Hailing a change: comparing taxi and ridehail service quality in Los Angeles

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Abstract
For decades, taxis have provided for-hire vehicle service without significant competition from other modes. But in 2012, ride-hail services such as Uber and Lyft upended the taxi business model by connecting riders to drivers through smartphone applications. Since then, few studies have considered how taxis compare to their new competition or how service quality varies across the two modes. We use data from 1680 ride-hail and taxi trips taken in a Los Angeles audit study to ask: how do service qualities—including trip price, reliability, and accountability—vary across ride-hailing (Uber and Lyft) and taxis? We find that, for the same origin and destination pair, ridehail users pay 40% lower fares and wait about one-quarter of the time compared to taxis. In addition, ride-hailing nearly guaranteed a ride, while about one in five taxi riders were never picked up. We utilize semi-structured interviews of frequent taxi and ride-hail users to examine potential explanations of the stark quantitative differences observed across modes. Findings reveal that, despite technological disruption, travelers continue to prioritize the long-standing tenets of transportation services: affordability, reliability, and accountability. Ride-hailing successfully implemented technologies to deliver on these traveler priorities, while taxis have largely failed to capitalize on new technologies. Findings suggest that taxis will need to do more than lower prices or put more cars on the road if they hope to compete with ride-hailing services, and that both new and old modes should harness technology to deliver on long-standing transportation service goals.

Keywords Ride-hail · Taxi · Transportation network company · Service quality · Travel reliability
Introduction

For decades, taxis have provided for-hire vehicle service without significant competition from other modes. But in 2012, ride-hail services such as Uber and Lyft upended the taxi business model by connecting riders to drivers through smartphone applications. Since 2012, both the popular press and policy interventions have pitted taxis against ride-hail services, often focusing on plight of the taxi driver and the possible extinction of these legacy services (Nelson 2016; Fitzsimmons 2018). Fewer studies have considered how service quality compares across the two modes. Studies that have examined the ongoing battle between taxis and ride-hail companies have focused primarily on ride-hailing’s low trip prices as the primary culprit for falling taxi trips (Byrne 2017; Nelson 2015). However, trip cost is just one element of service and research documents that travelers place high value on other service elements including wait time and reliability [see for example Yoh et al. (2011)]. A more holistic understanding of taxi and ride-hail service is imperative as cities consider taxis and ride-hail policy.

In this research, we ask: how do service qualities—including trip price, reliability, and accountability—vary across ride-hail services (Uber and Lyft) and taxis? We answer this question using data from 1680 Uber, Lyft, and taxi trips taken in a Los Angeles audit study. We use semi-structured interviews of frequent taxi and ride-hail users to offer potential explanations of the stark differences observed across modes and highlight how such differences translate into lived experiences. Findings yield implications for understanding the surge of ride-hailing alongside the decline of taxi hails (Los Angeles Department of Transportation 2017a), considerations for taxi and ride-hail policy, and lessons for both legacy and future innovative modes.

Following this introduction, we divide this paper into four parts. First, we discuss the state of the taxi and ride-hail industries and three potential explanations for their respective decline and rise. Second, we introduce the data and methods used in this research. Third, we discuss differences in service quality across ride-hail and taxi services. Finally, we conclude that taxi regulations and service must evolve if taxis are to survive, and that both new and old modes should harness new technologies to deliver on long-standing transportation service goals, including affordability, reliability, and accountability.

Taxi and ride-hail services

The advent of ride-hail services (also known as transportation network companies and ridesourcing) in 2012 is the first large-scale challenge to the taxi industry’s dominance in the for-hire vehicle market. Across the country, increasing ride-hail trips have accompanied falling taxi trips. In New York City, a stalwart taxi market, Schaller (2017) found that monthly yellow cab trips fell by 24% between Spring 2015 and Fall 2016, while monthly ride-hail trips grew by 253% during the same time period. In the nation’s second largest city, Los Angeles, taxi trips fell by 51% between March 2013 and March 2017 (Sam Schwartz Engineering 2019), and in 2016, Lyft—the second largest ride-hail company serving Los Angeles after Uber—alone completed five times as many trips per month
compared to taxis (1.76 million vs. 405,000 per month) (Brown 2018). The comparison between taxis and Lyft demonstrates the scale that ride-hail services have achieved relative to taxis in just a few years of operation. Why has taxi service fallen over time while ride-hail services have exploded? In addition to operating in different regulatory environments, previous research suggests that four factors may help to explain the explosive growth of ride-hailing relative to dispatched taxis: price, availability, reliability, and accountability.

**Regulatory environments**

Compared to taxis, ride-hailing faces far fewer regulatory constraints (Cetin and Deakin 2019). In general, cities and airport authorities have imposed increasingly far-reaching taxi regulations over time (National Academies of Sciences Engineering and Medicine 2016). Ride-hail companies, like taxis, have largely been regulated at the local level to date (National Academies of Sciences Engineering and Medicine 2016), but have lobbied for state rather than local regulation (Zeitlin 2019). In 2013, California passed the first statewide ride-hail legislation, an approach followed by other states; statewide ride-hail regulations typically impose fewer fees and requirements compared to traditional taxi operators (National Academies of Sciences Engineering and Medicine 2016; Sam Schwartz Engineering 2019).

Cooper et al. (2010) outline three broad areas of taxi regulations: (1) quality control, such as vehicle age and appearance; (2) quantity control, which limits the number of cabs permitted to operate; and (3) economic controls such as fare settings. Some elements of taxi regulation are approached with relative uniformity across the country, such as requiring background checks for drivers and vehicle safety inspections. Others, like market entry rules, vary substantially from place to place (National Academies of Sciences Engineering and Medicine 2016; Schaller 2007). Market entry systems typically take one of four forms: first, permit or medallion systems in which a set number of permits or licenses may be sold and have economic value; second, certificate systems in which taxi companies can operate under non-transferable certificates; third, franchise systems in which cities issue franchises in a competitive process and set the number of taxis each may operate; and finally, open entry systems, which do not limit the number of taxis (National Academies of Sciences Engineering and Medicine 2016). While many places attempted to deregulate taxi market entry and economic controls beginning in the 1980s, efforts were mixed and created challenges such as higher fares, “clogging” at hotels and airports, and operator disputes. As a result, many American cities that deregulated taxi industries, re-established regulations over market entry and economic controls (Harding et al. 2016). Today, cities often justify continued taxi regulation citing consumer protection and environmental concerns (Cetin and Deakin 2019). Research, however, finds that regulatory successes depend largely on the taxi market. Market entry regulations prevent oversupply in cab stand and street-hail markets, but can create service deficiencies in dispatch markets (Schaller 2007).

