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Transportation-enabled urban services: A brief discussion

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Transportation-enabled urban services: A brief discussion

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1. Introduction

Nearly 55% of the world's population lives in urban areas or cities, and is expected to rise above 70% over the coming decades. Rapid urbanization brings steadily more residents and a growing freelancing workforce into cities. The developments of city infrastructure and technologies—for instance, mobile location tracking and computing, autonomous and connected vehicles, wearable devices, robotics and robots, smart appliances, biometric authentication, various internet-of-things devices, and smart monitoring systems—are creating numerous opportunities and inspiring innovative and emerging urban services. Among these innovations, complex systems of urban transportation and logistics have embraced advances in technologies and, consequently, been significantly reshaped (Agatz et al., 2021).

Novel challenges and opportunities arise in transportation and logistics, and many innovative urban services have been enabled and empowered by advanced transportation and logistical systems in a general context of smart cities. A list that is far from complete includes food delivery (e.g., UberEats, DoorDash, Meituan); on-demand grocery delivery (e.g., Amazon Fresh, Instacart); local freelancing services (e.g., TaskRabbit, Handy); and on-demand homecare and healthcare (e.g., Caregiver, Papa Pal).

Specifically, with the rapid development and popularization of mobile and wireless communication technologies, companies usually leverage internet-based platforms to operate services. These platforms connect customers, service/product producers, and drivers/couriers. For example, in food delivery, platforms connect customers who order food online, restaurants that prepare and sell food, and couriers who pick up food from restaurants and deliver it to customers. In on-demand homecare and healthcare, platforms connect patients who need medical services at home, medical teams who have the requisite qualifications and equipment, and transportation fleets who transport medical teams to patients' homes.

Based on the relations between the service/product producers and the transportation fleet, we can classify transportation-enabled urban services into two groups: (a) service producers who own and operate a dedicated fleet with full-time drivers/couriers, and (b) service producers who have no fleet so the transportation/delivery are provided by third-party full-time or part-time drivers/couriers. The first group produces a two-sided market, with customers on the demand side and service producers (with their own fleets) on the supply side. The second group produces a three-sided market, with customers on the demand side, service producers on the supply side, and a third-party transportation/delivery fleet in the middle to physically transport the service teams or products from the supply location to the demand location. Note that such transportation-enabled urban services, which have online platforms that enable individuals or small entities to act as buyers, sellers, or transportation to interact effectively and efficiently in a two-sided or three-sided market, are not necessarily part of the shared economy or gig economy.

Food and grocery delivery are common and representative transportation-enabled urban services with a three-sided market. DoorDash, for instance, operates an online food ordering and delivery platform, which served 0.45 million merchants, 20 million customers, and 1 million deliverers as of late 2020 (SEC, 2020). Meituan, the largest food delivery platform in China, had 569 million annual transacting users and 7.1 million annual active merchants in over 2,800 cities and counties in China as of early 2021 (PRNews, 2021). Instacart, a grocery delivery and pick-up service provider in North America, had an estimated 9.6 million active users and over 0.5 million shoppers who pick up the items as of late 2020 (Curry, 2021). These companies have become increasingly popular and important, especially during the Covid-19 pandemic.

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Designing and operating transportation-enabled services is vital—and challenging—for all stakeholders: customers, service/product producers, drivers/couriers, platforms, policymakers, and the public. In what follows, the author briefly describes the system in a concise framework, which delineates the components and interactions in the system. The author also summarizes important research problems concerning transportation-enabled services that merit investigation both academically and practically.

2. System description

In transportation-enabled urban services, customers usually use a mobile app or website to place their service request; the request includes the selected service producer, service/product type and configuration, delivery time window, address, etc. The platform often decides which service producers are visible to the customers, based on the service requirement and the addresses of both the customer and service producers. Then, service producers who receive the order decide whether to accept it and at what time the service teams or products must be prepared to be picked up. Service producers with their own dedicated fleets will arrange their own transportation. For service producers without their own fleets, the platform will administer the order bidding and dispatching process to match accepted orders (with pickup and delivery information) with third-party drivers/couriers.

In this process, customers pay a certain price to the service producer and a transportation/delivery fee to the drivers/couriers. The platforms withhold commissions from each of the two or three sides, depending on the service/product type and configuration, time, region, and company. After completion of each order, the two or three sides may rate each other, which results in a multilateral rating record.

If service producers have their own transportation fleet, the system interacts as a typical two-sided market. The interactions of general two-sided markets are described by Rochet and Tirole (2003) and, more specifically, by Bai et al. (2019) in the context of on-demand platforms and Wang and Yang (2019) in the context of ride-sourcing and ride-hailing services.

