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Market structure, competitive dynamics and regulatory implications

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AUTONOMOUS TAXI OPERATIONS: MARKET STRUCTURE, COMPETITIVE DYNAMICS AND REGULATORY IMPLICATIONS

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ABSTRACT

Autonomous taxis hold disruptive potential for urban transportation systems. Researchers and transportation planners seek to anticipate their impact with simulation studies. One frequent assumption is a monopolistic dispatcher.

Seeking to verify this assumption, we conduct a prospective, qualitative analysis of the market structure grounded in microeconomics and industrial organization. We find that significant economies of scale might propel international consolidation to few autonomous taxi operators with significant market power, bringing new competition to previously local urban transportation markets. While acknowledging the efficiency of a monopoly or oligopoly of few, it naturally causes regulatory concerns. We discuss discriminatory pricing, geographic service restrictions and safety precautions of autonomous taxi operators and propose regulatory remedies.

Our findings are of interest to academia, as they confirm the likelihood of the original assumption, however question simultaneous pricing at or near marginal costs without suitable regulation. Transportation planners and regulating authorities might use them to plan the role of public transportation organizations in the provision of autonomous taxis, their integration into the existing public transportation system and to anticipate suitable regulation to avoid regulatory voids similar to those ride-sourcing companies have been operating in.

Keywords: Autonomous Taxis, Market Structure, Industrial Organization, Regulation, Policy
**INTRODUCTION**

Autonomous vehicles have recently gained a lot of attention with companies showcasing their pilots at international automobile conferences and testing vehicles on public roads. One expected application is autonomous taxis (AT) in geofenced urban areas in high-income countries (1, 2, 3). Though researchers agree that ATs hold disruptive potential for urban transportation systems, results of impact studies are ambiguous (4, 5).

Impact studies build on explicit and implicit assumptions. One often implicit assumption concerns the market structure of AT dispatchers. Most studies assume a centralized, i.e. monopolistic dispatcher (1, 6-12). Only one recent study (13) compares system performance for a monopoly/oligopoly in terms of travel time and vehicle miles travelled, finding that market structure significantly influences performance. This result seems obvious both from the perspective of operations researchers (global optima are ‘better’ than local optima) and industrial organization economists (market structure influences firm conduct which in turn influences both firm and market performance). Yet it poses the question whether the assumption of a monopolistic dispatcher (and the broader assumption of a monopolistic operator) is realistic to expect?

Only little research has been conducted on topics related to the specific economics of AT dispatchers and the broader economics of AT operators and none to our knowledge has targeted the market structure and its competitive dynamics comprehensively seeking to give answer to questions such as the above. Yet they seem important both to academia, to improve the validity of assumptions such as the above, and to practitioners, to plan the role of public transportation organizations in the provision of ATs and to prepare suitable regulation to avoid ‘regulatory voids’ (14) similar to those ride-sourcing companies have been operating in.

This paper seeks to advance our understanding of the prospective market structure of AT operators. We choose this broader scope as dispatching might only be one activity of a larger operator and thus the singular existence of dispatchers depends on the broader industry structure. We first derive attributes that define market structures from the theories of microeconomics and industrial organization. We then define AT operations and develop propositions on its prospective market structure building on the literature related to AT markets. We discuss regulatory implications and conclude with a discussion of our main findings and directions for future work.

**DEFINING AND DIFFERENTIATING MARKET STRUCTURES**

Microeconomic theory focuses on two stylized market structures, perfect competition and the monopoly, and firm behavior within. Acknowledging that these market structures are rare in the real-world, industrial organization examines ‘the field inbetween’, giving rise to concepts such as the oligopoly, monopolistic competition and product differentiation. One of its major lines of thought is the structure-conduct-performance (SCP) paradigm (15-18). Its main claim is that market structure influences firm conduct which in turn influences firm performance, and vice versa. While researchers have become cautious about the proposed causal relationships, especially inferring market power from market structure, the relationships per se remain unquestioned and the framework continues to be one of the fields’ major frameworks (19, 20).