Ride-hail regulations, too, vary by geography. They typically include regulations such as requiring regular vehicle inspections, displaying ride-hail logos when in service, and mandating that companies carry liability insurance. Some, but not all, states also require data

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1 Jarvis Murray (Taxicab and Franchise Administrator, Los Angeles Department of Transportation), in conversation with the author, 2017.
reporting and that ride-hail companies to pay for business licenses to operate (National Academies of Sciences Engineering and Medicine 2016).

While cities have sought to improve taxi service for years—for example, New York City proposed the Green Taxis in 2011 to better serve the outer boroughs (Barron 2018) and Minneapolis lifted its cap on taxi licenses in 2006 (McGrath and Sanders 2016)—competition from ride-hail services have accelerated concerns that taxis, or the regulations governing them, may be outdated. Taxi and ride-hail regulations remain markedly different, and the regulatory path forward is murky. Some researchers argue that ride-hailing and taxis should be regulated as a unit because they are substitutes (Wyman 2017), while others question more broadly what regulations are appropriate given the new technologies employed by both services (Cetin and Deakin 2019).

Price

Trip price has been central to the discussion of the respective rise and fall of ride-hail and taxi companies (Byrne 2017; Nelson 2015; Silverstein 2014). While price regulations vary by location—and indeed, some places do not regulate taxi fares—cities often mandate taxi base, cap, per-mile, and/or per-minute fares. Cities do not impose similar fare regulations onto ride-hail companies apart from per-trip fees levied by some cities and states (Kim and Puentes 2018). Like taxis, ride-hail companies charge a base fare, per-mile, and per-minute fare. They additionally charge a booking fee and may apply a surcharge when rider demand exceeds driver supply (Uber 2019; Lyft 2019). Limited field research found that in Los Angeles, taxis are both more expensive and have greater price variation compared to UberX (Uber’s most popular, non-shared, ride-hail service); for the same trip origin–destination pairs, taxi prices ranged between $8 and $22 compared to between $4 and $12 for UberX (Smart et al. 2015). Cities have responded to price differences between taxis and ride-hail in two ways. First, in select cases, they have relaxed fare regulations for taxis, such as by removing price floors (Nelson 2015). Second, cities have imposed flat and percentage-based taxes and fees on ride-hail trips in response to—among other publicized woes like congestion—taxis’ complaints over unfair treatment (Kim and Puentes 2018). While prices likely play a role in the relative attractiveness of ride-hailing compared to taxis—contrary to speculation (Silverstein 2014)—it may not be the primary factor. In San Francisco, for example, only 7% of surveyed taxi riders reported taxis were too expensive; by contrast, 24% reported poor availability and 19% reported poor reliability, which we discuss further below (San Francisco Municipal Transportation Agency 2013). In other cities, passengers have expressed confusion about fees occasionally levied on top of standard taxi fares (Nelson Nygaard 2013) and two-thirds of surveyed taxi riders in Los Angeles state that taxi affordability is poor or fair compared to other for-hire vehicle services (Sam Schwartz Engineering 2019).

Reliability

Travelers across modes report reliability as a primary motivator or concern in making travel decisions (Bhat and Sardesai 2006; Yoh et al. 2011). Despite the importance of travel reliability, taxi service is notoriously unreliable, a factor which may stem at least in part from historical supply shortages in entry-regulated dispatch markets (Schaller 2007). Taxi user surveys show that 19% of taxi riders reported poor reliability (San Francisco Municipal Transportation Agency 2013) and most frequently cite driver punctuality as an area of
improvement (Sam Schwartz Engineering 2019). Wait times are also highly variable across space; in Boston, between 33 and 80% of taxi trips are served within 20 min—the threshold used as a measure of “responsiveness”—depending on the neighborhood (Nelson Nygaard 2013). More recently, research has begun to contrast taxi to ride-hail services, albeit not always for comparable routes or years. In San Francisco, surveys of ride-hail travelers and taxi trips found that, depending on the time of day, between 88 and 93% of ride-hail trips arrived within 10 min compared to 25 to 39% of taxi trips (Rayle et al. 2016). Differences were similarly stark among a field experiment of riders in low-income Los Angeles neighborhoods: riders waited 4 to 57 min for a dispatched taxi to arrive, compared to between 1 and 20 min for an UberX to arrive (Smart et al. 2015). In Seattle, researchers observed 53% longer taxi wait times compared to Uber and Lyft (Ge et al. 2016).

Availability

One element affecting service reliability is vehicle availability. Multiple studies report poor taxi availability that results in long wait times and spatial gaps in service (Austin and Zegras 2012; Schaller 2007; San Francisco Municipal Transportation Agency 2013). Over one-quarter of taxi users in San Francisco remarked that taxi availability from their home was “terrible” and another quarter reported that taxis overall have “poor availability” (San Francisco Municipal Transportation Agency 2013). In Boston, taxi trip completion rates ranged from 59 to 88% depending on neighborhood (Nelson Nygaard 2013).

Poor taxi availability—and the uneven spread of taxi service across space—may be explained by three primary factors. First, market entry controls in dispatch markets have strictly limited taxi supply so that it falls short of demand (Schaller 2007). For example, between 2000 and 2016, the City of Los Angeles added just 58 taxis at the same time as it added 280,958 people (a 2 vs. 7% growth, respectively) (Los Angeles Department of Transportation 2017a; U.S. Census Bureau 2000, 2016). Such trends hold nationally in the U.S.; since 1970, there is no correlation between the growth (or decline) of taxi licenses and overall city population (King et al. 2012). Unlike taxis, ride-hail companies face no or very light regulatory barriers to enrolling new vehicles or drivers; as a result, ride-hail companies may increase driver supply in response to elevated rider demand, granting them greater flexibility than taxi companies can typically achieve under current regulatory structures.

