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How can the taxi industry survive the tide of ridesourcing? Evidence from Shenzhen, China

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ABSTRACT

This paper aims to examine the impact of ridesourcing on the taxi industry and explore where, when and how taxis can compete more effectively. To this end a large taxi GPS trajectory data set collected in Shenzhen, China is mined and more than 2,700 taxis (or about 18% of all registered in the city) are tracked in a period of three years, from January 2013 to November 2015, when both e-hailing and ridesourcing were rapidly spreading in the city. The long sequence of GPS data points is first broken into separate "trips", each corresponding to a unique passenger state, an origin/destination zone, and a starting/ending time. By examining the trip statistics, we found that: (1) the taxi industry in Shenzhen has experienced a significant loss in its ridership that can be indisputably credited to the competition from ridesourcing. Yet, the evidence is also strong that the shock was relatively short and that the loss of the taxi industry had begun to stabilize since the second half of 2015; (2) taxis are found to compete more effectively with ridesourcing in peak period (6–10 AM, 5–8 PM) and in areas with high population density. (3) e-hailing helps lift the capacity utilization rate of taxis. Yet, the gains are generally modest except for the off-peak period, and excessive competition can lead to severely under-utilized capacities; and (4) ridesourcing worsens congestion for taxis in the city, but the impact was relatively mild. We conclude that a dedicated service fleet with exclusive street-hailing access will continue to co-exist with ridesourcing and that regulations are needed to ensure this market operate properly.

1. Introduction

The spectacular rise of *ridesourcing* is probably the most significant disruption occurred to the personal mobility market in decades. Offered mostly via mobile platforms, a ridesourcing service connects passengers to rides provided by private drivers using personal vehicles. The process that matches passengers and drivers on-line and in real-time is often called *e-hailing*, in contrast to traditional *street-hailing*. While those that offer ridesouring service - the likes of Uber, Lyft and Didi Chuxing, known as *Transportation Network Companies* (TNC) - are still locked in intense battles with each other around the world, it seems at least to some that collectively they have dug the grave for the once formidable rival: the traditional taxi industry (Oremus, 2016).

Mounting evidence suggests that the taxi industry has indeed suffered great losses in market share, revenue, workforce and asset. In Los Angeles, the annual number of taxi trips has plummeted from 8.4 million in 2013 to 6.0 million in 2015, a nearly 30% fall in less than three years (Nelson, 2016). The taxi industry in San Francisco, where both Uber and Lyft are headquartered, lost almost two thirds of its market share between 2012 and 2014 (Davidson, 2014). Not surprisingly, the Yellow

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Cab Inc. in San Francisco, the largest operator in the city, had to file bankruptcy protection in early 2016 due to "serious financial setbacks" (Corrigan, 2016). On the east coast of the US, the price for a yellow taxi medallion in New York City (NYC) has been cut in half since May 2013, when it was valued roughly at $1.32 million (Zuylen-Wood, 2015). Some taxi dispatchers, such as McGuinness Management, has seen almost half of their medallions become idle due to the lack of drivers, creating so-called "taxi graveyard" in the city (Whitford, 2015).[1]

Despite the gloomy picture, it may be premature to declare that the future of the taxi industry is all but doomed. Bershidsky (2015) observed that TNCs' success so far is due in large part to the aggressive pricing strategy that cannot be sustained in the long term.[2] At the end of the day, he argued, "the survival of licensed, regulated cabs is the only safeguard against" the potential monopoly of the winer emerged from the TNCs' hunger game. Steier (2015) noted that the demand for UberX in NYC may have peaked, based on the fact that only about 2,000 UberX drivers (out of more than 20,000 registered) were serving its CBD area between 7 AM and 7 PM from June through July 19 of 2015. He suggested that the ability to offer the old fashioned street-hailing is an important advantage held by traditional taxis, and predicted that the loss of the taxi industry should begin to level off. Newman (2016) observed that the pace of declining taxi ridership in NYC might have been slowed. The official data published by NYC's Taxi and Limousine Commissions (see Fig. 1) show that the taxi industry in the city has lost about 25% ridership since 2012.[3] Fig. 1 offers no compelling evidence for market stabilization, however, even though the first half of 2016 did bounce back a bit more from the second half of 2015, compared to a year ago (marked by arrows in the plot).

