry, and distracted driving further promoting pedestrian and occupant safety. Intel conservatively estimates that “585,000 lives can be saved due to pilotless vehicles in the era of the Passenger Economy from 2035 to 2045” and that “reductions in public safety costs related to traffic accidents will amount to more than US\$234 billion” over the same era (Lanctot, 2017). Ninety-four percent of all accidents are due to human error, so removing humans from the equation will undoubtedly make a huge impact (US National Highway Traffic Safety Administration).

Regrettably, the progress of AVs is not yet at this level. Concerns have arisen due to a contentious fatal accident that involved a driverless car in automatic mode striking a pedestrian and other fatalities associated with drivers abusing their cars autopilot functions resulting in crashes. Furthermore, beyond problems with reliability, there are issues associated with “hacking” of cars computer systems and the ethics behind a car’s potential decision-making process. AVs might have to make “complex moral choices ...in some potential accident situations” (Greenemeier, 2016). These factors might delay the adoption of AVs greatly.

While the benefits of safety will be achieved on a more aggregate level, the improvement of productivity will occur on an individual basis. The single largest cost of travel is the time spent behind the wheel. AVs will reduce this cost and will enable occupants to “work, play, or just enjoy the scenery, as our cars will drive themselves” (Duranton, 2016). American

commuters, who once collectively spent over 250 million hours per year driving to work (as much as an hour a day), will be free to put that time to good use (Lanctot, 2017). For some that may mean an extra hour of sleep, but for others it may mean a chance to start working as soon as the trip begins. This gain is even greater for rural drivers who drive 20% more per day and globally this opportunity represents 60 billion hours per year available for other uses (Lanctot, 2017). Imagine how much more productive (or well rested) you could be with an extra hour in your day.

The ability of AVs to save us time will be heightened by their ability to reduce traffic congestion. Pilotless vehicles' ability to "access current traffic data and change the route of the vehicle to avoid heavy traffic or congestion" will reduce congestion and AVs will "swarm" using crowd-sourced traffic data to optimize their route to avoid congestion, construction or special events" (Lanctot, 2017). Furthermore, due to the heightened reaction time of computer driving systems AVs will be able to reduce the distance from the vehicle in front of it by a factor of four (Duranton, 2016). Coupled with the ability to reduce the distance of cars side-by-side and drive at higher speeds more safely than humans, the capacity of our roads could be greatly improved.

However, the possibility of more convenient and improved travel times raise concerns of increased urban sprawl and vehicle trips. Historically, "cheaper and better urban transportation has been strongly associated with the physical expansion of cities" (Duranton, 2016). Many might scoff at a 2-hour work commute to live in a greener setting today, but if work started as soon as your trip began then that proposition changes immensely. Coupled with the fact that AVs will allow certain demographics like the young, physically and mentally impaired, and elderly access to increased mobility means that Vehicle Miles Traveled (VMT) will increase. Some believe this will add to congestion and pollution. However, as cars undergo electrification and the safety of AVs allows for lighter frames, these fears are exaggerated, especially as the carbon intensity of electricity generation continues to decline. Combined with AV's ability to drive in "drag-reducing pods", the overall effect of AVs should be net positive (Fuller, 2016).

Another questionable pillar of the Passenger Economy is the large amount of ride-sharing that is predicted to take place. Some envision a future where riding with strangers in a car will be the norm. While this is already a reality for commuters who take trains, buses, or subways, the intimacy of a car cabin surely affects the willingness of people to shift towards this mode of travel. While personal safety concerns remain, prescreening and security cameras can reduce risks. Additionally, not all passengers would start and stop at the same places making trips longer and with more stops (Cox, 2018). If consumers adopt similar levels of safety and intimacy as public transit require, then ridesharing only further serves to reduce emissions and curtail VMT.

Uber and Lyft have already incorporated carpooling into their product line and have seen success in the cities that they have introduced it to. Uber's new Express Pool "links riders who want to travel to similar destinations. Riders walk a short distance to be picked up at a common location and are dropped off near their final destinations" (LeBlanc, 2018). The service, which began in San Francisco and Boston "found enough ridership to support it 24 hours a day. Round-

the-clock service was also rolled out ...in Los Angeles, Philadelphia, Washington, Miami, San Diego and Denver, with more cities to follow” (LeBlanc, 2018).

By incorporating ride-hailing and ride-sharing platforms into existing transit design, travel within cities and suburbs should improve significantly. This synergy is much needed because mass transit access is highly limited. According to the University of Minnesota Access Laboratory, “the average worker in large metropolitan areas can reach less than 2 percent of jobs by transit in 30 minutes and less than 10 percent of jobs by transit in 1 hour” (Owen and Levinson, 2014). However, by car over 65% of jobs are reachable within 30 minutes (Levinson 2013). This schism is a result of transit authorities’ focus on central business districts (CBDs), where demand is most concentrated. Over 80% of jobs are located in the suburbs, yet transit hardly services these areas.

This dichotomy constitutes the “last mile” problem – “the fact that most potential transit destinations, jobs and otherwise, are often beyond walking distance from transit stops” and “cannot be reached by the average resident in a time remotely competitive with the automobile” (Cox, 2018). By acting as an intermediary between transit options and final destinations, AVs will solve the “last mile” problem. However, if prices for AVs are low enough, they may displace transit use altogether as people opt to take AVs for the entire trip (Cox, 2018). This concern has been recently issued with regards to cities with high Uber and Lyft usage. While Uber and Lyft argue that they complement transit, others claim that they directly compete with them. A study by the Metropolitan Area Planning Council of Boston found that “ride-hailing companies are pulling riders off buses, subways, bicycles and their own feet and putting them in cars instead” (LeBlanc, 2018). While this may turn into a problem if ridership decreases enough to hurt city income, it will only serve as a signal that a city needs to rethink its transportation network.

Finally, the savings to consumers should be addressed. Besides homes, buying a car is one of the biggest financial decisions that we make. Beyond the initial price tag, cars also require constant maintenance and repairs as well as expensive fuel. Accounting for costs from “fuel to insurance to depreciation” the average American car owner pays \$12,5445 per year (Lanctot, 2017). However, despite these large costs, cars sit idle more than they move. One estimate claims that cars are parked over 90% of their lifetime (Burgess, 2012). These factors should prompt car owners to reconsider their spending model for driving. Following contemporary trends in car ownership and with the approaching Passenger Economy, many will opt to instead subscribe to a “Car-on-demand” service, making our use of cars much more efficient (Duranton, 2016).

Because cars, and the freedom they provide, are such strong cultural markers for those in the U.S, some claim giving up the wheel will never happen. Yet, the deployment of AV vehicles is likely to include “various options, from private ownership to mobility companies that send driverless vehicles on demand” and in addition, the deployment of “a fully driverless vehicle fleet likely would not eliminate the residential garage or private ownership” (Cox, 2018). Individual ownership will continue and many owners could take advantage of peer-to-peer programs available already that allow for renting cars on short-term basis. Websites like

turo.com and getabout.com already fulfill this niche. This is similar to the way in which Uber and Lyft drivers use their own cars for business use, thus realizing a return on investment. For example, an AV owning individual who is at work could let their AV perform errands and pickups for others while they are in the office. This will offset the cost of AVs for an individual and provide additional income streams. Cox argues that “the advantages of the driverless vehicle are likely to be achieved regardless of the pattern of personal vehicle ownership” (Cox, 2018).

Others hypothesize that fractional or micro ownership will emerge where consumers “purchase a fractional ownership ‘share’ or ‘interest’ in one (or more) vehicles. This share will come with usage ‘rights’ or ‘terms’ that can vary depending on the consumer’s needs and the vehicle provider’s business priorities or focus”. Consumers could purchase these fractional or micro shares from a carmaker “and define vehicle usage or availability based on frequency, time of day, number of miles, or for specific tasks or other time-defined periods (e.g., work commutes, weekends)” (Lanctot, 2017). For example, an individual with a lawn-care business could select a dedicated fleet of trucks that come and assist with operations during business hours.

Ultimately, one of the biggest hurdles for AVs are consumer preferences and perceptions. Consumers will have to strengthen their perceptions for AV’s safety and reliability as well as change their preferences for vehicle ownership and mobility products. Being relaxed enough within an AV to take your attention off the road, is not a notion that most are at ease with today. In order for the Passenger Economy to arrive, consumers must believe AVs are 100% safe. Tech giants and automakers will have to complete billions of miles of testing to ensure this, however I’m sure the first person to ride a horse or car found it difficult to convince the second person to follow. Furthermore, state and federal level legislators will have to create regulations that foster AVs on tomorrow’s roads. While the technology to deliver fully autonomous vehicles is developing rapidly it is still a number of years away. Furthermore, the “regulatory and potential infrastructure changes required will happen over the next several generations instead of the next few years” (Lanctot, 2017). Despite these hurdles, the future of transportation will be defined by AVs. Much like how the car prompted suburbanization and the entrance of women into the workforce prompted two-car households, the advent of AVs will prompt consumer decisions on time, money, and attention that will have enormous repercussions.