Second, taxis typically operate fares that are fixed by mile and minute. This inhibits taxi companies from using prices to nudge driver behaviors and better balance driver supply with rider demand, which may help reduce service gaps and wait times. Ride-hailing balances driver supply and rider demand by raising prices in certain areas to draw drivers to underserved neighborhoods. Once driver supply and rider demand are again balanced, prices return to equilibrium. Research from Los Angeles and New York suggests that, relative to taxis, ride-hailing expands where and when people hail trips (Schaller 2017; Brown 2019).

Finally, increased ride-hail availability may be related to city-mandated taxi service geographies; cities often stipulate, for example, which companies may pick up riders within city limits. Particularly in regions where local jurisdiction boundaries frequently abut, such restrictions can create a tangled patchwork of taxi service (National Academies of Sciences Engineering and Medicine 2016). For example, a rider traveling between home and work in two different jurisdictions may choose one company to take to work, but must select a different company for the return trip due to city regulations. Such a patchwork
system may be particularly confusing for infrequent users, who comprise the bulk of both taxi and ride-hail users (NHTS 2017; Brown 2019). Unlike taxis, ride-hail companies may operate across jurisdictional boundaries, creating a uniform service region and eliminating availability uncertainty for riders.

**Accountability**

Accountability in taxis can vary based on the entry regulation structure. Schaller (2007) argues that company-level licensing requirements can foster accountability, while open entry without supply restrictions can undermine service accountability. Cities often build company and driver accountability into taxi franchises or service agreements; for example, the Los Angeles Department of Transportation (2010) reserves the right to suspend or terminate taxi franchises for failing to comply with regulations. They also post a Taxi Rider’s Bill of Rights online, operate a complaint hotline, and monitor online complaints (City of Los Angeles 2019). Past researchers have attributed improved taxi accountability structures—including performance metrics and sanctions based on such measures—to increased service efficiencies and passenger satisfaction in taxi paratransit services (O’Connell 2005). Accountability at the company level also extends to ride-hailing, when regulations are imposed. For example, the California Public Utilities Commission, which regulates ride-hail vehicles for the state of California, requires ride-hail companies to carry insurance; companies operating without sufficient insurance will have their operating authority suspended or revoked (California Public Utilities Commission 2019).

Cities typically stipulate measures of taxi company accountability, including outlining permissible driver behaviors and outlets for passenger complaints. Recourse for taxi customer complaints, like in many industries, remains murky from a user perspective. Among Access (taxi paratransit) patrons in Los Angeles, only 55% of those who had filed a complaint report being satisfied with the response they received (Sam Schwartz Engineering 2019). Ride-hail companies offer more immediate feedback for customer complaints. For example, ride-hail companies require a driver to maintain a minimum rating or may deactivate the driver account. Company policy also ensures that riders who have a bad experience with a driver (and give a low ride rating) will be refunded their fare and not be matched to that driver again in the future (Uber 2018; Lyft 2018).

Despite abundant regulatory and supply-side differences between taxis and ride-hailing, it remains unclear how service directly compares between ride-hailing and taxis. We therefore ask: how do service qualities—including trip price, reliability, and accountability—vary between ride-hail services (Uber and Lyft) and taxis? We ask this question in the context of Los Angeles, the second largest city in the United States and an early market for ride-hailing.

**Data and methods**

We relied on two data sources from Los Angeles. First, we conducted an audit study and collected data on 1680 UberX, Lyft, and taxi trips; we do not consider wheelchair-accessible vehicles or pooled (UberPool, Lyft Shared) trips in this study due to project scope and budget constraints. Audit studies are field experiments designed specifically to identify differences between otherwise identical situations; in this case, we tested the quantitative differences in taxi and ride-hail cancellation rates, wait times, and prices, by instructing
hired riders ("auditors") to hail Uber, Lyft, and taxi trips between two pre-determined locations. The limited study geography effectively controls for the potential effects of the built environment on service, which is important given that previous research finds differences in both ride-hail and taxi service across space (Hughes and MacKenzie 2016; Austin and Zegras 2012). Site 1 was located in downtown Culver City, an independent city encompassed by City of Los Angeles; Site 2 was two-miles away at the intersection of two Los Angeles neighborhoods, Baldwin Hills/Crenshaw and West Adams. Both sites are centrally located in dense, rail-adjacent neighborhoods just eight and six miles west of downtown Los Angeles, respectively. Service quality were broadly similar at the two sites with no statistically significant differences in either cancellation rates or wait times, controlling for taxi company. Given the overall similarities in service between the two sites, we do not differentiate between trips taken from Site 1 versus Site 2 in our findings discussion.

We selected the two largest taxi companies serving each site (Culver City Finance Department 2017) (See Footnote 1); at Site 1, riders rode Independent Taxi Company and United Independent Taxi. At Site 2, riders utilized LA Yellow Cab and United Independent Taxi. We discuss both taxis and ride-hailing as a single mode rather than differentiating between companies as services did not vary substantially across companies. Riders summoned taxis by phone dispatch rather than by app (which were available for each of the taxi companies) for two reasons: first, phone-hailing remains the dominant dispatch method; as of April 2017, just 9% of monthly taxi trips (7400 of approximately 82,600 taxi trips) were dispatched by app in the City of Los Angeles (Los Angeles Department of Transportation 2017b) (See Footnote 1). Second, we tested three taxi apps (Curb, RideYellow and the United Taxi app) and found each presented challenges that made them unusable; we discuss the technological challenges experienced in taxi e-dispatch in our findings.