Market structure is typically differentiated by five attributes: the number and size of sellers and buyers, the extent of vertical integration, the degree of product differentiation, the height of barriers to entry and exit (which are closely connected to the industry’s cost structure) and the degree of diversification (19-22). While the first three are natural to assume, the latter two require explanation.

First, the height of barriers to entry and exit will be explained due to their strong
relevance in the long-term stability of market structures. Entry barriers can be defined as “the advantage of established sellers in an industry over potential entrant sellers […] being reflected in the extent to which established players can persistently raise their prices above competitive level without attracting new firms to enter the industry” (17, p. 3). Examples of such barriers are economies of scale, absolute cost advantages and capital requirements (17). Exit barriers complement entry barriers. They also deter new firms from entering and are typically associated with sunk costs. Barriers to entry and exit as structural attributes of markets are thus necessary, however not sufficient to realize above normal profits. This ability of incumbent firms is generally referred to as market power. It follows that the presence of barriers to entry or exit stabilizes market structure. A market with few firms and significant barriers is called ‘not contestable’ (23).

Second, a higher degree of diversification of firms has been hypothesized to be associated with greater market power in general. Since the original works (15-18), this hypothesis has become subject of empirical and theoretical scrutiny. Some influential studies, however, have shown the opposite relationship (diversified firms have lower market power in each respective market) (24, 25).

Using these attributes, what constitutes a monopoly? One definition using three of the five elements is the following: a single entity selling a unique (without substitutes) product with substantial barriers hindering competition from entering the market (26). How do monopolies form and remain? We have already discussed the role of barriers in entry and exit. At least five additional alternatives exist: mergers and acquisitions, knowledge advantages, government action preventing entry into a market and thereby creating and maintaining a monopoly and strategic actions by incumbent firms (e.g., predatory pricing) (19). Finally, the market may only be large enough for one firm to operate efficiently (natural monopoly).

PROPOSITIONS ON THE PROSPECTIVE MARKET STRUCTURE OF AUTONOMOUS TAXI OPERATIONS

In this section, we define AT operations and present propositions on its prospective market structure. We survey the related literature and present our argument before formulating each proposition.

Autonomous taxi operations

We define autonomous taxi operations as the entirety of activities necessary to provide a service similar to today’s human-operated taxis with the exceptions that rides may be shared among several non-related parties and that vehicles are driverless, i.e. fulfil SAE J3016 level 4 (27). Figure 1 provides an overview of the operational activities involved. While several vehicle types are conceivable (e.g., Chrysler Pacifica Hybrid, Mitsubishi i-MiEVs, Daimler F 015 Luxury in Motion), they should be clearly differentiated from low-speed automated shuttles (e.g., EasyMile EZ10, Navya ARMA, VW Cedric) and multi-purpose platforms (e.g., Toyota e-Palette), which arguably fall into a different market segment closer to public transit and are not focus of this analysis.

Cost structure

Understanding the cost structure of an industry is central to analyzing the market structure as reasoned above. It is therefore surveyed first. Many preceding studies focus on the economics of centrally organized autonomous taxi operators (1, 6, 28-31). Cost structures reveal the authors assumptions on operators’ activities
and are often divided by ownership costs and operating costs:

- In a study of Ann Arbor, Michigan (6), ownership costs include vehicle purchase (depreciation), finance charges, registration, taxes and insurance costs. They sum up to 46% of total costs. Operating costs include fuel, maintenance, repair and overhead costs (wireless communication, information system, advertising costs). They account for the remaining 54%.
- Several different cost scenarios are presented in a study of shared taxi services in Austin, Texas (30). For comparability, we choose the gasoline-powered, mid-cost scenario. Ownership costs include insurance/registration and vehicle purchase costs, and accumulate to 45% of total costs. Operating costs include fuel, maintenance, general administration and attendance (e.g., for refueling), and account for the remaining 55%.
- Different cost scenarios are also presented in a study of Zurich, Switzerland (31), of which the ‘individual autonomous taxi without pooling’ seems most adequate to compare. Ownership costs in this study include depreciation, tax, insurance and interest, and account for 20% of total costs. Operating costs include cleaning, maintenance and wear, overhead and vehicle operations (e.g., management, HR, fleet-coordination, advertising), fuel, parking and tolls. They account for the remaining 80%. This high share of operating costs is explained by the inclusion of new elements into the analysis (e.g., cleaning, parking and tolls, which in sum account for 36.7% of total costs). Wage differences between Switzerland and the USA might explain further differences.

From these analyses we derive our understanding of the main operational activities of an AT operator (Figure 1). Some of these activities may be outsourced and other activities such as marketing, IT development, procurement, HR and finance are of great importance to the success of an AT operator, but disregarded here due to their lower importance in terms of market structure.

![FIGURE 1 Main operational activities of an AT operator](image)

**Economies of scale**

Intuition suggests that economies of scale can present significant barriers to entry particularly in capital-intensive, vertically disintegrated industries. Two reasons are cost advantages of large firms in capital provisioning and their bargaining power towards suppliers.

While automobile manufacturing is one obvious example of such an industry, the
operations of autonomous taxis might be another. First, vehicles have to be procured by the AT operator. As shown above, these “ownership costs” might sum up to 45% of total vehicle costs per mile in the USA. Buying/leasing large quantities is likely to entail a price advantage. Capital costs follow the same argument with large companies having an advantage over small ones. This argument holds in particular if a company can use its own vehicles instead of procuring them from a third party. Second, vehicles have to be insured, cleaned, maintained (including repairs) and customer operations have to be supported (e.g., through call centers). It has been argued that these operating costs could represent 40% of total vehicle costs per passenger mile in Switzerland (31). Similarly, larger procurement volumes lead to higher bargaining power which may result in lower prices. Third, we suggest that autonomous taxi services classify as two-sided markets (32, 33) with autonomous taxi app operators classifying as two-sided platforms (34), in which customers benefit from a high number of taxis resulting in high availability, and an operator benefits from a high number of customers resulting in high vehicle utilization. Fourth, autonomous vehicles’ driving capability and its backend predicting future demand are improved, amongst others, by the analysis of trip data. Here, again, companies with large fleets have advantages over companies with small fleets. Thus follows

Proposition 1: Autonomous taxi operations are likely to exhibit significant economies of scale, both in vehicle ownership and vehicle operations, yielding cost advantages of large firms over small ones.

Vertical integration

As reasoned above, operators of AT fleets might choose to procure several services such as cleaning, maintenance, repair, insurance, payment and customer operations. It is questionable how integrated two core customer-facing activities, dispatching and vehicle movement coordination, will be, and whether today’s ‘asset-light’ business models of ride-sourcing companies and app-based dispatchers are likely to persist.

Similar to today’s taxi and ride-sourcing apps, customer valuation will depend on vehicle availability within a short timeframe. A major difference is that (empty and occupied) vehicle movement will be coordinated by the fleet operator centrally. Thus, vehicle availability depends on effective relocation and dispatching based on real-time demand and supply information, stemming from vehicle operators (supply side) and dispatchers (demand side). One could think of four possible organizational configurations: (A) one or several integrated operators in charge of both relocation and dispatching, (B) a single fleet operator receiving demand information from several dispatchers, (C) a single dispatcher handing demand information to several operators who coordinate their fleets, and (D) multiple fleet operators and dispatchers (Figure 2).
FIGURE 2 Organizational configurations of dispatchers and operators

