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Surge Pricing and Labor Supply in the Ride-Sourcing Market

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Abstract

This study proposes equilibrium models under different behavioral assumptions of labor supply in a ride-sourcing market and then investigates the performance of surge pricing. A time-expanded network is first proposed to delineate possible work schedules of drivers. Based on the proposed network, we provide formulations and algorithms for both neoclassical and income-targeting hypotheses to characterize the labor supply of ride-sourcing drivers, i.e., their choices of work hours. We then investigate the impact of surge pricing using a bi-level programing framework, with the lower-level problem capturing the equilibrium work hour choices while the upper-level one representing revenue-maximizing surge pricing. Compared to static pricing, the platform and drivers in general enjoy higher revenue while customers may be made worse off during highly surged periods. A simple regulation scheme to reduce market power is discussed.

Keywords: Ride-sourcing; Labor Supply; Surge Pricing; Work Schedule; Time-Expanded Network

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1. Introduction

Ride-sourcing companies (also known as transportation network companies or TNC) such as Uber and Lyft are eroding the traditional taxi market by providing services that can efficiently match a requesting customer with an affiliated private car driver nearby. Since gaining market share, ride-sourcing companies have brought heated discussion over the market's regulation. One of the central issues is the surge pricing enabled by ride-sourcing apps, which is essentially a dynamic pricing scheme that adjusts trip fare in real time. Based on the market condition of a geographic area, the base trip fare is adjusted by a multiplier automatically generated from the platform's algorithm. The information of the surge multiplier (SM) is provided to both the customer and the driver before a transaction happens. With the dual effect of suffocating demand and increasing supply, surge pricing is advocated to guarantee a reasonable amount of waiting time for customers. In most cases, the surge multiplier falls below 1.5 times. However, it can soar seven times or higher without a cap limit (Curley, 2014; The Economists, 2014). Platforms generally benefit from the surges since commission is charged as a fixed percentage of the final trip fare. Therefore, platforms may surge unnecessarily high or more frequently to exploit customers, given that no regulation is imposed and the surge algorithms are proprietary.

Ride-sourcing companies provide flexibility for drivers to choose their work schedules. Some may work full time like professional taxi drivers while others only provide service for limited hours (e.g., on their way home from work). Such flexibility enables the use of drivers' fragmented time particularly with the existence of price surge. On one hand, drivers may adjust their work schedules to cover more profitable periods; on the other hand, temporal variation in the wage rate induced by surge pricing may further affect drivers' decision of how long they would like to work (Chen and Sheldon, 2016). Therefore, it is intriguing to investigate the effect of surge pricing by considering drivers' work hour choices in a dynamic context.

However, current analytical models are mostly static and often consider a stationary state to simplify policy evaluation (He and Shen, 2015; Taylor, 2016; Wang et al., 2016; Zha et al., 2016). These models are not able to capture the flexibility of drivers' work hour choices where temporal variations in market dynamics play a key role. In the literature of labor economics, competing theories or hypotheses exist in understanding how a driver determines his or her shift length. The neoclassical theory expects drivers to work longer when their wage rate is higher, while the income-targeting theory speculates that drivers have target levels after which they are more likely to stop (Camerer et al., 1997; Farber, 2015). No consensus has yet been achieved on which theory better explains taxi drivers' labor supply decisions, even though empirical analyses have been carried out. Furthermore, the analyses mainly focus on inputs such as wage rate and work hours while structural information such as shift starting and ending times is largely overlooked.

The goal of this study is two-fold. We first propose formulations and solution algorithms for the work hour choice equilibrium model under both labor supply hypotheses, given the lack of sufficient empirical evidence on the labor supply in a ride-sourcing market. Based on the proposed equilibrium models, we will then develop an analytical framework for studying surge pricing. To achieve this goal, we construct a time-expanded network to outline the drivers' work schedule. Given the variations in customers' demand and surge multipliers, drivers' equilibrium choices of start and end times, break and work durations are all endogenously determined. Two formulations are proposed that follow the neoclassical and income-targeting hypothesis, respectively. The equilibrium solutions of the proposed formulations as well as their implications for labor supply are demonstrated through numerical experiments. Next, we investigate the impact of surge pricing using a bi-level programing framework. The upper level specifies the platform's objective of revenue maximization while the lower level captures the equilibrium work hour choices of the drivers. A simple regulation scheme is presented when market power is a concern. Further insights on surge pricing and regulation outcomes are discussed via numerical experiments.

The remainder of this paper is organized as follows. Section 2 presents a review of the related literature. Sections 3-4 present our basic modeling pieces and different formulations with solution algorithms. Section 5 numerically demonstrates the properties of the proposed models. The structures of the bi-level programs for studying surge pricing and the market outcomes under the proposed regulation are discussed in Section 6. Finally, we conclude the paper and provide directions for future study.