Auditors, recruited from the UCLA undergraduate and graduate student population through job-boards and email advertisements, hailed taxi, UberX, and Lyft trips between the two sites and collected data 7 days a week from 9:00 am to 9:00 pm between October and December 2017. Drivers on all modes were tipped approximately 20%, although we exclude tips from the prices reported in this study. All riders were reimbursed trip costs by the research staff. In total, 18 riders hailed 1271 ride-hail and 409 taxi trips. On each trip, auditors recorded wait times, ride request cancellations, and trip prices. Riders also had the option of recording open-ended trip comments. Recorded wait times reflect the time elapsed between hailing a ride-hail trip or calling a taxi dispatcher and when the vehicle arrived; we do not directly examine estimated versus actual wait times for either taxis or ride-hail trips. Upon completion of one ride, riders hailed a return trip, rotating through the three different modes. For example, a rider who completed a Lyft trip would hail a taxi or Uber for the return journey. Appendix A includes further outlines data collection methodology, including data collection instruments. All point estimates are reported alongside a 95% confidence interval (CI). Data collection methods are nearly identical for taxi and ride-hail trips, with the exception of slight wait time measurement differences necessitated by phone versus app hail (see Appendix A). Taxi wait time is measured as the time elapsed between dialing a company dispatcher and when a taxi arrived. Ride-hail wait time is the time between when the rider hits “request” to when a ride-hail vehicle arrives. The wait time measurement for ride-hailing therefore does not include the time required to open the app or enter the origin and destination in the app, while taxi wait time includes the time required to state trip origin and destination to the dispatcher. The measurement difference may therefore slightly underestimate ride-hail wait times, although the minimal time required to open the app and enter an origin and destination is unlikely to substantively affect overall empirical differences between services.
We note that taxi wait time and cancellation rates observed in this study are likely low estimates; due to the limited number of taxi drivers, drivers often drove more than one rider over the course of the study. Repeat drivers occasionally remarked on the high volume of trips dispatched to and from the field sites. Remarked one rider: the driver said he was going to “park…to wait for us since he has done a lot of this trip recently.” These comments occurred despite precautions taken to discourage such behavior—including rotating taxi and ride-hail services, allowing no more than three riders to collect data in the field at a given time, and ceasing to hail a taxi company for the remainder of the day if a driver voiced suspicions—and may have altered taxi driver behaviors, including depressing wait times and cancellation rates. The research team elected to maintain the same data collection sites throughout the course of the study in order to produce a robust sample size across which to analyze service differences by mode.

In addition to quantitative differences between taxi and ride-hail services, we conducted semi-structured follow-up interviews with 14 of the 18 auditors who participated in the study to offer insight into reasons underlying quantitative differences observed across modes and highlight how such differences translate into lived experiences. The interviewed individuals were uniquely positioned to provide comparative perceptions of the services as each interviewee hailed between 47 and 247 taxi and ride-hail trips between October and December 2016; together the 14 interviewed auditors completed 1321 (79%) of all trips made in the audit study, providing rich experiences over which to compare service qualities across modes. Interviewees include a mix of men and women and riders who identified as Asian, black, Hispanic, and white. All were young adults between the ages of 20 and 30. Interviews adhered to themes shown in the literature to be important in transportation such as reliability and price (Yoh et al. 2011) and were used to better understand quantitative differences observed between services. Interviews were structured to introduce topics using open-ended questions that allowed riders to express their opinions without projecting interviewer viewpoints into the conversation; Appendix B includes detail on the interview methodology including questions that guided the semi-structured interviews. Due to small sample size and non-representative sample of the population, we do not draw implications for the broader public; however, the interviews highlight potential explanations for quantitative differences and reveal service elements worthy of further research. We structure our discussion around three themes discussed in both the literature and revealed by quantitative analysis and rider interviews: price, reliability, and accountability.

**Results**

Stark differences emerged between ride-hail and taxi services. In the following sections, we discuss how price, reliability, and accountability varied across taxi and ride-hail services.

**Price**

Table 1 and Fig. 1 show that, on average, ride-hail trips were 40% cheaper compared to taxis, and had both lower fare minimum and maximums. Differences between ride-hail and taxis are statistically significant (p < 0.01), which holds with previous research that finds lower prices for ride-hail than taxi services (Smart et al. 2015). Interestingly, taxi fares varied more than ride-hail trips, despite advertising flat-rate fares compared to Uber and Lyft’s variable fare structure subject to surcharges. While taxis do charge a prescribed base fare
plus per-mile and per-minute fare (Los Angeles’ rates are below the average of the nine most densely populated cities in the country with a $2.85 base fare, $2.70 per mile charge, and $29.19 per hour wait rate (Sam Schwartz Engineering 2019)), idling in congestion and varying route lengths resulted in fares ranging from $8.25 to $22.45 for the identical origin–destination pair.

For riders, the differences between taxi and ride-hail prices were unquestionable. Many riders said that taxis were “for sure the most expensive” and others stating, “I would never take taxi on my own ‘cause it’s just so expensive” and that taxis were frequently “double the price” of ride-hail services. In their discussions of trip price, many riders cited circuitous routes that drove up fares; we discuss navigation accountability later in our findings. Riders reported satisfaction with ride-hail pricing—regardless of what the price actually was—in part because the fares were shown up-front before making the decision to hail a trip, creating a sense of predictability. Quantitative differences and rider experiences reported in this research do not reflect extreme fare peaking that is sometimes reported for ride-hailing, such as on holidays events or when bars close at 2:00am. Such events may introduce uncertainty in the fares riders can expect to be quoted up-front. However, for the

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Prices exclude tips
same origins, destinations, and times of day not subject to extreme fare peaking, findings suggest that overall ride-hailing provides more transparent and consistent fares compared to taxis.

**Payment process**

Riders used credit cards on both taxis and ride-hailing, but noted divergent payment experiences on the two modes despite identical payment methods. Interviewed riders universally preferred the ride-hail payment process—which stores one’s credit card information and automatically bills the card once the ride is completed—and stated that ride-hail payment was “simple,” streamlined, and far quicker compared to paying for taxis, which require riders to swipe their credit card at the end of the trip and wait for the payment to be processed before alighting.

Riders paid for taxis at the end of a trip using an in-car credit card machine. Riders repeatedly described this process as a “hassle” and time-consuming, citing slow machines, machines out of receipt paper, and broken machines. Multiple riders described taxi drivers being “upset with me” and “very rude” when they did not pay with cash, despite being legally required to accept credit cards (City of Los Angeles 2018). Possible reasons for taxi drivers’ preference for cash fares include credit card fees incurred, a preference to have money on hand to pay operational expenses like gas and the taxi lease, and not having to wait for the taxi company to process the payment before taking home earnings (Cab 2014).