Configuration (B) seems unlikely as the operator could launch a customer interface himself to capture the entire market. Configurations (A), (C) and (D) seem probable considering today’s free-floating carsharing market, where several providers (e.g., Zipcar, Car2Go, DriveNow) coexist with several demand-aggregating apps (e.g., Free2Move, urbi). However, economies of scale will likely limit the absolute number of both dispatchers and operators, if not result in monopoly or oligopoly of few as in the carsharing market of some cities (e.g., the merger of Car2Go and DriveNow). The potential welfare-enhancing advantages of a single taxi dispatcher for an entire municipality have been frequently been raised (35-37). For autonomous taxis, the benefits (higher level of service at lower costs) are likely to be even larger due to system-optimal relocation of empty vehicles (1, 4). Thus follows

Proposition 2a: Autonomous taxi operations might be loosely vertically integrated with several services procured from third parties.

Proposition 2b: Two core activities of customer-facing autonomous taxi operations, dispatching and relocation, can be handled by separate companies. Effective vehicle relocation, however, depends on close integration of demand-side data (customer location) and supply-side data (vehicle location).

Proposition 2c: Economies of scale might drive consolidation both for dispatchers and operators, eventually resulting in an oligopoly or integrated monopoly for a specific service.

Proposition 2d: Assuming imperfect information, only a single entity integrating all supply and demand side data can perform system-optimal relocation of empty vehicles and thus minimize empty vehicle miles travelled.

Locality

Although not a typical attribute used to differentiate market structures, locality can be of importance to competitive dynamics influencing market structure. How local is a market for the various services described above and how local are competing firms?

Major segments of urban transportation have been served by local organizations such as municipality-owned urban transportation providers, bus operators or taxi firms. In developed cities, these organizations are nowadays often provided with monopoly power by law (for a discussion of the institutional evolution, we refer to the final chapter of this paper). Competitive
dynamics changed with the advent of ride-sourcing. Globally acting firms such as Uber entered local markets and started operating often in regulatory voids, presenting significant competition to taxi firms and public transportation providers. Several large international companies are actively developing and testing autonomous taxi solutions, such as information and communications technology providers (e.g., Waymo, Apple) and automobile manufacturers (e.g., Chrysler, Ford, Volvo, VW, Daimler) who often partner with ride-sourcing companies (e.g., Uber, Lyft). Although physical vehicles need to be stationed in a city, customer interaction is likely to be app-based, which enables scalable and digitized business models. Due to loose vertical integration, many services can be procured, be it internationally (e.g., insurance, customer operations, payment) or locally (e.g., cleaning, maintenance). Thus follows

*Proposition 3: Though autonomous taxi operations entail many local activities (such as cleaning or maintenance), competition for the provision of autonomous taxis is likely to be dominated by international firms exploiting economies of scale.*

Product differentiation

The degree of product differentiation is relevant not only to describe a market structure, but also to assess the market power of monopolists, which is intuitively larger where no substitutes exist. Several studies have analyzed future demand for autonomous taxis, often focusing on acceptance rates by different user groups, perceived benefits/concerns and resulting preferences considering established modes of transportation (38-46). Similar to today’s differences between taxi and limousine services, autonomous taxis might exhibit some product differentiation. Several studies suggest a wide range of user’s willingness to pay (38-41, 44). Willingness to pay depends not only on sociodemographics, but also on service attributes (28, 40). These may be influenced by ancillary vehicle equipment (e.g., food and drinks, level of seating comfort up to provision of a bed; screens with TV and Internet access) or service levels (e.g., travel time, waiting time, costs). Willingness to pay is also likely to depend upon whether a vehicle is shared or not (45). These thoughts are mirrored in current industry development for conventional vehicle-based taxis (e.g., Chrysler Pacifica Hybrid, Mitsubishi i-MiEVs, Daimler F 015 Luxury in Motion) and multi-purpose platforms (e.g., Toyota e-Palette). Thus follows

*Proposition 4: Autonomous taxis are likely to exhibit product differentiation by main purpose besides travel (e.g., working, sleeping), on-board equipment and service level.*

Considering the market for urban autonomous taxis, services are likely to be less differentiated as certain activities (e.g., sleeping) only appear relevant for longer travel distances. In line with our propositions, economies of scale might propel consolidation of (international) AT operators for core activities such as vehicle movement coordination and dispatching to an oligopoly of few or monopolistic competition. The market structure is likely to be relatively stable due to barriers of entry. Assuming imperfect information, only a single entity integrating all demand and supply information can achieve optimal vehicle relocation and servicing, but naturally causes regulatory concerns.

