An Empirical Analysis of Price Formation, Utilization, and Value Generation in Ride Sharing Services

Extended Abstract

Motivation

The advancement of mobile Internet technologies have led to the birth of ride-sharing platforms such as Uber and Lyft and their Chinese counterpart Didi. These ride-sharing platforms link consumers and drivers in an efficient and real-time way through mobile applications. The dynamics of both demand (consumers) and supply (drivers) on ride-sharing platforms are distinctively different from the ones in traditional taxi industry. Through ride-sharing mobile applications, consumers can choose a range of car services and can instantly review the number and locations of nearby active cars in real time, and make decisions based on up-to-date information about availability and pick up times. On the supply side, the capacity or the number of active drivers is not centrally controlled by the ride-sharing platforms. Instead, the number of drivers working at a specific time is determined by the independent choices of individual drivers.

Given these unique market characteristics, ride-sharing platforms often set prices dynamically to balance the demand and supply for their services. Fare setting rules and proprietary algorithms used by these services for managing their operations play an important role in value generation for their customers as well as their drivers, and important questions center around their pricing and regulation. In this paper, we develop an empirical model, and analyze price formation and surplus generation of these services using a comprehensive data set obtained from Didi, the largest ride-sharing platform in China, who provides regular taxi as well as ride-sharing services, known as Kuaiche, on its platform. In particular, we study (i) the factors that determine the consumer demand and driver willingness to participate in ride-sharing platforms; and (ii) the welfare effects of certain proposed government regulations on pricing and capacity of ride-sharing services.

Empirical Model and Estimation

We first develop an empirical model to capture the demand and supply dynamics on a ride-sharing platform like Didi. We apply a multinomial logit discrete choice model to describe both customers’ choices among different services and drivers’ choices on whether to be active at a given time. On the demand side, when a consumer is looking for a service on Didi’s platform, the consumer needs to select a service/option out of three available options: Kuaiche, taxi, and the outside option such as taking public transportation.
Consumer utility is modeled as multinomial logit. A consumer will select the option that will generate the highest utility. Then, the market shares of the three options at a given time can be derived based on the multinomial logit choice probability calculations, which specify the demand dynamics on the platform. On the supply side, Didi offers two services: Kuaiche and Taxi. At any given time, a driver for either service has two options: driving or not. We again model driver utility as multinomial logit. Based on the utility functions, the proportion of registered Kuaiche drivers (taxi drivers) that decide to drive at a given time can be obtained, again through multinomial logit choice probability calculations, specifying the supply dynamics of Kuaiche drivers (taxi drivers) on the platform.

Based on this empirical model, we then estimate the model parameters using three datasets, two from Didi and one from public sources, to conduct the empirical analysis. The first dataset we obtained from Didi contains transaction level data in Beijing including observations on the locations at which each customer is picked up and dropped off, the time the customer submits a request through the mobile app and the time the driver accepts the request, the drop-off time, and the total fare of the ride. The second dataset from Didi contains the driver’s information. Finally, we also employ an independent public data to control for other factors and conditions during the timespan of the data set.

Performing the estimation, we find that price has different effects on consumers’ choices of Kuaiche in different time periods in a day. It has a significantly negative effect on consumer’s choice of Kuaiche during the night time, i.e., 11 pm-6 am, while its effect is not significant during morning rush hour from 7 to 9 am. The after-dinner period, from 8-11 pm, also demonstrate lack of consumer sensitivity to the price. This can be explained from two aspects, namely reduced availability of transportation choices in the evening, and consumers’ higher valuation of convenience and comfort. On the supply side, Kuaiche drivers’ choices of whether to drive or not depend on the observable parameters like the number of open orders around, current estimated price per order as well as how much money the driver has made so far in a day. The number of consumers is always a positive incentive for Kuaiche drivers in all time periods. The price effect, however, is negative and significant in 11 pm-6 am, 6-7 am and 9-10 am and positive in other time periods. Taxi market share is affected by the number of available taxi drivers positively for all time periods. We find that price per order for taxi service is negative or insignificant with its market share for all time periods except the night time. Limited public transportation forces consumers to take taxi during night time even if the night price is higher.

**Counterfactual Analysis on Government Regulation and Welfare**

We then utilize our estimation results on the demand and supply dynamics to investigate the impact of potential government regulations on pricing and capacity through counterfactual analysis. Governments
around the globe are often concerned about the lack of regulations in ride-sharing industry. In China, there are proposed regulations commonly focusing on enforcing constraints on pricing and limiting the number of Kuaiche drivers. To evaluate the impact of government regulations on ride-sharing platforms, we estimate both consumer and driver welfare through log-sum method, and evaluate the difference between the current levels and scenarios that assume the implementation of price caps and capacity limitations on Kuaiche service.

We first examine the impact of price caps imposed by a regulator on Kuaiche prices based on taxi prices. Under the proposed price caps, Kuaiche prices cannot be lower than taxi prices at any given time. We find that under the proposed price cap, consumer welfare will decrease 61.31% on average. The decrease comes from the interaction of various connected factors. The price increase reduces consumer’s welfare directly. The drop of consumer orders taking Kuaiche afterwards further decreases consumer welfare because Kuaiche drivers’ willingness to drive is also negatively affected. As a result, although a group of consumers may benefit from shorter waiting times due to larger decrease of consumers requesting Kuaiche than the number of available Kuaiche drivers, price regulation dramatically decreases consumer welfare as a whole. The increased price leads to a 5.31% decrease in total Kuaiche driver welfare. Surprisingly, we find that taxi drivers that participate in the platform do not benefit from the price caps on Kuaiche either, with an average welfare loss of 20.12%. Although the Kuaiche prices are regulated to be no less than taxi prices, many Kuaiche customers would likely respond by choosing an outside transportation option. This, creates an imbalance in favor of supply for the Kuaiche service, which results in lower waiting times for Kuaiche, and induces some taxi consumers to switch to Kuaiche.

We then analyze the effects of potential capacity regulation on Kuaiche by considering the proposed scenario of limiting the number of Kuaiche drivers from the current 95,000 to the current number of taxi cabs, 66,000 in Beijing. We observe a significant decrease of 50.06% in total consumer welfare and a decrease of 56.35% in Kuaiche driver welfare under this scenario. We find that the shortage of Kuaiche capacity is likely to decrease consumers’ willingness to choose the Didi platform and further jeopardize Kuaiche drivers' incentives to participate because of the decreased number of orders. However, our analysis shows that taxi drivers would also experience a loss of surplus in this case, and the joint effect of the changes of consumers and drivers due to capacity regulation causes various degrees of losses to all participants on the platform.

Our results suggest that common government regulations on pricing and capacity of ride-sharing platforms could perform poorly in enhancing the social welfare and balancing demand and supply in the market. Hence, more careful design of regulating mechanisms is needed to improve the efficiency and social benefits of ride-sharing platforms.