Taxi payment experiences likewise unearthed unethical and illegal driver behaviors prohibited under the Los Angeles Taxi Riders’ Bill of Rights and city regulations (City of Los Angeles 2018). For example, two riders were denied taxi service altogether because the driver refused to drive without an up-front cash payment. Refusing to accept credit card payment is a direct violation of the Taxi Riders’ Bill of Rights (City of Los Angeles 2018). Drivers also exhibited a range of responses to broken credit card machines. Once, the driver did not require the rider to pay the fare. A number of times, drivers insisted on taking riders to an ATM, where the rider withdrew money and incurred additional fees to access the ATM. In another case, a driver took a rider to the gas station and “filled up his gas and had me pay for the exact amount [of the fare]. He stopped it [the gas] at the same amount.” Such behavior again violates codes of conduct for taxi drivers; while relatively rare events, payment issues were also not isolated events. Additional research would be needed to determine how pervasive payment violations are.

**Reliability**

**Cancellations**

Hailing a ride-hail trip was a near-guarantee of being picked up (99.7%). By contrast, hailing a taxi was not. About one in five taxi riders (19.5%) were not picked up. Reasons for not being picked up by a taxi included: a taxi did not arrive within 1 h (62%), dispatchers reported that no taxis were available (17%), the taxi dispatcher did not pick up the phone (16%), or a taxi refused to provide a ride upon arrival (6%). While ride-hail drivers did occasionally cancel on riders (4% of trips), ride-hail apps assigned riders to a new driver 18 s later on average. As a result, 99.7% of ride-hail riders (all but 4 of 1220 trips) reached their destinations. In other words, while ride-hail services reliably picked up passengers, and virtually guaranteed they would reach their destination, the one in five chance of not
being picked up by a taxi undermined taxi service reliability. Emphasizing this uncertainty, one rider described the experience waiting for a taxi: “they [the taxi] would show up. Or they wouldn’t even show up at all.”

**Wait times**

More varied wait times produce uncertainty and reduce reliability. For example, if a traveler needs to get to a job interview by 10:00 am, and they can expect their ride to arrive anywhere from 2 min to 1 h (if at all), when should she hail a ride? Ride-hailing provided consistently lower and more reliable wait times compared to taxis. On average, ride-hail riders waited 5.7 [5.5 to 5.9, 95% CI] minutes between hail and pickup. Taxi riders waited four times longer (24.3 [22.5 to 26.2, 95% CI] minutes) on average, while more than one in ten (11%, n = 44) riders did not get picked up after waiting 1 h. As previously discussed, taxi wait time estimates are likely low estimates as some drivers voiced suspicion about the relatively high number of rides to and from Sites 1 and 2. Even these low estimates, however, are worse than official reports. The Los Angeles Department of Transportation (LADOT) (2017b) reported 13 min average wait times in 2015 and fewer than 1% of wait times greater than 60 min. Figure 2 shows how the distribution of total taxi wait times at Site 2 (Los Angeles) contrasts to ride-hail wait times and wait times reported by LADOT from the same taxi service zone. While about 99% of ride-hail trips arrived within 15 min, 57% of taxi trips did, far below the 73% reported by LADOT (2017b). One possible explanation for these discrepancies is that LADOT excludes passenger “no show” trips from
its wait times calculations; “no show” trips do not state the reason for the passenger “no show”, but could occur if passengers seek other taxi companies or modes after waiting 60-plus minutes for an originally-dispatched cab (See Footnote 1).

Figure 3 shows a more granular distribution of arrival wait times (the time between when a rider hailed a ride and the vehicle arrived) for both ride-hail and taxis. While over 90% of ride-hail trips arrived within 10 min, taxi arrival times spanned the entire hour, undermining reliability or a rider’s ability to predict when she will reach her destination.

Interviews highlighted the poor reliability of taxis. In addition to waiting a long time for taxis to arrive, riders often waited at length to talk to taxi dispatchers. Said one rider “Sometimes I was on hold for more than 30 min and other times they would just hang up on me.” What’s more, actual taxi wait times almost never aligned with dispatcher-predicted wait times. Thirteen of 14 interviewed riders explicitly stated that the taxi dispatch service was either slow, nonfunctional, and/or simply aggravating. In some cases, riders blamed the dispatch service, rather than the drivers, for long wait times. Said one rider: “A lot of times the taxis, when they would come, they would tell me like, they had just received a call, even though it was 40 min of me waiting. It wasn’t them necessarily who took a long time. It might have been the dispatch finding them, or contacting them.” Multiple riders noted that dispatchers nearly always quoted wait times of between 5 and 15 min, regardless of the actual wait time. In the words of one rider: “the wait time is never accurate. It’s never five or 15 min, sometimes it’s an hour. Sometimes it doesn’t even show up.” Like taxis, estimated ride-hail wait times may not be accurate, although other research finds the differences between estimated and actual ride-hail wait times less glaring compared to the taxi wait times observed here. For example, Ge et al. (2016) find that, in Seattle, ride-hail wait time estimates are about 1 min shorter on average than actual wait times.

In addition to taxi dispatchers reporting unreliable (and typically inaccurate) wait time estimates, riders reported that they rarely received updated arrival times from dispatchers, even if actual wait times were double or triple of those predicted. Said one rider “they don’t call you to let you know, so you have to call them back.” When dispatchers did call riders back, it was typically to alert a rider that no taxis were available and to cancel the request.

Figure 3 Arrival time reliability across services. The figure shows the distribution of ride-hail versus taxi wait times. Ride-hail wait times are left-skewed, with half of trip wait times under 5 min and an additional 42% between 5 and 10 min wait times. Taxis, by contrast, had much less reliable wait times, with about 35% of trips under 10-min wait times and remaining wait times distributed between 10 and 60 min.
Frustrations over long and unreliable wait times are hardly unique to Los Angeles. Nearly one in five taxi riders in San Francisco reported poor reliability (San Francisco Municipal Transportation Agency 2013). Passenger comments about uncertain taxi wait times underscore the important role that dispatching may play in the taxi passengers experience. Delays may also arise from overall shortages of drivers; additional research is needed to understand mechanisms behind taxi delay, whether it is on the dispatch or driver end. Interestingly, although taxi companies ostensibly compete against one another, dispatchers in this study often referred riders to other taxi companies when none of their own cabs were available.