REGULATORY IMPLICATIONS

Microeconomic theory suggests that perfect competition maximizes welfare at the competitive equilibrium (19). As we have argued, conditions for perfect competition are unlikely to evolve in the market of AT operations mainly due to economies of scale. Under these conditions, a monopolist may be the most efficient service provider assuming that market power is not used
adversely. Which regulatory concerns might arise from this situation and what are potential remedies?

**Price and externalities**

A monopolistic AT operator could use its market power to set the price above marginal cost, apply surge pricing or even first-degree price discrimination (charging a different price for every ride provided to maximize profits by fully exploiting consumers’ willingness to pay), without attracting new entrants due to the barriers to entry. This is a classic example of economic decision-making targeting profit maximization (marginal cost pricing would not cover total costs), which leads to a suboptimal outcome in terms of welfare (‘deadweight monopoly loss’). The ability to price above marginal cost, however, does not only depend on the supply side. It also requires a low elasticity of demand with regard to price.

The conventional taxi industry gives a first indication for the range of elasticities for ATs. Research on demand elasticities varies widely between -0.23 and -1.75 (47). One explanation is that demand elasticities are likely to differ by consumer segment. For the Melbourne metropolitation area, the tourism segment is identified to react stronger to price changes (-1.04) than the business segment (-0.65) (47). For ATs, demand might be more elastic as we expect a higher number of customers to use ATs than conventional taxis due to lower prices. These customers are also likely to exhibit a higher elasticity with regard to price, as they have chosen different transportation modes before. Elasticity also depends on the availability of substitutes and switching costs. While the impact of ATs on other transportation modes is uncertain, public transportation may only persist in high density urban areas (31, 48, 49). Thus, where ATs substitute public transportation, alternatives might be limited and switching costs might be high, resulting in market power of the potential monopolist. Which societal costs do the different pricing strategies (first-degree price discrimination, surge pricing, pricing above marginal cost) incur and how to counteract them?

First-degree price discrimination raises obvious equity concerns, especially where low-frequency bus lines are replaced with ATs. Surge pricing has some benefits as it reduces demand during peak times and incentivizes ride-sharing at peak hours. A more efficient way to internalize the congestion externality resulting from all vehicles, however, would be congestion pricing, which several authors have suggested to reduce congestion resulting from empty vehicle relocation (50-52). Congestion pricing could funnel charges for incurred externalities to a redistributive authority instead of a profit-maximizing company. However, the problem of a monopolist charging above marginal cost remains.

Regulating for standard fares similar to taxicabs seems natural in theory, however is complicated in practice. First, information asymmetries regarding actual cost structures between the operator and the regulator complicate pricing at marginal cost (‘first-best pricing’) and even pricing that maximizes social welfare (‘second-best’ or Ramsey pricing). Second, experience with price regulation and deregulation in the taxicab industry, where the argument is even built on additional information asymmetries and transaction costs, has not produced uniform results suggesting that prices in regulated urban transportation markets might even be higher (53). Third, in the radio-dispatching taxicab segment, which is structurally closer to the AT market, price regulation seems to be less relevant due to lower information asymmetries and transaction costs (54-56). However, theoretical analysis has shown that even in the structurally closest ridesourcing industry, competition does not necessarily result in low prices or improved social welfare (57). Finally, regulation might be ‘captured’ (58, 59) and used to the advantage of the
parties regulated, e.g. serve as a medium for collusion (54). Traditional, human-driven taxicabs might also present a natural price ceiling.