CRE, Parking, and AVs

For the real estate industry, there are a number of implications from the introduction of AVs on a wide-range of asset types, which will undoubtedly influence property values. Many of the implications of AV adoption described above are directly linked to CRE, such as “individual travel decisions, transportation system impacts, and industrial and logistical impacts” (Henderson & Spencer, 2016). These impacts and decisions are primarily driven by reduced vehicle ownership and increased travel that will result from AV implementation. Household vehicle ownership is estimated to “decrease by up to 43%, from 2.1 vehicles per household to 1.2 vehicles per household by the time AVs become the dominant mode of vehicular transportation” (Sivak & Schoettle, 2015) and VMT will increase 11% (Spencer & Henderson, 2016). MIT’s SENSEable City Lab estimates that in an entirely AV dominated scenario, it would require 80%

less cars to fulfill all passenger demand (Claudel & Ratti, 2015). The largest single disrupter for real estate owners from reduced car ownership will be a significant reduction in parking demand.

Parking will be affected greatly because of three aspects of the AV revolution. The first is simply the idea that more people will rideshare or will be driven, rather than drive to destinations. Second, AVs will be able to park much more compactly and efficiently than before reducing the overall space needed to house a given number of parked cars. Furthermore, the parked AVs will not have humans entering or exiting them in the parking area, but rather at a designated pick up/drop off zone, so parking area will be even further reduced. Finally, because AVs will operate in fleets and will be continuously roaming or performing tasks, they will not need to park. This is much like how Uber and Lyft drivers are continually driving while being supplied new coordinates for their next pick up. Currently there are roughly 1 billion parking spaces in the U.S, which take up around 15-30% of urban land, however with a reduction in vehicle ownership combined with AVs only needing 60% of the parking space of a current vehicle and the roaming nature of AVs, the surface parking footprint “could be reduced by 35-50 percent in the next 20 years” (the equivalent of all the land in Connecticut and Vermont combined) (Marcut, 2018). While it is foolish to think that AVs will never park, when they do eventually have to park for repairs, charging, or storage they can be sent outside of the city to high-density parking structures, like “Car Banks”.

Parking by itself is a contentious topic in real estate already (which will be discussed in later sections), so advancements in parking by AVs will be favorably received. Stemming from the reduction of parking, a number of shifts in development and design will take place due to the influx of land and space. Suburban areas could see significant drops in demand for driveways, parking lots, and streets currently set aside to park vehicles creating rededication opportunities and lessening the burden of infrastructure costs for new development (Mammen, 2017). Since AVs will reduce the amount of space necessary for parking, they will allow cities to put the curbside space on “public roads and in high-density neighborhoods to better uses, including bike lanes, expanded sidewalks, space for vendors, and green space or ‘pocket parks’” (Fuller, 2016).

Additionally, commercial spaces will be able to build more densely, which is vital for prime real estate locations. Accommodating parking for office properties is quite hard for office space developers. By removing constricting factors like parking, developers will gain a “breadth of building design options and locations” and will be able to “simplify office layouts”. Secondly, “commute tolerance will increase with driverless cars, which will impact the kind of workforce offices can attract” (Marcut, 2018). For existing offices with parking incorporated the revenue drop from reduced parking can be offset by expanded footprints and by “[subleasing] to other vendors to maximize space density. Others will attempt to repurpose office garages” (Marcut, 2018). However, instead of parking, developers will need to include designated pick-up and drop-off zones in their designs for travelers and deliveries.

Because parking will become “uncoupled” from real estate, new developments will be denser and will be used more productively (Henderson & Spencer, 2018). A similar story to Office assets will impact other property types like Multifamily, Hotels, and Retail as all to some extent have parking factored into their design and implementation. Existing apartments will be

able to build more units and offer more amenities on the land they possess now, and new developments will be able to be built on parcels smaller than previously possible. This will significantly increase the supply of housing (especially in city centers) and help quell rising rental rates, driving affordability. Furthermore, as commutes become easier, quicker, and cheaper, areas that are underdeveloped now will be able to thrive. However, as travel patterns change, hotels, and the businesses located at previous cross roads, might lose customers since individuals can choose to sleep in AVs and skip lodging all together. Retail, which has large swaths of parking dedicated to it will need less land to operate and could add additional retail and entertainment options. Existing stores and shopping centers might also start to “take advantage of AVs and use their stores as distribution centers for home deliveries, shifting space from floor retail to logistical operations” (Henderson & Spencer, 2016). Retail sites near prime CBDs might find themselves bought up in order to rededicate these lots. Other industries like logistics and warehousing will see autonomous trucks “impact the delivery of goods from manufacturer to both retailer and the end-consumer, disrupting existing logistics networks and, consequently, the demand and location of warehouse properties” (Henderson & Spencer, 2016). Senior Living facilities may change as Baby Boomers gain additional mobility, affecting Healthcare property owners.

Most importantly, owners of parking garages will find themselves with extra parking capacity. Due to shifting traffic patterns, parking garages may increase in value while others decrease significantly. Some AV “operators such as Uber, Apple, Lyft will likely be attracted to garages with more flexible and geometrically symmetrical layouts. These attributes will allow them to park more cars in these garages and install charging and cleaning stations” (Henderson & Spencer, 2016). Garages that do not have these traits will get converted to other uses like self-storage, but most will likely be demolished and replaced with higher valued land uses.

In addition to space generated from parking reductions, AVs are expected to increase the throughput and capacity of our roads between two to four times. While increased capacity would stifle the need to expand or create any new roads, the increased VMT from ease of travel could make “roads that become more congested... become significantly less pedestrian-friendly” (Henderson & Spencer, 2016). In addition, “certain roads that currently have minimal traffic could become more congested since the algorithms that control AVs will continuously look for the most efficient route” (Henderson & Spencer, 2016). However, some have proposed narrowing existing roads so that capacity remains unchanged. This would allow for the “additional space in front of buildings and in-between two-way boulevards... [to] provide for a range of usage options such as widened sidewalks, tree-lining, parking, retail seating, and storm-water runoff filtration” (Henderson & Spencer, 2018). This reduction in road widths should increase the “the ratio of permeable surfaces to total surface area” which would “increase the volume of storm water runoff that is absorbed and filtered by the underlying soil” resulting in a reduction of “the urban heat island effect, reducing the demand for air conditioning – and electricity – in the summer” (Henderson & Spencer, 2016).

Much like On-Demand transit is affecting transit use today; AVs are expected to significantly affect the land around transit hubs. Thus, if AVs are expected to supplant transit

then they will undermine the “premiums associated with transit-oriented development today unless the public and private sectors effectively integrate AVs into existing systems and facilitate multimodal transportation solutions” (Mammen, 2017). Some already consider the “\$5-\$7 Uber shed” (depending on the city minimum) as an alternative to truly transit-oriented locations and can document a price premium in these zones in some instances (Ducker & Mammen, 2017).

However, if AVs are expected to complement transit by solving the “last mile” problem, then urban infill sites less than a mile from transit will see great demand and growth for housing, retail, and other uses. Furthermore, the anticipated efficiencies in time and productivity as a result of AVs will incentivize some to live farther from city centers. Therefore, land “currently perceived as too far away from employment cores to be developed could become more attractive as AVs contribute to more convenient commutes” (Mammen, 2017).

As marginal advances in AV tech occur and the transportation network begins to change, income and asset values will start to show in every asset class even for those within a five to seven-year investment period (Ducker & Mammen, 2017). While full adoption may be several decades away, an intermediary period will take place quite soon, during which “land use economics will begin to shift meaningfully. The shrewd real estate strategy is to begin planning for this evolution today, well before its ripple effects are felt, and even if the Jetsonian future we all imagine is still far off” (Ducker & Mammen, 2017). Those planning on investing for the long term should turn their attention to these implications within the near term. Overall, the real estate industry has done poorly in reacting creatively to evolutions in technology despite the lucrativeness of doing so. Throughout history a select few have made fortunes by anticipating “major advances in transportation technology, including automotive, rail, and air” (O’Brien, 2016).

Parking

While literature on AVs and real estate suggest that parking demand will significantly decrease in the future, current literature on parking argues that it is already oversupplied. With this oversupply comes many externalities, which have long been critiqued by Donald Shoup, professor of Urban Planning at UCLA, who is widely regarded as an expert on the economics of parking. One of Shoup’s premier papers, “People, Parking, and Cities”, uses LA as a case study on the perils of poor parking policy.