Technology

Similar to how real-time arrival information reduces transit rider stress and uncertainty (Dziekan and Kottenhoff 2007), riders reported a strong preference for app-based dispatch that updated a drivers’ location in real-time, providing assurances of exactly when and where a driver would arrive. While taxi companies have introduced a variety of apps, their efforts largely fail to increase riders’ sense of reliability or streamline—or indeed enable at all—the dispatch process.

We tested a number of taxi apps at the outset of this project, but deemed each to be unusable. The first app we tested was the Curb app, which is advertised as the “#1 taxi app in the U.S. that connects you to fast, convenient and safe rides in 65 cities” and connects riders to the nearest taxi, regardless of taxi company (Curb 2017). The Curb app mirrors the interface of Uber or Lyft and partners with some of Los Angeles’ largest taxi companies to provide an app (rather than phone-based) dispatch service. Our efforts to use this app, however, met with failure. Over the course of 3 days, five riders made 32 attempts to hail a taxi with Curb. On each of these 32 attempts, the app timed out after 5 min and riders were informed that no taxis were available. This may reflect a supply-side shortage of taxis or other dispatch challenges.

In addition to multi-company apps, most taxi companies have launched their own apps. For example, LA Yellow Cab (the largest taxi dispatcher in Los Angeles) uses both the Curb app and operates its own app, RideYellow. RideYellow was deemed unusable as, during trial rides, the app (1) double-charged a rider, (2) continually crashed, and (3) directed a driver to an origin/drop-off approximately a half-mile from both the rider’s actual origin and destination (which were correctly entered into the app). Riders testing other taxi company apps noted that apps appeared “made for the older generations of phones…because the writings a lot bigger than it should be,” were frequently a mobile version of the website booking rather than offering a ride-hail-like interface, or failed to load. In other words, while considerable range in both app design and functionality exists, taxi apps currently fall far short of the user experience and sense of reliability delivered by ride-hail apps.

Accountability

Riders reported that driver and company accountability—ensuring that companies and drivers were responsive to passenger complaints or service issues—sharply contrasted between ride-hail and taxi services. Riders reported that the ride-hail rating system—which allows riders to provide instant in-app feedback—created an “open and transparent” service and positive interactions with drivers. By contrast, riders expressed that taxis had almost zero accountability for the service they provided. Riders stated that they did not
“feel like there’s a real [accountability] mechanism that’s accessible.” One rider who did attempt to complain to a taxi company, found an unresponsive audience. Said the rider: “I had to call the company, and they would tell me, oh, the person in charge of filing a complaint isn’t here.” Ride-hail driver rating systems may help to account for differing service accountability between ride-hail and taxi services. We discuss in the following sections two ways in which feedback may influence driver accountability.

Financial and physical safety net

Riders reported that the ride-hail star-rating system produced both a financial and physical safety net, particularly compared to taxis. Financially, ride-hail users who were not picked up were refunded the trip fare within minutes; this practice served as a financial safety net for riders by ensuring that payments—which are automatically processed using stored payment information after a driver reports a trip as completed—were not processed for services that riders did not receive. Rapid refunds for failed hails contributed to riders’ sense that companies were accountable and responsive to customer complaints. While such a financial safety net is necessary in ride-hailing—where companies automatically charge one’s credit card—dispatched taxis cannot charge one’s card unless one is actually picked up and a fare reimbursement system is therefore unnecessary. On occasion, however, taxi driver behaviors greatly increased the anticipated fares, with no perceived recourse for the riders. We discuss this further in the following “Driver Behavior” section below.

Riders reported that, in addition to providing a financial safety net, ride-hail star ratings and feedback system heightened their sense of physical safety compared to taxis. Riders reported feeling safer because they could read previous rider ratings and because companies removed the worst-rated drivers from the platform.

While riders reported that driver accountability and feedback enhanced their sense of safety on ride-hailing, overall feelings about safety on ride-hailing versus taxi were more mixed. Riders evaluated safety from both their experiences waiting for a car and time spent in the car. In general, riders’ perceptions of safety diverged based on rider gender. Female riders more frequently reported safety as a greater concern compared to male riders, which is consistent with previous studies of gender-related safety concerns in transportation (Yavuz and Welch 2010). Female riders in particular noted that long wait times for taxis undermined feelings of safety as waiting increased their exposure to street harassment. Riders reported uncertain taxi arrival times as contributing to their anxiety and concerns about safety. The importance of reliability and uncertain arrival time conforms to previous research that finds that real-time travel information reduces stress among travelers (Dziekan and Kottenhoff 2007).

Driver behavior

As previously alluded to, taxi driver behaviors may undermine price reliability, resulting in higher fares than anticipated. Interviews with riders, and confirmation with quantitative data, reveal an underlying explanation for these price differences: trip distances. With numerous possible routes between the two field sites, trip distances varied. The median trip distance across all services was 2.3 miles and the minimum distance was 1.28 miles. Figure 4 shows the distribution of trip distances across ride-hail and taxi trips. Eleven percent of taxi trips were more than four miles long (compared to less than 1% of ride-hail trips), driving up both the total meter charge and associated tip. Taxi trips longer than four miles were $5 (46%) more
expensive (excluding tip) on average than those shorter than four miles, controlling for time of day. Long trips were not isolated to a single driver making repeated long trips; about 10% of taxi drivers made at least one long ride. Long-route selection contributed to trip duration and increased arrival time uncertainty. While the evening peak period has the strongest association with trip duration (trips taken during the evening peak took about 5.5 min longer), each mile traveled also added about 2.7 min to a trip. In practice, this means that while the median trip (2.3 miles) took 10 min to complete, the 11% of taxi trips longer than four miles took about 15 min (50% longer), controlling for peak hour. Longer routes, in other words, extend arrival time uncertainty past arrival wait time to in-vehicle time.