If service producers require a third-party transportation fleet, the system interacts as a three-sided market. Drivers and couriers may be freelancers and can use their own or leased vehicles for transportation and delivery whenever and wherever they choose. They may design their working schedules more flexibly and decide whether, when, and how long to work on the platform. In such a case, the system is a meeting place for three groups of agents (customers, service producers, and drivers/couriers) who interact and provide each side with network benefits. Mathematically, consider a platform that charges c, s, and d per interaction to the customer, service producer, and driver/courier, respectively. The market is three-sided if the volume V of transactions realized on the platform depends on all three amounts—$c,\ s$, and d—even their summation $c + s + d$ is a constant. The amounts are also critical for coordinating and balancing demand, supply, and transportation. Same as ride-sourcing services in Wang and Yang (2019), Ke et al. (2020), and Zhu et al. (2021), this motivates various operational strategies for transportation-enabled urban services, such as dynamic or surge pricing, whereby the platform adjusts the price suggested to the service producers and commissions for the three sides dynamically depending on real-time supply, demand, and transportation information, while taking both platform performance (such as revenue, number of served orders, market share, and profit) and social welfare (including customer utility, producer revenue, and driver income) into consideration.

A concise framework to describe the transportation-enabled urban service is depicted in Fig. 1, which illustrates the intrinsic relations between the three groups of agents.

Analogous to the ride-sourcing market in Wang and Yang (2019) and Lyu et al. (2019), the objectives of transportation-enabled urban services operate in multiple dimensions and may change according to the service and product type, platform developmental stage, market conditions and competition, and government regulations. Some common objectives include balancing demand, supply, and transportation over time and space; maximizing long-term and/or short-term platform revenue and profit; maximizing long-term and/or short-term market share and penetration; and maximizing social welfare. To efficiently operate and achieve these objectives, platforms must employ various operational strategies and make decisions from diverse perspectives. For instance, some or the critical strategies deployed and decisions made by platform operators include static, dynamic, or surge pricing suggested to the service/product producers; the list of service providers visible to each customer; static, dynamic, or surge wage and incentives for drivers; the order bidding and dispatching mechanism; guidance and repositioning of idle drivers; information sharing with and disclosure to each side; multilateral rating mechanisms, etc.

Customer demand, service supply, and the transportation fleet are the three major components. On the demand side, depending on customers' attributes, preferences, and behavior, potential customers evaluate services and products based on the service quality, price charged by the service producer, and commission charged by the platform; after comparing with alternative services, they make their request decision. On the supply side, depending on the service producer's attributes, service/product type, and service capacity, and considering demand from other channels (e.g., dine-in restaurant customers in the case of food delivery services), service producers set a price, sometimes with guidance from the platform, and decide whether to accept the order and when the service teams or products must be ready to be picked up. On the transportation side, if the drivers/couriers are freelancers, depending on drivers' attributes, qualifications, and behavior, potential drivers make working decisions regarding whether to work on the platform (Sun et al., 2019). If they decide to work, when and how long to work and which orders to bid for or assigned orders to transport, in response to many variables and factors, are compared with other job options, including income level, working environment, job security, comfort level, pressure of work, exposure to risk, etc.

In transportation-enabled urban services, the interface between demand and supply is rife with meeting frictions depending on the transportation that facilitates physically connecting them. The level of transportation provision, in turn, depends on the realized transactions between demand and supply. Therefore, customer demand, service supply, and the transportation fleet are strongly