Competitive tendering and contracting for AT operations, as practiced for the operations of many public transportation services, might present a viable solution (60, 61). Alternatively, it has been argued that for the ride-sourcing market under the assumption of homogeneity in value of travel time, regulating only the dispatching platform commission could guarantee second-best pricing (57). While heterogeneity in value of travel time is important to account for, this might be an interesting direction to pursue further research also for the AT market.

**Equity and accessibility**

Proving altered mobility options at lower price to people currently without (e.g., people with poor access to public transportation services, the elderly, poor, young and in general people without a driver’s license) is one way to reap the benefits of ATs (48). Considering higher utilization rates in dense city centers, one can ask whether AT operators in general (not only a monopoly operator) might restrict their service to these areas as car-sharing companies have done. A fundamental difference is that car-sharing operators face high relocation costs (manual labor), while the marginal cost for an AT to be parked in an area of low utilization is smaller. Indeed, evidence from ride-sourcing shows that Uber has grown most in areas underserved by public transportation and taxicabs (e.g., the outer boroughs of New York City) (62).

Whether utilization outside of city centers can be profitable and whether subsidies or universal service regulation are necessary to provide service guarantees, is yet another area for future research. It should be noted that today’s taxicab operators often face regulation forcing them to equip a certain number of vehicles with special equipment for disabled people. As human-driven taxis are expected to vanish due to their cost disadvantages compared to ATs, paratransit services might see increasing ridership.

**Safety**

Another general regulatory concern might be vehicle safety. First, autonomous vehicles have to be regarded ‘safe enough’. Second, companies competing on price might choose to save investment in vehicle safety, i.e. delayed repairs resulting in inferior mechanical properties of the vehicle or employ only partial insurance. These aspects are unknown, however potentially dangerous to the consumer, and have warranted regulation in the case of taxicabs. While for taxicabs a key problem related to safety is the singularity of business (many customers, excluding business travelers, are unlikely to use the same taxicab twice and thus managers/drivers have little incentive to provide superior service), the need to protect the reputation of large AT fleet operators might limit the need for regulation.

Recapitulating the launch of Uber in 2010 and acknowledging the current, still widely varying regulatory landscape for ride-sourcing companies with no commonly applicable set of best practices (63), transportation planners and regulating authorities may find these first thoughts on regulatory concerns and potential remedies useful to start a discussion that, arguably, cannot be started soon enough.

**CONCLUDING DISCUSSION**

It is widely acknowledged that autonomous taxis hold disruptive potential for urban transportation systems. Their attractiveness depends on many factors, pricing, accessibility and safety being three of importance. Research in industrial organization has shown that firm
behavior (i.e., pricing) is influenced by market power, which in turn is influenced by market structure.

We analyze the prospective market structure of AT operations. We find that significant economies of scale might propel international consolidation to few AT operators with significant market power, bringing new competition to previously local urban transportation markets.

While acknowledging the efficiency benefits of a monopoly or oligopoly of few, it naturally causes regulatory concerns. We discuss remedies against potential price discrimination such as competitive tendering and platform commission pricing. Subsidies and universal service regulation could enforce equitable access in economically less lucrative areas, arguably one of the main societal benefits of ATs.

One cannot, however, analyze a single transportation mode without its interference with others. Taking a broader perspective and assuming competition or regulation result in ‘ideal conditions’ (i.e., marginal cost pricing and universal service provision), what would be the impact on the public transportation system?

Arguably, ATs could draw many of users away from the existing public transportation system, leading to increasing congestion due to worse spatial efficiency (even if ride-sharing is assumed). A number of well-known transportation policies should be reconsidered to ensure an economically sustainable, space-efficient mass-transit backbone: road pricing as a way to include the externalities caused by all vehicles, bus priority lanes to allow for an efficient alternative in peak hour transit, and incentives for ride-sharing.