In his paper he brings up the pop culture image of LA as “an ocean of malls, cars, and exit ramps; of humorless tract homes and isolated individuals whose only solace is aimless driving on endless freeways” (Shoup, 2004). While this narrative is attractive, Shoup disputes the claim that Los Angeles is the poster child for sprawl. Since the 1980’s, Los Angeles has been “the densest urbanized area in the United States... [making] it the least sprawling city in America¹” (Shoup, 2004). Furthermore, compared to other U.S cities, LA does not have

¹ Shoup admits that LA is by no means denser in all respects than NY or SF by explaining that, “when we say that Los Angeles is denser than New York we are actually saying that the Los Angeles urbanized area, which is Los Angeles and its suburbs, is denser than the New York urbanized area, which includes not just New York City but its suburbs as well... without doubt, the cities of New York and San Francisco are denser than the city of LA” (Shoup 2004).

extraordinary rates of car ownership. Shoup thus asks the question, “if density is a barometer for healthy urbanism, and Los Angeles is denser than cities like New York or San Francisco, then why are Manhattan and downtown San Francisco such vibrant places, and why is downtown LA comparatively lifeless?” (Shoup, 2004). The answer to this question lies in the way that each city regulates the design and development of their downtowns (especially parking). Without revealing quite yet what these regulations are, the result is that LA is a dense area without a dense core, while NY and SF are less dense overall, but have exceptionally dense cores. Without a dense core, LA misses out on the prime advantage of density in a metropolitan area which is proximity, meaning the “immediate availability of a wide variety of activities. The clustering of museums, theaters, restaurants, and offices is the commodity a downtown can offer that other areas cannot” (Shoup, 2004).

The culprit behind the deadening of LA’s core can be tied to the way parking is regulated in the Central Business District (CBD), primarily attributable to the presence of Minimum Parking Requirements (MPRs). Before I discuss specific examples of how LA differs from NY and SF in terms of parking, I will give a background on MPRs and their implementation.

Minimum Parking Requirements

The motivation behind MPRs came as a result of the post-WWII boom in car ownership. Planners and developers realized they were living in a world where everyone owned a car. They also realized that in order for a CBD to “thrive, a CBD must receive a critical mass of people every day but do so without clogging itself to the point of paralysis. One way to do this was to require off-street parking spaces... [which] could reduce the cruising for parking that often strangles the streets of CBDs” (Shoup, 2004). This “critical mass”, or peak demand for free parking, was the baseline that Urban planners used to set the MPRs for every type of land use. Accordingly, “parking is free for 99% of automobile trips in the United States” (Shoup, 1999). The foundation for parking is also rather biased. In 1996 Richard Willson surveyed planning directors in 144 cities to gauge how they determined MPRs, finding that the two most frequent responses were “survey other cities” and “consult Institute of Transportation Engineers (ITE) Handbooks”. Both of these approaches lead to oversupply.

By assuming that other areas are correctly determining parking requirements one is merely repeating the mistakes of someone else. Moreover, this is amplified when the “other cities” are simply using ITE guidelines which are biased themselves. These guidelines are called Parking Generation and are published by the ITE. The report gives a parking generation rate for each type of land use, “defined as the peak parking occupancy observed in surveys by transportation engineers” (Shoup, 1999). The majority of these surveys, however, are performed in suburban developments not served by public transit. That means that parking requirements for CBDs are influenced by “peak demand for parking observed in a few surveys conducted at suburban sites that offer ample free parking and lack public transit” (Shoup, 1999). Furthermore, the parking rates generated from the surveys do not give context to when or where the surveys were completed, ignoring questions like length of surveys, length of peak occupancy, and off-peak occupancy. Finally, the pricing aspect of parking which is included in these surveys goes unaddressed. Transportation engineers do not consider price of parking “as a variable in

estimating parking generation rates”, therefore Urban planners who follow ITE guidelines will make the same error by interpreting “ITE parking generation rates as the demand for parking, neglecting the fact that demand has been observed only where parking is free” (Shoup, 1999). Shoup describes this planning process as circular in nature, arguing that:

Peak parking occupancy observed at sites that offer free parking becomes the minimum number of parking spaces that all development must provide. Ubiquitous free parking then stimulates the demand for vehicle travel. The observed travel demand becomes the guide for designing the transportation system that brings cars to the free parking (Shoup 1999).

This dysfunctional relationship causes serious problems and has been a topic that has generated ample debate recently. Those who criticize MPRs usually protest that MPRs “cause an oversupply of parking, exacerbating urban sprawl by significantly increasing the land area devoted to parking, lowering the resultant density of commercial and residential development and encouraging further car dependence” (Cutter, 2012). Consequently, the amplification of car use generates externalities related to energy consumption, pollution, and traffic congestion. In addition, parking lot surfaces increase the amount of impervious parking surfaces which “consume open space while causing an urban heat island effect and water-related externalities” (Cutter, 2012).

MPRs increase the supply and reduce the price, but not the cost of parking. Thus, developers get the short end of the stick and must consider this cost when designing, budgeting, and constructing. Shoup estimates the cost of MPRs by taking the number of required spaces and the construction cost per space, finding that “aboveground structured parking often costs about US\$10,000 per space and that underground parking often costs about US\$25,000 per space” (Shoup, 1999). Therefore, in LA, where the average cost of an office building was estimated by Shoup to be \$150/square feet, the “the cost of four aboveground parking spaces per 1000 square feet of office space increases the cost of the office space by 27%” and the cost of “four underground parking spaces per 1000 square feet of office space increases the cost of the office space by 67%” (Shoup, 1999). Cutter (2012) contends that the “mismatch between the costs and the marginal willingness to pay for parking area [by drivers] suggests that the private costs of MPRs are high” and further that “marginal parking costs (land plus construction costs) are approximately \$21/ft more than the marginal value of parking area”. This imbalance results in a deadweight loss of “\$1.5 billion (total parking sqft (75,845,000) * \$21/ft²)” when examining the Los Angeles properties in Cutter’s (2012) dataset. Cutter’s results show that MPRs “lower site density, increase land consumption, oversupply parking and reduce profits per unit of covered land” (Cutter, 2012).

There is a consensus that reducing parking standards for retail and office in combination with effective pricing of curb parking will “improve urban design, reduce traffic congestion, restrain urban sprawl, conserve natural resources, and produce neighborhood public revenue” in addition to reducing the cost of housing, goods, and services which have been artificially raised by their coupling with parking costs by developers (Shoup 1999, Cutter 2012).

Los Angeles – Example of Parking Perils

The impact of parking requirements is demonstrated through Shoup's (2004) comparison of LA, NY, and SF. New York and San Francisco "have strict limits on how much parking they allow in their CBDs; Los Angeles, however, pursues a diametrically opposing path—where the other two cities limit off-street parking, LA requires it" (Shoup, 2004). Shoup uses the concert halls of LA and SF to highlight how design, cost, and experience are all constrained by parking requirements. Los Angeles requires, "as a minimum, fifty times more parking than San Francisco allows as its maximum. Thus the San Francisco Symphony built its home, Louise Davies Hall, without a parking garage, while Disney Hall, the new home of the Los Angeles Philharmonic, did not open until seven years after its parking garage was built" (Shoup, 2004). Furthermore, the Disney Hall schedules at least 128 concerts each winter, not due to demand, but rather to generate the cash sufficient to pay off the debt service on the parking garage beneath it. Thus, the "minimum parking requirements have led to a minimum concert requirement" (Shoup, 2004).

Design-wise, the garage for the Disney Hall is situated underground, meaning that most patrons enter from underneath rather than outside. Accordingly, the designers took the flow of patrons into consideration, "so while the hall has a fairly impressive street entrance, its more magisterial gateway is a vertical one: an 'escalator cascade' that flows up from the parking structure and ends in the foyer" (Shoup, 2004). This type of design obviously has consequences for street life. A concert-goer can "drive to Disney Hall, park beneath it, ride up into it, see a show, and then reverse the whole process—and never set foot on a sidewalk in downtown LA" (Shoup, 2004). However, in SF when a theater or concert show lets out, the masses swarm the streets and enjoy the stroll past restaurants, bars, and other public spaces. This presence of people further encourages people to be out and about, because it is vibrant, fun, and exciting. No one likes eerie, empty streets therefore "although the absence of parking requirements does not guarantee a vibrant area, their presence certainly inhibits it" (Shoup, 2004).

So, although LA is not distinguished from other cities by its sprawl, car usage or population density, it sets itself apart through its "high human density combined with its high parking density" (Shoup, 2004). Through the "parking coverage rate" (ratio of parking area to total land area), we see that LA parking spaces if "spread...horizontally in a surface lot... would cover 81 percent of the CBD's land area", while SF and NY have 31 percent and 18 percent, respectively (Shoup, 2004). Overall, these MPRs make LA a collection of buildings that serve as individual destinations, not as pieces of a whole.

Thus, on many fronts, the way parking is designed and regulated has implications for development, urban design, congestion, city-life, the environment, and cost of living. Accordingly, many cities have recently reconsidered their regulations and approaches to parking. Some of these examples are discussed below.

Recent Parking Regulation Activity

Reduced and more accurate parking requirements reflect a shift in thought, whereas "the old paradigm assumed that parking should be abundant and free; the new paradigm recognizes that too much parking is as harmful as too little, and that parking should be managed and priced

for efficiency” (Litman, 2017). Thus far, jurisdictions around the country have begun reducing or even eliminating minimum parking requirements. Ahead of the game, Spartanburg, SC and Fayetteville, AR dropped parking standards in 2007. In 2017, Miami reduced their requisite parking requirements for certain Multifamily properties by more than 30% (Heller & Tachmes, 2018). Los Angeles has been considering a zero minimum parking requirement ordinance for some time, meaning that future development could rise without parking whatsoever.

