ABSTRACT

Electric Rickshaws (e-rickshaws) are a battery-driven, three-wheeled, and demand responsive informal public transport mode operational in various developing countries worldwide, used mainly for last-mile and short trips. In semi-urban and rural areas in India, e-rickshaws serve as one of the major transport modes catering to the demand gap due to insufficient and/or absent public transit modes. But in urban areas like Delhi, public transit system (e.g., buses, metros etc.) is well established, hence e-rickshaws mainly operate as feeder to these.

Being a demand responsive mode without any fixed schedule, e-rickshaw operations are often chaotic and disorganized. As the e-rickshaws do not follow any schedule, drivers often wait for their vehicles to fill up before starting the journey, and they may even wait at intermediate stops for an indefinite time. Such practices increase passengers' pre-journey waiting and dwell time, affecting the overall trip experience and ability to connect to buses/metros. Unregulated e-rickshaw operations also cause congestion on roadways leading to increased trip durations. Another major issue affecting the efficiency of e-rickshaw operations is lack of charging infrastructure, leading to reduced working hours and fewer daily trips for the e-rickshaws. This encourages malpractices of opening private charging places for e-rickshaws. Often e-rickshaw drivers charge and park their vehicles at these privately owned unregulated facilities by paying high tariff.

This dissertation focuses on three major areas: analyzing the service and operational characteristics of e-rickshaws, designing charging infrastructure for e-rickshaws, and assessing the economy of owning and operating an e-rickshaw. Primary surveys were conducted in Delhi, India to conduct the research work for this dissertation.

At first, e-rickshaw route network, trip, and operational characteristics were analyzed. Further the e-rickshaw trip duration reliability was assessed using various reliability indices, and trip duration reliability-based level-of-service thresholds were identified for the e-

rickshaws using clustering algorithm. Various machine learning based regression models were used to model e-rickshaw pre-journey waiting time, dwell time, and trip durations and identify the factors significantly impacting them.

Next, charging infrastructure for e-rickshaws were designed using a stochastic bi-objective maximal covering type model developed as a part of this dissertation. Optimal locations were identified to set up charging stations and the optimal number of chargers installed at the charging stations were also determined. The concept of dynamic tariff was introduced in the model to achieve a demand-supply equilibrium of e-rickshaw charging workload at the charging stations. E-rickshaw drivers' charging preferences were incorporated in the formulation as parameters and constraints while designing the charging infrastructures. The optimally designed charging stations showed significant performance improvement over the existing charging stations.

Further, the dissertation focused on assessing e-rickshaws as an investment/business opportunity. The e-rickshaw lifecycle cost and profits earned by owning and operating an e-rickshaw were estimated. Next, the impact of discount rates, lifecycle, battery replacement cycle, and daily distance travelled on the e-rickshaw lifecycle costs and profits were analyzed. Finally, linear regression was used to model e-rickshaw lifecycle cost.

Overall, this dissertation highlighted the existing condition of e-rickshaw operations in Delhi and focused on identifying factors impacting the e-rickshaw operations, designing charging infrastructure for e-rickshaws, and analyzing the economy of owning and operating an e-rickshaw. This dissertation can be referred to by stakeholders and policymakers for planning of improved and efficient e-rickshaw services by understanding their operations and providing them with optimally designed infrastructure, which will in turn foster the growth of electric mobility in India.