Different trip lengths were reflected in divergent navigation strategies between ride-hail and taxi drivers. Interviewed riders reported that ride-hail drivers invariably used app-based navigational tools, while taxi drivers typically relied on mental maps, despite global positioning system (GPS) installed in each cab. Familiar with the route, riders quickly spotted long taxi routes, commenting that “Some of them would literally drive you in circles,” it “seemed like he went an unnecessarily long route” and “I had to give directions after an extremely circuitous route.” Unlike Ge et al. (2016), who observed that drivers took female riders on longer routes, we observed no difference in trip length by rider characteristics. While some riders felt that taxis drove the same routes as ride-hail drivers and that their reliance on mental maps gave taxis a “cool” old-school atmosphere, others felt cheated and that a lack of navigation device undermined driver accountability. For example, one rider stated: “Uber and Lyfts are very open and transparent to which route they’re taking, how they’re going. If they go a super long route you could easily complain to Uber and Lyft on the app.”

**Discussion**

The numbers discussed in this paper are specific to Los Angeles, and modal comparisons of price, reliability, and accountability will certainly vary by market and location. Research from other cities, however, suggests that the service issues examined in this research are not isolated to Los Angeles. Researchers find, for example, 53% longer taxi wait times in
Seattle compared to Uber and Lyft (Ge et al. 2016), and agency reports from other cities have documented taxi unreliability (San Francisco Municipal Transportation Agency 2013; Nelson Nygaard 2013). Findings from this research demonstrate that although the technology has changed, the basic tenets of transportation planning remain central in helping to explain the success of innovative mobilities over legacy modes. Just as for transit and car travel (Bhat and Sardesai 2006; Yoh et al. 2011), price, service reliability, and accountability are paramount in traveler decisions and satisfaction (Albert and Mahalel 2006; Taylor and Fink 2003). Ride-hailing successfully uses new technologies to deliver on each of these service elements where traditional taxi services fall short. We discuss each transformation and the implications for innovative mobility and taxi policy. We note that the discussed implications and policy recommendations will vary greatly based on local and regulatory context. Some taxi recommendations, in particular, may be challenging to enforce in some markets given existing labor laws and business practices governing independent contractors.

**Price**

Lower ride-hail fares compared to taxis are a function of divergent industry financial models, regulation, and technology. Critics argue that current ride-hail business models artificially lower fares through venture capital subsidies and by imposing operating costs like car repair and maintenance on drivers, who operate as independent contractors (Ongweso 2019). This study is limited to the price paid by riders and does not compare driver compensation across services; journalists and researchers disagree whether ride-hail or taxi drivers take home more pay (McCarthy 2016; Hall and Krueger 2018; Ridester 2019), and future research is needed to fully examine compensation-related labor issues. In addition, and unlike taxis, which are subject to minimum fares and set per-minute and per-mile fares, ride-hail companies are free to change prices based on supply, demand, or competition. While some cities have attempted to level the playing field by deregulating taxi fares (Nelson 2015), the economics of the taxi industry, in which drivers typically rent their taxi for a daily flat fee, may inhibit taxis from lowering fares enough to compete with ride-hailing at its current prices. In lieu of, or in addition to, regulatory changes, taxi companies could take two technology-related steps to lower fares. First, taxi companies could reduce prices by requiring drivers to use GPS to find the shortest and least-trafficked route. Efficient routing would eliminate the meter abuse (overly-long routes) observed in this study, lower fares, and reduce trip durations, enabling drivers to complete more trips in the same period of time. In addition, lower fares may attract new riders, particularly low-income riders who disproportionately rely on taxis for travel (Schaller 2015; NHTS 2017). Second, a broader adoption of app-based dispatching could reduce the labor costs associated with phone dispatch and potentially facilitate quicker driver-passenger matching. Finally, technology can help to make pricing more transparent and boost reliability and accountability, which we discuss next.

**Reliability**

An unrestricted supply of ride-hail drivers ensures that service is always close by and nearly on-demand, compared to dispatched taxis which often face market entrance restrictions and suffer from chronic undersupply (Schaller 2007). Other innovative modes have already taken the ride-hailing point-to-point on-demand mobility strategy to heart.
Transportation

Electronic scooters and dockless shared bikes are inundating city streets with new vehicles to ensure vehicles are always close by (see for example Lien (2018) and Schmitt (2018)). Fleet management may also influence service reliability by ensuring balanced supply, demand, and response times. Across the transportation industry, companies are embracing a dynamic supply and demand model to ensure consistently low wait times and constant service availability. Strategies to achieve these goals vary. When supply outstrips demand, ride-hailing companies raise prices to deter some riders from hailing and to encourage more driver to work. Alternatively, the e-scooter company Bird uses a dynamic cap to balance supply and demand; the company adds new vehicles to the network as daily scooter usage increases (Bird 2018). Regardless of the strategy, however, companies use technology to balance supply and demand and to provide reliably available and nearby service.

By contrast to innovative mobilities, taxi regulations inhibit companies’ ability to respond dynamically to changing market conditions. Schaller (2016) calls for the elimination of dispatched taxi limits. Without eliminating or greatly raising the caps on the number of taxis permitted to work in a city, taxis will not be able to greatly reduce wait times, nor adapt to future market changes. Regulatory reform to increase the number of taxis is not the only way to increase taxi reliability. Taxis must take other steps to increase reliability and ensure both that a taxi arrives and that wait times are more predictable. Solutions to both of these may come in the form of a user-friendly app. Ideally, the app would follow the Curb model and connect riders to the nearest driver, regardless of cab company. A single hailing platform would add efficiency and formalize the currently ad-hoc referral system observed in this research, in which taxis companies referred riders to other companies when they had no cabs available. Improved taxi apps should include a real-time arrival or location information to reduce actual or perceived wait times (Dziekan and Kottenhoff 2007; Watkins et al. 2011) and help to allay safety concerns voiced particularly among female riders faced with uncertain (and often lengthy) wait times. By recognizing that safety concerns occur not only in a vehicle, but also on the journey to or wait time for a vehicle, taxi companies and innovative modes can take steps to address safety concerns at all points of a trip.

Accountability

Riders reported that both ride-hail drivers and companies were responsive to customer needs and complaints, but that taxis lacked accountability. Findings from this study reveal that, regardless of the technology, accountability is a critical service element that can be aided by new technologies.