The recent support for decreases in MPRs are based on multiple factors, but can primarily be tied to the fact that MPRs were set during different transportation circumstances. The rise of Uber, Lyft, and other mobility services has led to significant decreases in people using their own vehicles for transport. However, despite this recent uptick in consideration for parking policy, most cities remain woefully behind the curve as a “2015 study by the National League of Cities found that only 6% of member city transportation plans include the potential impact of driverless technology, and only 3% take into account private transport companies such as Uber and Lyft” (Henderson & Spencer, 2016).

Many have already noticed how oversupplied parking is as a result of lower vehicle ownership and use. A study by SmartGrowth America examined parking around Transit Oriented Destinations (TODs) to gauge how much less parking is required at TODs and how many fewer vehicle trips are generated than the standard industry estimates (ITE rates). The TODs in this study had built less parking than recommended by ITE, yet even this reduced amount was not used to capacity as the “the ratio of demand to actual supply was between 58 and 84 percent” (Ewing, 2017). By ITE standards the peak occupancy was only 19%-46% of parking generation rates. Furthermore, “vehicle trip generation rates for the five TODs... were, on average, less than half of what ITE estimates” (Ewing, 2017).

Moving Forward – Parking Property Owners

So where does this leave parking property owners? As a parking property owner, you’ve been told that driverless cars will reduce car ownership even more than then the current dip, but you don’t know how far way that reality is. You are aware that certain types of structures and garage layouts can be rededicated, but are not sure if your property fits the bill or how much it will cost. Logically, you sense that if some garages are demolished and people continue to drive for some time you could be the only garage in town, but you are unsure if traffic patterns will make your location prime. Furthermore, you have even overheard that tech companies are looking to buy up suitable garages to transform them into “CarBanks” for storage and charging, but you certainly don’t know when that will take place. Finally, you have seen firsthand how occupancy has dipped, but are also aware that parking regulation and requirements may shift occupancy in your favor if other land uses reduce their parking footprint. To top it all off, the economy is flourishing and has been for quite some time (longer than anyone has anticipated), raising expectations that a recession is right around the corner.

With all of these variables floating around, each with an uncertain factor in both time and magnitude, some might decide to lock in their profits and jump ship. Essentially, more uncertainty in the market for parking properties results in properties changing ownership more

often. This shift of attitude in parking structure ownership, I believe, could have been sparked by the current dip in own-vehicle usage attributable to Uber, Lyft and other mobility services. When owners saw that these ride-hailing/sharing firms were not fads, but here to stay, surely they contemplated a future where all types of travel were accomplished without ownership, and by extension without parking. Uber's are ride-hailing, ride-sharing, and food-bringing entities, basically the driverless cars of the future just with drivers. Furthermore, Uber has already been diligently working to create its own fleet of driverless cars, ready for rollout to every city that has already adopted their services. Accordingly, through analysis of Uber growth and parking structure sales, this paper seeks to identify whether a period of uncertainty in parking property ownership coincides with Uber's explosion.

Data & Methodology

This paper examines if Uber's proliferation, in terms of driver count, can be tied to trends in parking structure sales. The data set used for regressions and tables is comprised of a few different sources, merged together to create a unique data set.

The data for Uber's growth come from Uber's Chief Economist Jonathan Hall, and are the same data used by Hall and Krueger (2005). Uber's growth is tracked on two bases, on a national level, and on a city level. The number of Uber drivers nationwide was reported on a monthly basis from July 2012 (year of Uber's introduction) to December 2015. The number of Uber drivers on a city level is also measured monthly, but by months since Uber's arrival in said city. Some cities have growth data from Uber's first day till 2015, while others were introduced to Uber later. For the city data, there are 19 cities available for analysis. The main metrics taken from this data is the Uber driver count for each city and for the nation on a yearly basis. While Uber rides or revenue by market may be better proxies for Uber's presence in a given city, driver count still reflects to some degree the amount of demand in the market for rides and the supply of drivers willing to work for such demand. At the present moment this paper uses the data at hand, but future edition may take advantage of better proxies.

The data for parking structure sales come from Costar, the nation's leading information provider for commercial real estate professionals. Costar tracks \$1.5 trillion worth of commercial real estate transaction activity and has regularly updated information on over 5.3 million buildings.

The data for this paper come from CoStar's search function, which allowed me to search by asset class within certain markets. I chose to look for parking garages and surface lots in 10 different large markets within the U.S. These markets are Atlanta, Austin, Chicago, Dallas, Houston, Los Angeles, Miami, New York, San Francisco, and Washington D.C. Using CoStar's definition of "Market", these selections are defined as "Geographic boundaries that serve to delineate core areas that are competitive with each other and constitute a generally accepted primary competitive set of areas". As such, the Los Angeles Market contains properties within Downtown LA, West LA, Mid-Wilshire, South Bay, Mid-Cities, Burbank, Glendale, and South Pasadena. The other markets are treated similarly.

By limiting this study to the aforementioned 10 markets and only parking garages/lots, the search yielded 1665 different properties. Each property in this report has data on a multitude of different metrics. For the sake of this paper, I focused on the following metrics: Location of

Property, Last Sale Date, Last Sale Price, Number of Spaces, Year Built, and Building Status. While most properties had data for each metric, many did not have all metrics within this selection because some are hard to collect or observe. This means that sales are under-observed and that the number of sales could be much higher.

Parking structure sales are partitioned by market and month in order to compare to the Uber driver data. By looking at parking property sale trends in conjunction with Uber driver data, we can see any potential effects of Uber’s presence in each market and on a national level.

Another metric for driverless car adoption is the INRIX score, which comes from a study done by INRIX, a Seattle based big data firm, that “leverage(s) vehicle connectivity, advanced parking management, dynamic data for city planning and traffic flow optimization” to produce mobility research products. The score is an indicator that takes into account transit patterns, parking design, and demographics. The 50 biggest cities in the U.S by population were given scores that utilize one year’s worth of travel (1.3 billion trips). INRIX used StreetLight InSight, “an industry-leading mobility analytics online platform” and evaluated any trips that originated and concluded within 25 miles of the downtown area. These trips were compared to “aggregate regional trips (including outbound, inbound, and passing-through trips) to establish a percentage of intra-city travel”. Finally, each city was given a score out of 50 for two aspects, for a max total of 100 points. The first was percentage of aggregate intra-city trips, and the second was percentage of aggregate trips 10 miles or less. Essentially, the cities who would best utilize AVs (based off travel patterns and demographic weightings) are ranked highest by the INRIX study. This score is used as a sort of validity check on each cities Uber driver data. By this I mean that the score serves as a way to see if places that rank highly in the INRIX study also rank highly in terms of overall Uber presence. Because “Car-On-Demand” services like those provided by Uber are a centrality of the Passenger Economy, a city that is suited well in terms of traffic patterns and demographics for AVs should also see a large Uber presence. If a high INRIX score is correlated with high Uber usage, then using Uber as variable for driverless car adoption is further justified.

Additional data for the markets being examined are sourced from the U.S Census Bureau and the Federal Reserve Economic Data (FRED). The yearly population for each market from 2012 to 2017 was gathered, as well as the real Gross Domestic Product (GDP) for the nation from 1989 to 2017. Population is used to normalize Uber driver count across markets, and the lag of real GDP is used to reflect attitudes towards future economic levels.

The datasets above are used to create four varying regression models:

$$1) Avg. Monthly Driver Growth Over Study Period_i = \beta_0 + INRIXScore_i[\beta_1] + \varepsilon$$

$$2) Yearly Parking Property Sales_{it} = \beta_0 + Uber?_t[\beta_1] + RealGDPLag_{t-1}[\beta_2] + \varepsilon$$

$$3) Yearly Parking Property Sales_{it} = \beta_0 + UberDriversPerPerson_{it}[\beta_1] + RealGDPLag_{t-1}[\beta_2] + \varepsilon$$

$$4) Log(Yearly Parking Property Sales_{it}) = \beta_0 + Market_{it}[\beta_1] + DriversPerPerson_{it}[\beta_{10}] + RealGDPLag_{t-1}[\beta_{11}] + \varepsilon$$

Regression 1 uses INRIX scores for the 19 cities that the Uber study follows and the variable “Average Monthly Driver Growth”. This variable is constructed by first creating month

over month growth rates for each city in terms of Uber drivers. Then, an average growth of Uber drivers is taken across the entire study from the monthly rates for each city. Average Monthly Driver Growth measures how strongly each city adopted the mobility product over the study. INRIX Score is expected to be positive as a city better suited for AV use is expected to have high Uber use as well.

Regressions 2 and 3 use longitudinal data for each market (10) from 1989 to 2017, yielding 280 observations. Each observation records the year, the sales in that year, the number of Uber drivers for that market in that year, the population of that market in that year, and the real GDP of the nation during that year. A 1st lag variable was created for Real GDP to control for how expectations of future GDP might affect property sales. Expectations for the health of next year's economy are likely formed from the state of the economy in which the expectations are made. Accordingly, the lag of real GDP is expected to be positive as forecasts for future GDP growth are expected to motivate property sales since cash generated from sale can be invested in better opportunities going forward. Additionally, a binary event variable was generated called "Uber(Y/N)/Uber?" which signifies whether Uber exists at the time (=1 if true). This variable is also expected to be positive as it signifies that parking property owners are operating under attitudes of heightened uncertainty. Finally, a third variable has been generated called "Uber Drivers per Person". This variable is constructed to normalize driver count across markets of varying population sizes. Essentially, it is constructed by taking Uber drivers in that market during a given year and dividing by population of that market in that same year. This variable is expected to be positive as a higher number of drivers per person reflects a higher Uber presence, which is expected to lead to more uncertainty for parking property owners. Both **Regressions 2 and 3** use the "absorb" command to control for fixed effects between markets. Additionally, they are both "areg" form regressions and have robust standard errors.