One naturally wonders what TNCs' expansion looks elsewhere in the world. More intriguing questions have to do with the underlying mechanisms that drive the interactions between the ridesourcing and taxi services. For example, where and when does the traditional taxi service compete more effectively against ridesourcing, and hence it may more easily retain market share in those market segments? To what extent can e-hailing applications help the taxi industry counteract the competitive edge of the TNCs?

To explore answers to these questions this paper mines a large taxi GPS trajectory data set collected in Shenzhen, China. We track more than 2700 taxis (or about 18% of all registered in the city) in a period of three years, from January 2013 to November 2015 and examine how various aspects of their operations are affected, temporally and spatially, by e-hailing and ridesourcing. Our results suggest that ridesourcing inflicted a disruption of similar scale as in NYC on the Shenzhen taxi industry, but it struck in a much shorter time period, with the average taxi ridership falling about 25% in less than a year. Interestingly, the taxi industry there has already begun to stabilize since the second half of 2015, according to our analysis. In general, the insights from our analysis agree that a dedicated taxi fleet equipped with exclusive right to street-hailing and e-haling should and will continue to exist, despite the strong competition from ridesourcing. In the near future, before autonomous driving wipes out human drivers, the personal mobility market is likely to benefit from a mixed supply model with both dedicated and part-time drivers. It is city managers' job to determine how to best regulate this market for the collective good of the society. While directly informing such policy making is beyond the scope of this paper, the empirical evidence and analysis presented herein could help guide the modeling process in due course.

In what follows, Section 2 briefly reviews related studies and Section 3 presents the details of the taxi data set and shows how it is processed to generate useful results. Sections 4–6 report findings from the data: Section 4 focuses on outputs measured by average hourly ridership and distance/time travelled, Section 5 discusses productivity and Section 6 examines spatial heterogeneity. The last section elaborates and analyzes the findings, and offers concluding remarks.

2. Literature

Due to its peculiar behavior,[4] the traditional taxi market has attracted ample attention from economists and transportation analysts since 1970s (see e.g. Douglas, 1972; De Vany, 1975; Beesley and Glaister, 1983; Arnott, 1996; Cairns and Liston-Heyes, 1996; Yang et al., 2002; Flores-Guri, 2003; Yang et al., 2005; Moore, 2006; Schaller, 2007; Yang et al., 2010). Most of these efforts focus on modeling market equilibrium and argue for or against the tight regulations imposed on these markets, such as entry control and price ceiling. Surprisingly, according to our search of literature, scholarly research on ridesourcing remains relatively scarce, despite the obsessive media coverage in recent years.

Santi et al. (2014) performed a simulation study based on a dataset of 150 million taxi trips in NYC, and found a large portion of the trips are routinely shareable. They show that with a modest increase in passenger discomfort (in terms of extra waiting and riding times), the cumulative vehicles miles travelled (VMT) could be reduced by 40% or more. A survey study conducted in San Francisco by Rayle et al. (2016) shows that at least half of the ridesourcing trip replace a non-taxi trip, indicating that the markets of two services have overlaps but also significant differences. They also found that ridesourcing consistently outperforms taxis in terms of waiting time. Hughes and MacKenzie (2016) tracked a UberX vehicle for two months through Uber's developer API, and generated a GPS trajectory sample with more than one million data points. After correlating the waiting time data with the socioeconomic variables in each zone, they found that (1) the waiting times for the

[1] For what is worth, this author was told similar stories by taxi drivers when traveling in Chengdu, China in the summer of 2016.

[2] For example, Uber lost more than $1 billion in the first half of 2016 largely because the pricing war it waged with competitors - see e.g. http://www.nytimes.com/2016/08/26/technology/how-uber-lost-more-than-1-billion-in-the-first-half-of-2016.html?_r=0.

[3] As a side but interesting note, the ridership in the second half of a year is always significantly lower than that in the first half, likely due to Uber's appeal to visitors during summer break and winter holidays.

[4] Specifically, the fact that the vacant taxi operating hours is both a blessing to the level of service and a waste for the service provider.