Both future modes and taxis can improve accountability by providing transparent mechanisms for direct user feedback. Feedback serves two important roles. First, customer feedback can help companies address current service shortcomings—feedback could, for example, alert taxi companies of malfunctioning credit card machines—and identify new opportunities for future innovation or improvement. Research finds that customer feedback can make companies more efficient, which can lower prices, and increase customer satisfaction (Van Doorn et al. 2010). Second, responsive feedback systems bolster user perceptions of service. Researchers find that customer feedback is an overlooked factor linking service quality and customer satisfaction (Voss et al. 2004) and that refunds for delayed transportation, encouraging traveler complaints, and personalized complaint responses are associated with high levels of customer satisfaction (Disney 1999). Overall, ride-hailing’s customer-oriented system responsive to customer feedback and complaints suggests
that both new and old modes should foster open and responsive communication between companies and travelers to improve customer satisfaction, service efficiency, and service quality.

**Conclusion**

Ride-hail services have harnessed technology to achieve what researchers have long known is important to travelers: price, service reliability, and accountability. Findings from an audit study in Los Angeles suggest that app-based hailing has transformed for-hire vehicle services across quantifiable differences between ride-hail and taxi services. While ride-hailing virtually guaranteed a ride, one in five taxi riders was never picked up. Taxis were also 40% more expensive and had greater price variation than ride-hail trips, which can be partially attributed to ride-hail venture capital subsidies and overly-long taxi routing. Additionally, taxi riders waited four times longer on average compared to ride-hail services (5.7 vs. 24.3 min). Qualitative observations reveal nuance and the lived experiences underlying these quantitative differences.

Given the complexity and diversity of ride-hail and taxi regulations and practices across cities and states, cities should consider their specific context to implement locally-tailored policies most effective at ensuring quality service across for-hire vehicles. Generally, findings from this study suggest that regulatory changes, such as eliminating dispatch taxi caps and removing price floors may help improve taxis’ competitive edge and ability to respond more dynamically to future market forces. Regulatory changes, however, may not be enough to keep taxi companies—many of which continue to experience falling ridership numbers—afloat. Other business practice changes to improve taxi services, such as providing robust app-based hail services, more responsive customer service, or better fleet management strategies, may also be needed. Ride-hailing, too, presents a challenge for cities as its ongoing labor debates (e.g. Scheiber (2019)), questions of profitability, and long-term business sustainability (e.g. Sisson (2019), Sam Schwartz Engineering (2019)) could reshape the level of service it offers—or the price it provides that service at—in the future. While practices already vary widely across cities and companies, findings suggest that—whether in approaching service quality from the regulatory and non-regulatory side—taxis, ride-hailing, and future modes should adhere to the basic tenets of transportation planning and use new technologies to deliver on long-standing goals of transportation: affordable, reliable, and accountable service.

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**Compliance with ethical standards**

**Conflict of interest** On behalf of all authors, the corresponding author states that there is no conflict of interest.
Appendix 1: Data collection methodology and instrument

Data collection for each ride-hail trip included the ten steps shown below:

1. Open app and enter origin & destination
2. Navigate to stopwatch, press “Start”
3. Return to app and hit hail/request
4. When driver assigned to you, take screenshot 1
5. Return to timer and press “Lap”
6. As soon as car pulls up to you (right before you open the door), hit “Lap” once more
7. Observe driver characteristics
8. At end of trip, exit car; when door is closed, hit “Stop”
9. Take screenshot 2 of your timer screen
10. Fill out post trip survey

The data collection methods were broadly similar for taxi trips. The ten data collection steps taken for each taxi trip are shown below:
Following each trip, research assistants input data into the following data collection instrument. The data collection instrument branched as dictated by trip characteristics such as if a trip was cancelled or not.
Transportation

Date *

Origin (Starting location) *

- Culver City
- Expo/La Brea

Mode *

- Lyft
- Uber
- Taxi

Cancelled Trip

Was this trip cancelled? *

- Yes
- No

(A) Trip Details

(A) What was the trip cost? *

Please record both dollar and cents. Example: $11.02 or $6.94.

Your answer

(A) Trip Screenshots *

Please upload your screenshots: (1) Timer screenshot, (2) Trip screenshot (Uber/Lyft) OR receipt screenshot (Taxi)

ADD FILE

(A) Driver Characteristics

Using the text box below, please identify your driver across the following characteristics.

Please include any additional detail about a driver, or want to clarify answers related to gender and/or race/ethnicity (such as specifying multiple races), in the last optional question (Driver - additional info).

(A) Driver name *

Your answer

(A) Driver Gender *

- Male
- Female

(A) Driver Race/Ethnicity *

- Black
- Hispanic
- Middle Eastern
- East Asian
- South Asian
- White
- Other

(A) Driver Approximate Age *

- 18-30
- 31-40
- 41-50
- 51-60
- 61-70
- 70+

(A) Driver - additional info (optional)

Is there anything else you want to include about the driver?

Your answer

Additional Comments

Add any comments here if necessary

Your answer

BACK SUBMIT
Appendix 2: Interview guides

Each interviewee was invited to participate in a follow-up interview after the completion of a 3-month fieldwork project in which each individual completed between 47 and 247 Uber, Lyft, and taxi trips. Each participant was interviewed separately. Interviews lasted for about 30 min and participants were compensated with a $25 gift card upon completion. Interviews focused on questions about experiences riding and perceptions of each Lyft, Uber, and taxis. Because we were interested in understanding what issues were important to riders, the questions were purposefully designed as open-ended and general to allow interviewees ample leeway to explore topics that they felt strongly about.

Interview guide

The below questions provided guidance in the semi-structured interviews conducted for this research.

1. Did you have any expectations of taxi service prior to your first ride?
2. How did/didn’t taxis conform to your expectations (i.e., what happened that you expected and what happened that surprised you?)
3. Pre-trip, what were your perceptions of:
   a. Dispatcher interaction
   b. Ease of finding driver at site/driver pickup
   c. Reliability
4. On the ride (in the vehicle), what were your perceptions of:
   a. Safety
   b. Cleanliness/quality of the vehicles
   c. Driver attitude/interactions
   d. Route
5. After the trip ended, what were your perceptions of:
   a. Payment process
   b. Trip cost
6. Of the discussed topics, what element(s) of ride-hail service is/are most important to you and why?
7. Did your experience riding taxis change your perceptions of taxis & if so, how?
8. How do you anticipate using taxis/Uber/Lyft in the future?

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