Regression 4 is a negative binomial regression which uses panel data and controls for fixed effects between heterogeneous markets. It is appropriate to use a negative binomial regression in this case because the dependent variable is a low integer. Furthermore, as evidenced in **Table 3**, the conditional mean of yearly sales is much lower than the conditional variance of yearly sales (condition being market), which is another marker for the appropriateness of a negative binomial regression (where over-dispersion is present). **Regression 4** uses Uber Drivers per Person and the lag of real GDP. Similar to **Regressions 2 and 3**, **Regression 4** has robust standard errors.

Data Summary and Analysis

I: General Characteristics

Using the Costar data, I was able to determine a number of summary statistics which can be found in **Tables 1 and 2** and **Figures 1 through 6**. Of the markets sampled, the average number of parking structures is 166 with New York having the most and Austin the least (370 vs. 36). The city with the most parking property sales after Uber's introduction was Chicago, followed by New York and Los Angeles (90, 85, and 55). The average number of structures sold is 38. On a percentage basis, Los Angeles and Chicago had the highest percentage of their supply sold with roughly 30% each, however Atlanta had the least with 10.8%. This is surprising, given

that Atlanta has the third most amount of properties and the average percentage of supply sold is roughly 23%. Using area as a basis, Chicago and Houston have the most land dedicated to parking properties with over 22 million square feet each. The average amount of land dedicated across the markets sampled is roughly 10 million square feet. To put that into perspective, 10 million square feet is roughly equivalent to over 200 football fields.

Looking at the year each property was built, there are noticeable trends which can be seen in **Figures 1** through **4**. Around the introduction of the car to the city (early 1900s) over 40 properties were built, likely simple surface lots. There are spikes in construction in 1910, and throughout the period before the Great Depression. A noticeable trough in construction is visible after the Great Depression and during both World Wars. From 1950 to 1990 the most consistent and high period of construction takes place, with roughly 15 properties being built each year in the sample. After this period a large dip occurs from 1990 to 1997, but peaks again before the “dot com” bubble and Financial Crisis. From 2016 to 2018 along with proposed construction through 2020 there is noticeable trough. Within these sampled markets, less than 5 properties are currently slated for construction in 2020.

Using the last sale date metric, I constructed a graph of parking structure sales over time (**Figure 2**). There are roughly 3 peaks and 2 troughs. Peaks occur in 2000, 2007, and 2016 with troughs in 2002, and 2009. From 2012 to 2016 a large upswing in sales takes place. This upswing is larger than any other in history, for the sample markets. In 2016, there were over 90 sales in the 10 markets sampled, the most of any year ever. Of the properties sold from 2012 to date, the average sale price for each year is highly variable suggesting higher uncertainty in the value of parking structures. This is visible in **Figure 3**. I constructed a table of total sales by quarter, which provides evidence of seasonality in sales. Most properties from this sample are sold in the fourth quarter, while quarters 1 through 3 have roughly equal amounts.

From the Uber data, I created additional summary statistics on usage. The market with the most drivers is LA with over 400,000. Each market’s Uber driver count across time can be seen in **Figure 6**. The market with the least amount is Houston with only 60,000. The average amount of Uber drivers across the markets is a little over 180,000. Over the period July 2012 to December 2015, Uber amassed over 460,000 drivers (**Figure 5**). Average growth, month over month, of Uber drivers over this period was 13%. Today, Uber is estimated to have over a million drivers in the U.S (Berry 2017). **Figure 4** shows Uber’s (nation-wide) yearly driver count alongside property sales.

With regards to the INRIX data, the highest ranked city within our sample is Austin, followed by Miami and Los Angeles. The lowest ranked are Chicago, Dallas, and San Francisco. San Francisco, out of all 50 cities ranked in the study, is ranked 48th. This is interesting, as this would suggest that the location of a huge chunk of driverless car research is ill-suited for HAV deployment. On average, and within the sample, the INRIX score is 84.44 out of 100. Although not in our sample, the highest ranked city for HAV deployment is New Orleans. These metrics are presented in **Table 1**.

II: Regression Results

The results of **Regressions 1** through **4** can be seen in **Tables 4, 5, and 6**. **Regression 1** regresses the average monthly Uber driver growth for each market over the period on the INRIX score. The INRIX Score is statistically significant at the 95% level, and the relationship is

positive as expected. A higher score indicates a market more suitable for HAV deployment and thereby more conducive towards Uber adoption rates. This regression implies that a 1-point increase in the INRIX score would predict a roughly 2% higher monthly driver growth rate in a given market. Although more factors determine whether a market will adopt Uber, these results give strength to the use of Uber's presence in each market as a proxy for attitudes for driverless car adoption. This regression has an R^2 of .273.

Regression 2 regresses the amount of parking properties sold each year in each market on the binary event variable "Uber?". The event variable is statistically significant at the 99% level and the relationship is positive as predicted. This regression implies that after Uber's arrival, there are on average 3.2 more sales a year in a given market. Additionally, this regression controls for future expectations of real GDP through the lag of real GDP. This variable is significant at the 99% level, implying that forecasted economic conditions are important when determining whether to sell a property. This makes sense as it is logical for an investor to want to have suitable investments available once cash is generated from sale of property, limiting their exposure to the depreciative effects of inflation. This regression has an R^2 of .538.

Regression 3 regresses the number of parking structure sales in each city in a year on the number of Uber drivers per person in each city in that same year. Uber Drivers per Person is statistically significant at the 99% level and its relationship is positive as expected implying that a market with more drivers per person will raise uncertainty in the market and prompt more sales of parking properties. The magnitude indicates that a 10% increase in drivers per person will predict 10.4 more sales per year in a given market. Similar to **Regression 2**, this model controls for economic forecasts through the lag of real GDP. It is significant at 99% level and the magnitude is roughly equivalent to **Regression 2's** lag. This regression has an R^2 of .532.

Regression 4 regresses the log of yearly parking property sales on the ratio of Uber Drivers per Person, controlling for fixed effects between heterogeneous markets. The coefficient on drivers per person is statistically significant at the 99% confidence level and positive as expected. The magnitude of the variable implies that a 10% increase in a market's driver per person ratio would predict an increase of 1.4% increase in the number of yearly parking property sales. The relationship is positive as expected, implying a market with more drivers per person will have higher uncertainty and thus more sales of parking properties. Additionally, the lag of real GDP has is statistically significant at the 99% level, and positive as expected. This regression has a pseudo R^2 of .2400. It is advised to take caution when comparing R^2 between linear regressions and negative binomial regressions as they are not equivalents.

Conclusion

In analyzing Costar data in combination with Uber proliferation, the results indicate that Uber's emergence coincides with a period of high ownership change in the specialty asset of parking garages and lots. From **Regressions 2** through **4**, it is possible to say that a driver behind parking property sales is Uber's proliferation. However, there are multiple factors that determine if an asset is sold. Additionally, these model's success rest on the strength of the assumption that Uber serves as a signal for the mobility economy and that investors/owners have been paying

attention to it. From the literature review it is likely that Uber is a powerful showcase for the kind of mobility product that is expected to shape real estate in the future. However, this may not be the case, and the time period used to gather Uber data may be too small to draw any meaningful results from. Furthermore, the use of only 10 markets may be biasing the regression models since each market is chosen from the top 15 biggest markets. These markets may share some feature that other markets not in the top 15 don't have, which may influence parking property ownership. Furthermore, the number of Uber drivers may not be the best metric for evaluating Uber's presence overall. Uber trip counts or total revenue by market could yield better results. Finally, the assumption that parking property owners are selling their assets may be less attributable to uncertainty and more attributable to economic trends. **Regressions 2 through 4** attempt to control for this, but there may be better proxies available than the lag of real GDP. Regardless of the Uber data, it is evident that parking properties are changing hands more than ever. There is certainly a factor influencing this phenomena, and as the next few years go by, it will be interesting to watch this asset type. Prudent real estate owners will need to be on high alert as the next wave of driverless technology and regulations take form. Those who anticipate the changes that have been outlined previously have a shot at enormous fortunes. And for the rest of us, maybe we'll at least get to snooze on the way to work.