The ultimate goal, however, should be to integrate ATs with efficient mass-transit. ATs could be used as feeder services, efficiently connecting low-density areas with the public transportation system. Current first/last mile partnerships of public transportation agencies with ride-sourcing firms could provide insights into the design of incentive structures. Their effectiveness, however, remains to be evaluated.

Public transportation organizations will eventually have to decide whether to provide AT services themselves or allow third parties to operate (and under which conditions). Our results suggest a trade-off between singular operational efficiency in the provision of AT services (where large international AT operators are likely to have a cost and branding advantage) and comprehensive operational efficiency of the entire transportation system with integrated ATs (where, arguably, local public transportation companies have a knowledge advantage).

In this context it is worthwhile to remember the origins and benefits of a centrally orchestrated integrated urban transportation system as it persists in many developed cities. In 1859, Edwin Chadwick pointedly described early-stage public transportation in Paris and London as “vehicles provided by numerous conflicting small capitalists giving inconvenient, and, in every way inferior, service to the public” (65, p. 390). Characteristics of such a system, as witnessed today with jitneys in many developing cities, are: hazardous driving in competition for customers, oversupply on routes with high ridership and undersupply on others, multiple fares and long wait times in case of transfers, and redundant land use. While structural differences let jitneys flourish in some contexts, developed cities such as Paris and London have evolved to more integrated transportation systems led and coordinated by a central authority. Competition takes place mostly for the market, not in the market (67, 68). Given their centrality in the current system and its development, local transportation authorities will have to play a central role in the design of future integrated urban transportation systems. Where they decide to let third parties offer AT services, regulation targeting price, safety and equity might become necessary. We suggest that competitive tendering and contracting might be a suitable mechanism to achieve competition for the market that would not develop naturally, while simultaneously reaping scale
efficiencies of a single or few providers and retaining centralized planning sovereignty.

Procurement cycle length should be adjusted to product maturity, as ATs will be improved with
time and experience. Clearly, these first ideas need further analysis and validation.

Our work motivates several other areas for future work. First, additional research is
needed on the economics of AT operation as a function of population density and vehicle usage
to determine whether the substitution of low-frequency buses at off-peak hours is viable and
whether universal service regulation might be needed. Analyses of the recent experiences of US
cities piloting the (partial) substitution of public transportation with ride-sourcing services would
be interesting to anticipate results for autonomous vehicles. Second, we expect ride-sharing to be
necessary to reap the full potential of ATs to ease traffic congestion. While plenty of research on
pricing exists, we are not aware of qualitative analyses of the barriers to ride-sharing that need to
be overcome.

We conclude with a cautious stance on regulation. While there is plenty of theoretical
evidence that monopolies or oligopolies price above marginal cost, regulation does not come free
and should always be a consideration between expected benefits and costs. The economic theory
of regulation and many examples in the transportation sector have shown that regulation can be
operationalized by incumbent firms to extend their market power, impeding innovation. In line
with the basic assumptions of industrial organization, the larger environment in which a firm
operates impacts its performance. This may be one of the reasons why economists do not reach a
conclusion on the impact of price and entry regulation in the taxicab industry. Urban
characteristics, such as sprawl and density, public opinion and many other factors are also likely
to impact the performance of AT markets. Regulation, thus, should always be tailored to local
conditions. There might not be a ‘one-size-fits-all’ solution.
AUTHOR CONTRIBUTION STATEMENT

The authors confirm contribution to the paper as follows: conception and design: Daniel J. Reck and Kay W. Axhausen; literature review: Daniel J. Reck; analysis and interpretation: Daniel J. Reck and Kay W. Axhausen; manuscript preparation: Daniel J. Reck and Kay W. Axhausen. All authors reviewed the results and approved the final version of the manuscript.
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