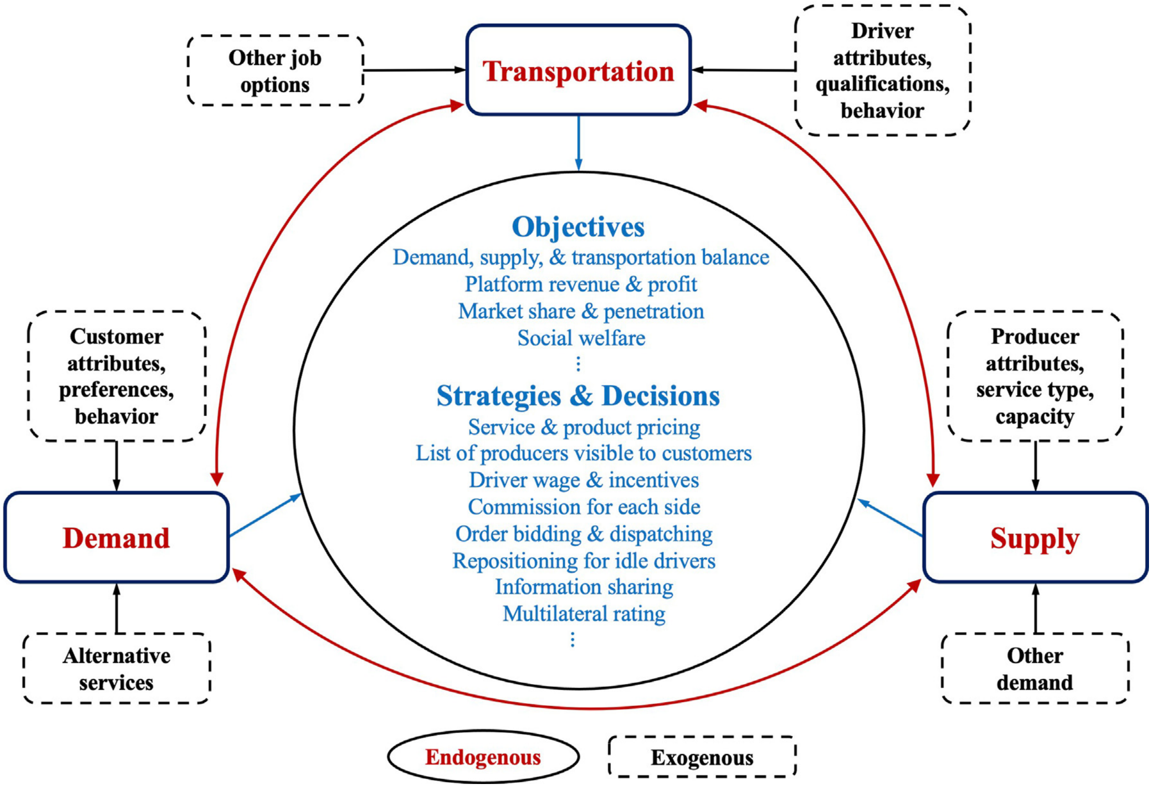

Fig. 1. System of transportation-enabled urban services.

endogenous and interactively dependent, whereas the endogenous influences and interactions are highly dynamic with strong spatial and temporal patterns.

3. Research problems

As described in Section 2, systems of transportation-enabled urban services are complex, with many endogenous factors and interactive decisions. The design and operation of such services is challenging and encompasses numerous research problems from diverse perspectives.

On the demand side, research problems include (1) spatial-temporal demand estimation for transportation-enabled urban services, (2) customer choice in the face of alternative services, and (3) the list of service producers visible to each customer.

On the supply side, research problems include (1) service provider supply models to describe short- and long-term service capacity, (2) service region and priority allocation, and (3) mechanisms and algorithms for static and dynamic pricing or price guidance.

On the transportation side, research problems include (1) driver decision models to describe short- and long-term transportation capacity, (2) driver supply elasticity with respect to multiple factors, and (3) mechanisms and algorithms for static and dynamic driver wage and incentives.

To operate services better and improve system performance and efficiency, research problems for operators include (1) estimated time of arrival (ETA) for both pick-up and delivery routes, (2) the static and dynamic commission charged to each side, (3) order bidding and dispatching to match accepted orders with drivers, (4) guidance and repositioning of idle drivers, (5) information sharing with and disclosure to each side, and (6) multilateral rating mechanisms. To solve these problems, we must consider and depict the interactions between all three sides or a subset of two sides among demand, supply, and transportation.

In considering such services as one part of the entirety of a smart city, research problems arise from (1) platform competition, (2) competition and impacts on other urban services, (3) impacts on transportation and logistical systems, (4) societal and environmental impacts, and (5) relevant governmental regulations and policies.

To address these research problems, many models and algorithms that employ advanced methodologies, both classic and novel, could be developed and implemented. Analogous to the discussion of ride-sourcing systems in Wang and Yang (2019), these methodologies include statistics and econometrics, labor economics, microeconomics, queueing theory and stochastic process, integer and combinatorial optimization, stochastic and dynamic programming, game theory and mechanism design, and machine learning techniques.

4. Conclusion

The combination of rapid development of infrastructure and technologies, various innovations in urban services, and advances in analytics, computing, and artificial intelligence will result in a steady stream of dramatic changes in urban systems and the reshaping of modern cities. Specifically, transportation-enabled urban services are booming and continue to evolve, which will have major and long-lasting impacts on everyday life around the globe. In this paper, the author briefly introduces transportation-enabled urban services and discusses the system in a concise framework. The author also describes the system's components and interactions and summarizes relevant research problems that merit investigation both academically and practically. The author believes that increasingly more urban services, which may not exist today, will be enabled by modern transportation systems, and exciting research will undoubtedly improve and reshape such services to the benefit of all in the general context of smart cities.

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Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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