Tables, Regression Results, & Graphs

Table 1

City	State	Parking Structure Sales After Uber	Total Structures	Pct of Supply Sold	INRIX Rank	INRIX City Score	Total Area (sqft) of Off-Street Parking
Atlanta	GA	25	231	10.8%	39	83.34	14,508,965
Austin	TX	10	36	27.8%	12	87.30	1,861,754
Chicago	IL	90	299	30.1%	40	83.31	23,086,800
Dallas	TX	30	112	26.8%	42	83.00	10,787,634
Houston	TX	25	124	20.2%	29	84.84	22,937,825
Los Angeles	CA	55	181	30.4%	15	86.60	7,268,422
Miami	FL	9	55	16.4%	14	86.67	2,559,150
New York	NY	85	370	23.0%	32	84.30	5,397,955
San Francisco	CA	39	185	21.1%	48	81.16	7,157,344
Washington	DC	15	71	21.1%	35	83.92	2,791,760
<i>Average</i>		<i>38</i>	<i>166</i>	<i>22.8%</i>	<i>26</i>	<i>84.44</i>	<i>9,835,760</i>

Table 2

Sales By Quarter

	Sales
<i>Qtr 1</i>	173
<i>Qtr 2</i>	171
<i>Qtr 3</i>	175
<i>Qtr 4</i>	193

Table 3

Average Yearly Sales by Market

Market	Mean Yearly Sales	Variance of Yearly Sales	Observations
Atlanta	2.07	4.64	29
Austin	0.38	0.89	29
Chicago	4.97	48.75	29
Dallas	1.38	4.32	29
Houston	1.31	3.44	29
Los Angeles	2.93	12.14	29
Miami	0.72	1.85	29
New York	7.28	42.71	29
San Francisco	2.31	9.44	29
Washington, D.C	0.83	1.79	29
Total	2.42	16.84	290

Table 4

Uber Proxy Validation Regression

Observations	19
R-squared	0.273
adj. R-squared	0.231
[1]	
VARIABLES	Avg. Monthly Driver Growth Over Study Period
INRIX Score	1.718** [2.529]
Constant	-127.3** [-2.217]

Robust t-statistics in brackets
 *** p<0.01, ** p<0.05, * p<0.1

Table 5

Regressions 2 & 3

Observations	280	280
R-squared	0.538	0.532
adj. R-squared	0.519	0.512
[2]		[3]
VARIABLES	Parking Structure Sales	Parking Structure Sales
Uber (Y/N)	3.204*** [4.748]	
Uber Drivers per Person		103.9*** [3.499]
Real GDP (1st Lag)	0.000432*** [5.520]	0.000552*** [7.672]
Constant	-3.720*** [-4.063]	-4.962*** [-5.772]

Robust t-statistics in brackets
 *** p<0.01, ** p<0.05, * p<0.1

Table 6

Panel Data Regression (4) Table

Negative Binomial Regression *N = 280 Pseudo R2 = .2400*

Parameter	Coef.	Std. Err.	95% Wald Confidence Interval		z	P> z
			Lower	Upper		
[Intercept]	-4.19	0.51	-5.19	-3.18	-8.15	0.000
Market						
Austin	-1.87	0.39	-2.62	-1.11	-4.83	0.000
Chicago	0.70	0.22	0.27	1.13	3.2	0.001
Dallas	-0.50	0.24	-0.97	-0.03	-2.07	0.039
Houston	-0.51	0.24	-0.97	-0.04	-2.15	0.032
Los Angeles	0.22	0.22	-0.22	0.65	0.98	0.329
Miami	-1.12	0.37	-1.85	-0.40	-3.04	0.002
New York	1.34	0.22	0.91	1.78	6.05	0.000
San Francisco	-0.12	0.23	-0.58	0.33	-0.53	0.599
Washington D.C	-1.10	0.28	-1.64	-0.56	-3.97	0.000
Uber Drivers per Person	14.14	4.13	6.04	22.24	3.42	0.001
Real GDP (1st Lag)	0.00036	0.00003	0.00029	0.00042	10.56	0.000

Figure 1

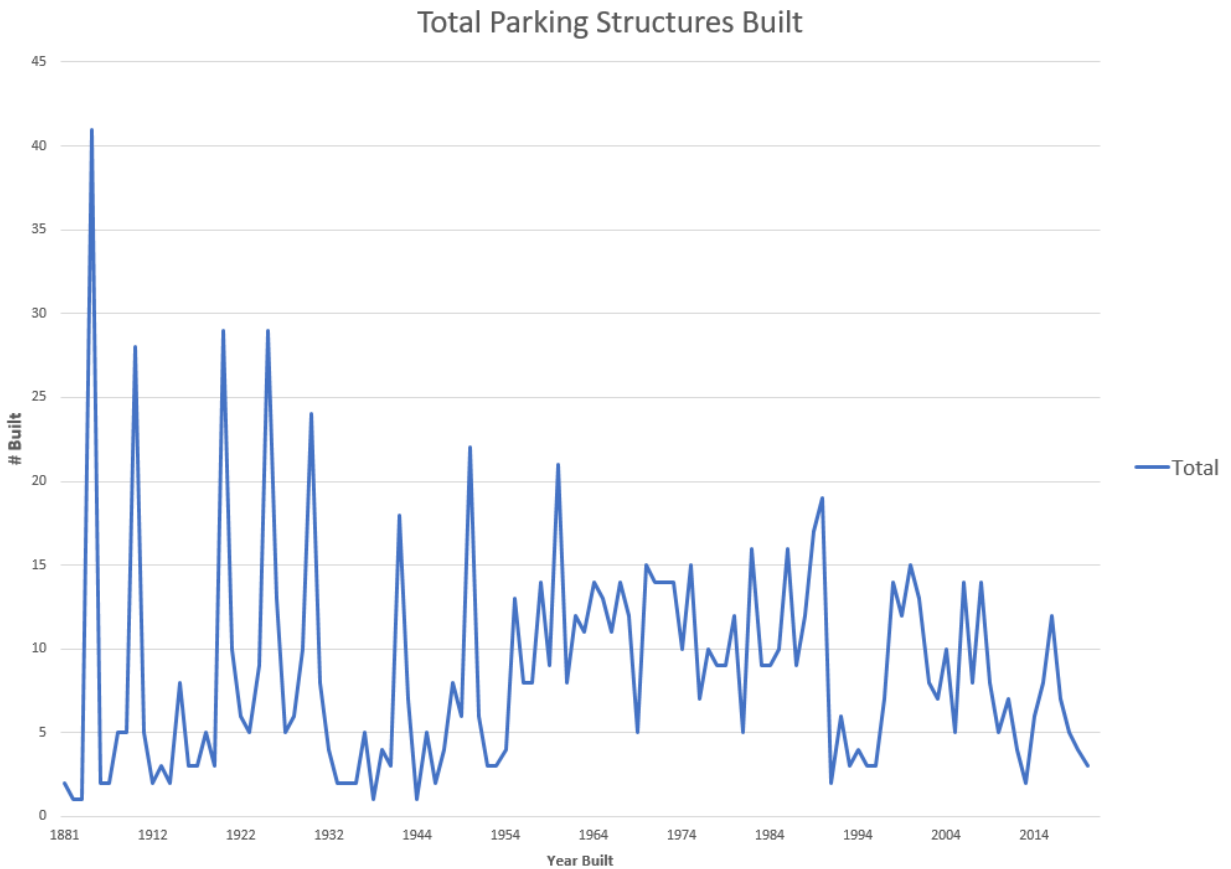
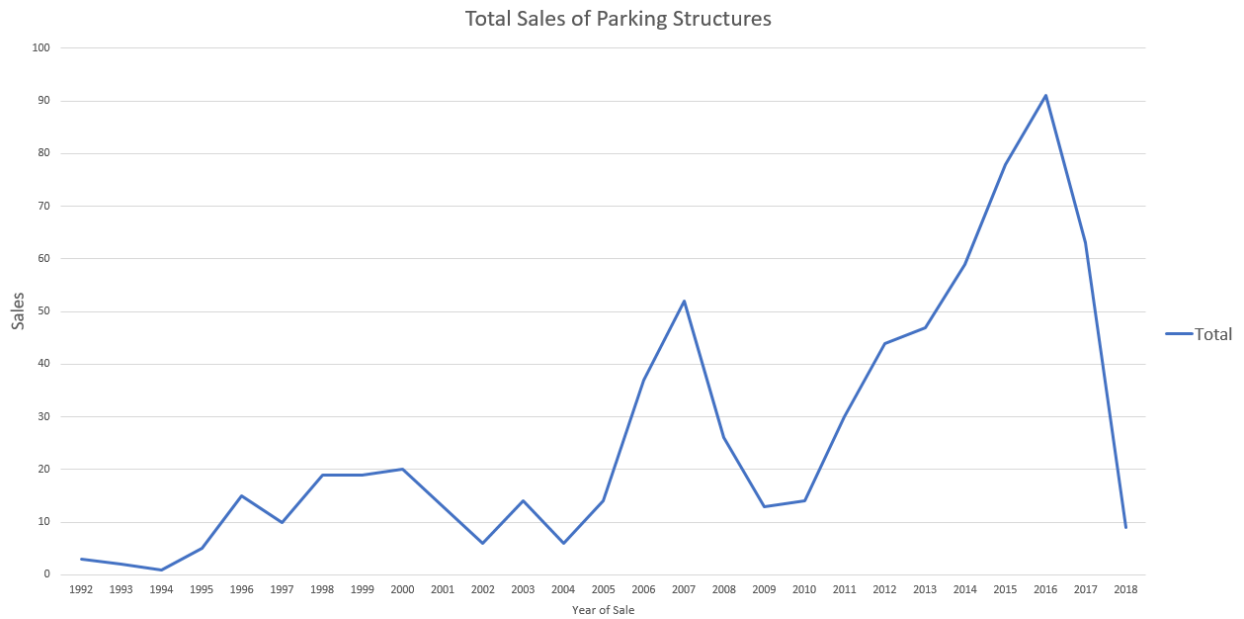


Figure 2



**Dip in 2018 is solely because 2018 has just begun.*

Figure 3



Figure 4

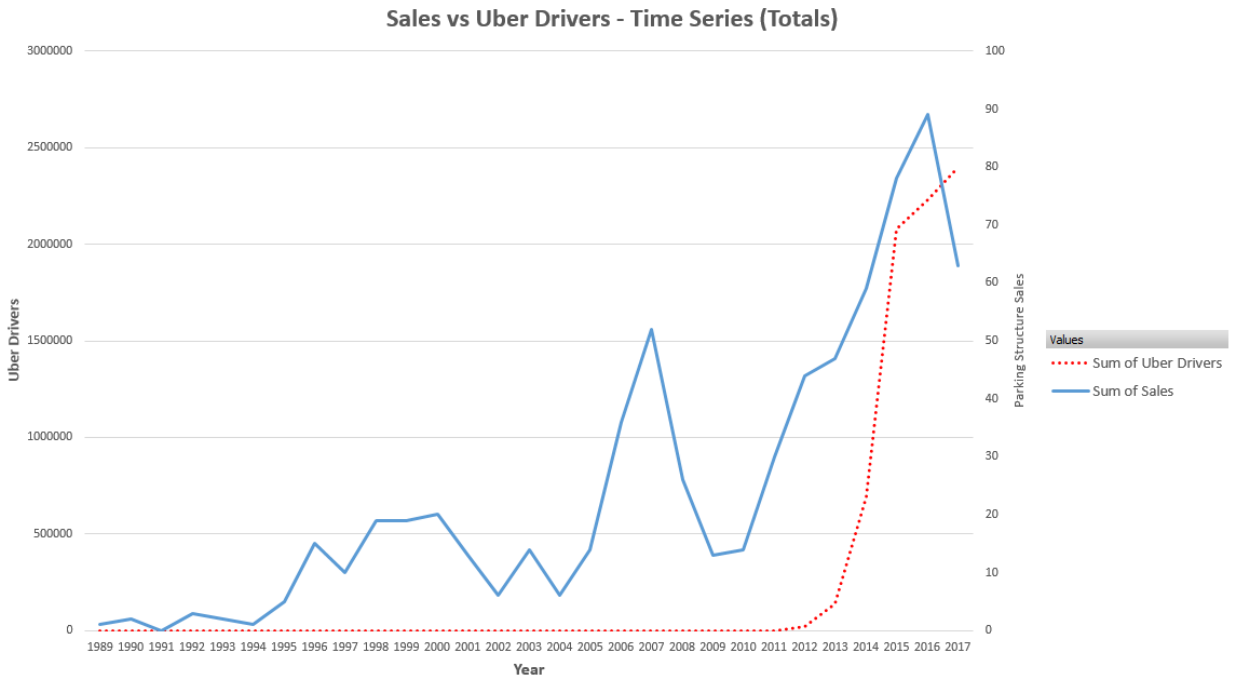


Figure 5

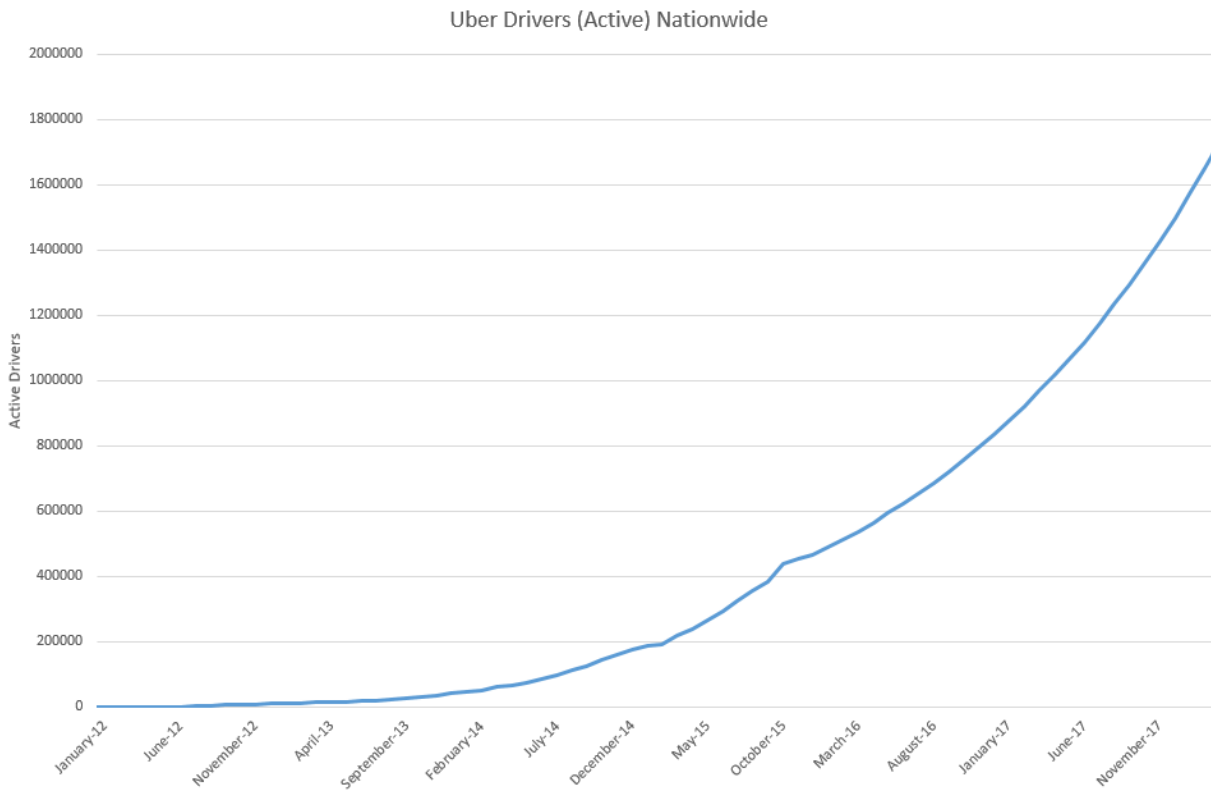
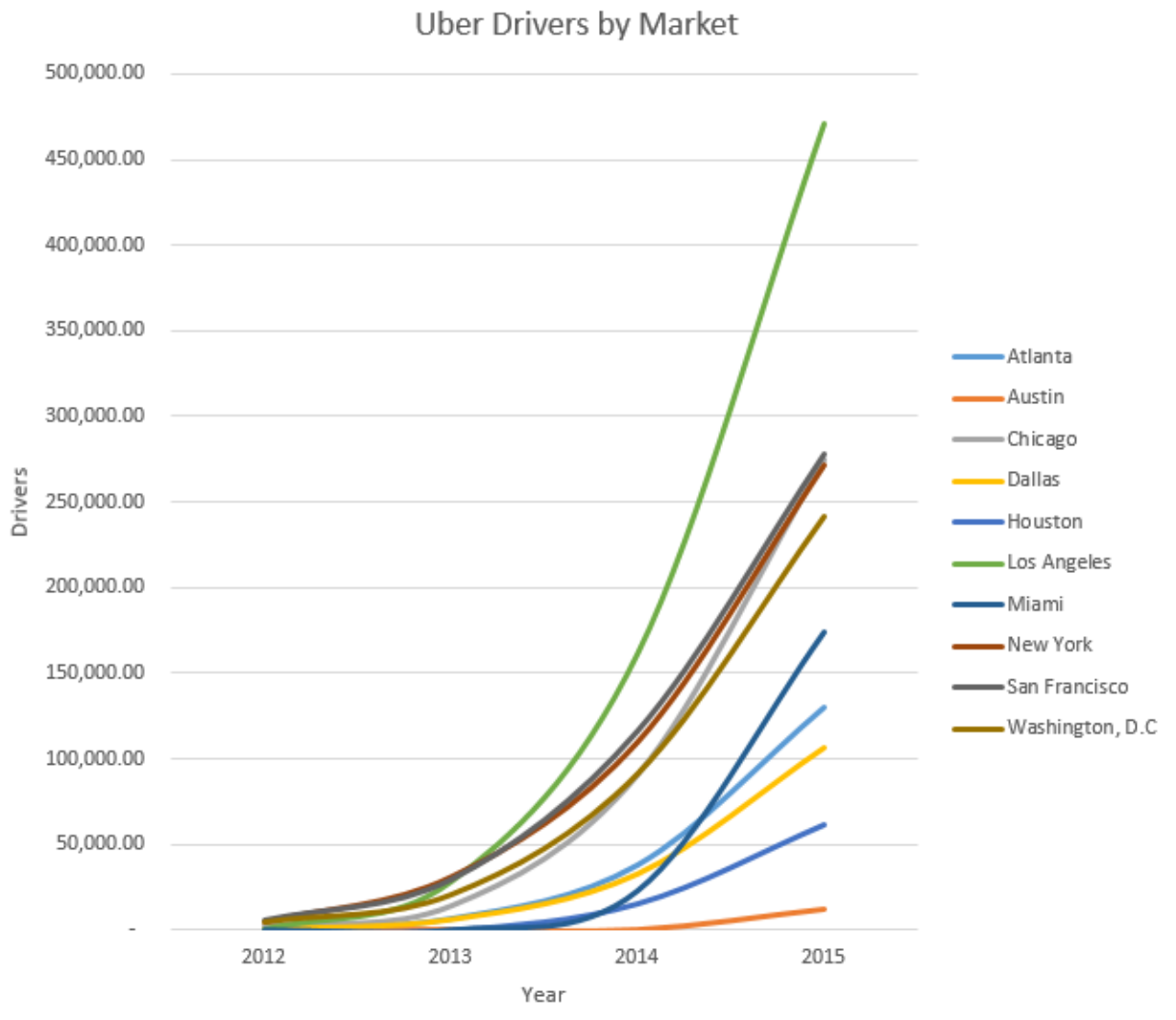


Figure 6



Bibliography

- 1) Lanctot, Roger. "Accelerating the Future: The Economic Impact of the Emerging Passenger Economy." *Strategy Analytics* (2017): 5.
- 2) Henderson, Jason, and Jason Spencer. "Autonomous Vehicles and Commercial Real Estate." *Cornell Real Estate Review* 14.1 (2016): 14.
- 3) Levine, Jonathan. "The Cost of Land Use Decisions: Applying Transaction Cost Economics to Planning & Development, by Edwin Buitelaar." *Journal of Regional Science* 49.1 (2009): 213-216.
- 4) Berry, Melissa. "How Many Uber Drivers Are There?" The Rideshare Guy Blog and Podcast, 3 Nov. 2017, therideshareguy.com/how-many-uber-drivers-are-there/.
- 5) Hall, Jonathan V., and Alan B. Krueger. "An analysis of the labor market for Uber's driver-partners in the United States." *ILR Review* (2015): 0019793917717222.
- 6) INRIX. INRIX Identifies Top U.S. Cities for Shared Highly Autonomous Vehicle Deployment. (2017)
- 7) Shoup, Donald C. "The trouble with minimum parking requirements." *Transportation Research Part A: Policy and Practice* 33.7-8 (1999): 549-574.
- 8) Manville, Michael, and Donald Shoup. "People, Parking, and Cities." (2004): 2-8.
- 9) Smart Growth America. Empty Spaces – Real parking needs at five TODs (Transit-oriented developments). (2017)
- 10) "The Milwaukee Sentinel." *Google News Archive Search*, Google, news.google.com/newspapers?id=unBQAAAAIBAJ&sjid=QQ8EAAAAIBAJ&pg=7304%2C3766749.
- 11) Bel Geddes, Norman. "Magic motorways." *New York Random House* (1940).
- 12) Cox, Wendell. "Driverless Cars and the City: Sharing Cars, Not Rides." *Cityscape*, vol. 18, no. 3, 2016, pp. 197–204. *JSTOR*, www.jstor.org/stable/26328283
- 13) Duranton, Gilles. "Transitioning to Driverless Cars." *Cityscape: Volume 18 Number 3 | Transitioning to Driverless Cars | HUD USER*, 2018, www.huduser.gov/portal/periodicals/cityscape/vol18num3/article12.html.
- 14) Fuller, Brandon. "Cautious Optimism About Driverless Cars and Land Use in American Metropolitan Areas." *Cityscape* 18.3 (2016): 181-184.
- 15) "2017 INRIX Autonomous Vehicle Study." *INRIX Identifies Top Cities for Shared Highly Autonomous Vehicle Deployment*, 2017, www2.inrix.com/2017-autonomous-vehicle-study.
- 16) Risen, Tom. "Obama to Propose \$4 Billion for Self-Driving Cars." *U.S. News & World Report*, U.S. News & World Report, 14 Jan. 2016, www.usnews.com/news/articles/2016-01-14/obama-to-propose-4-billion-for-self-driving-cars.

- 17) LeBLANC, STEVE. "Studies Are Increasingly Clear: Uber, Lyft Congest Cities." *AP News*, Associated Press, 25 Feb. 2018, www.apnews.com/e47ebfaa1b184130984e2f3501bd125d/Studies-are-increasingly-clear:-Uber,-Lyft-congest-cities.
- 18) Romm, Tony. "A Bill to Put More Self-Driving Cars on U.S. Roads Is Stuck in the Senate." *Recode*, Recode, 18 Jan. 2018, www.recode.net/2018/1/18/16905964/self-driving-car-testing-roads-congress-senate.
- 19) Cutter, Bowman. "Do Parking Requirements Significantly Increase the Area Dedicated to Parking? A Test of the Effect of Parking Requirements Values in Los Angeles County." *Transportation Research Part A: Policy and Practice*, Pergamon, 6 Apr. 2012, www.sciencedirect.com/science/article/pii/S0965856412000304.
- 20) Tachmes, Alexander, and Josh Heller. "Land Use and Government Trends for 2018." *Daily Business Review*, 16 Jan. 2018, www.law.com/dailybusinessreview/sites/dailybusinessreview/2018/01/16/land-use-and-government-trends-for-2018/?slreturn=20180320160055.
- 21) Litman, Todd. "Reduced and More Accurate Parking Requirements." *Planetizen - Urban Planning News, Jobs, and Education*, 24 Apr. 2017, www.planetizen.com/node/92360/reduced-and-more-accurate-parking-requirements.
- 22) Lewis, Craig. "Smaller Cities Lighten Up on Minimum Parking Requirements | NAIOP." *NAIOP Commercial Real Estate Development Association*, 2016, Summer, www.naiop.org/en/Magazine/2016/Summer-2016/Development-Ownership/Smaller-Cities-Lighten-Up-on-Minimum-Parking-Requirements.aspx.
- 23) Ewing, Reid. "Empty Spaces: Real Parking Needs at Five TODs." *Smart Growth America*, Jan. 2017, smartgrowthamerica.org/resources/empty-spaces-real-parking-needs-five-tods/.
- 24) Marcut, Adina. "How Are Driverless Cars Reshaping CRE?" *Commercial Property Executive*, Commercial Property Executive, 2 Apr. 2018, www.cpexecutive.com/post/how-are-driverless-cars-reshaping-cre/.
- 25) O'Brien, Robert T., et al. "2017 Commercial Real Estate Disruptor Report | Deloitte US." *Deloitte United States*, 29 Dec. 2016, www2.deloitte.com/us/en/pages/real-estate/articles/commercial-real-estate-disruptor.html.
- 26) Mammen, Taylor. "RCLCO FutuRE Series: A Driverless Vehicle Roadmap for the Real Estate Practitioner - Part 2." *Advisory: A Driverless Vehicle Roadmap for the Real Estate Practitioner - Part 2*, Dec. 2015, www.rclco.com/advisory-driverless-cars-pt2-2015-12-22.
- 27) Grant, Peter. "Say Goodbye to Garages as Developers Imagine a Driverless Future." *The Wall Street Journal*, Dow Jones & Company, 30 Jan. 2018, www.wsj.com/articles/say-goodbye-to-garages-as-developers-imagine-a-driverless-future-1517317200.
- 28) Ducker, Adam, and Taylor Mammen. "RCLCO FutuRE Series: A Driverless Vehicle Roadmap for the Real Estate Practitioner - Part 3." *RCLCO Real Estate Advisors*, 30 Nov. 2017, www.rclco.com/advisory-autonomous-vehicles-part3-2017-11-30.

- 29) Berry, Melissa. "How Many Uber Drivers Are There?" *The Rideshare Guy Blog and Podcast*, 3 Nov. 2017, therideshareguy.com/how-many-uber-drivers-are-there/.
- 30) Greenemeier, Larry. "Driverless Cars Will Face Moral Dilemmas." *Scientific American*, 23 June 2016, www.scientificamerican.com/article/driverless-cars-will-face-moral-dilemmas/.
- 31) Owen, Andrew, Brendan Murphy, and David M. Levinson. "Access Across America: Transit 2016." (2017).
- 32) Levinson, David M. *Access Across America*. No. CTS 13-20. 2013.
- 33) Burgess, Scott. "Parking: It's What Your Car Does 90 Percent of the Time." *Autoblog*, 23 June 2012, www.autoblog.com/2012/06/23/parking-its-what-your-car-does-90-percent-of-the-time/.
- 34) Sivak, Michael, and Brandon Schoettle. "Road safety with self-driving vehicles: General limitations and road sharing with conventional vehicles." (2015).
- 35) Claudel, Matthew, and Carlo Ratti. "Full speed ahead: How the driverless car could transform cities." *McKinsey Quarterly* (2015).