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# Price competition in ridesharing platforms: A duopoly supply chain perspective

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**Abstract**

A ridesharing platform with a price-setting power mechanism exists in practice. However, it is unclear how supply chain transactions (ride price) and yields are affected due to a commission fee on ridesharing platforms. To better understand, this study explores the impact of the service provider's price-setting (Model S) and service enabler's price-setting (Model E) power mechanism on supply chain profit under the influence of price competition in a ride sharing. We consider duopoly supply chains, wherein in one supply chain, a service provider delivers service through a service enabler, and in another, service providers offer direct customer service. Mathematical models are developed to analyze the difference in price-setting power mechanism effect, considering marketing efforts under different competitive scenarios. Results show that the supply chain profit is highest when the service provider sets the transaction price in Model S. Furthermore, when the commission fee exceeds a certain threshold (0.5), the total profit in Model E increases, but in Model S it decreases. In ridesharing platforms, the service provider loses with a rise in commission fees, while the service enabler profits from it. The study contributes to the growing interest in the intricacies of ride sharing businesses.

**Keyword:** Sharing platform, sharing economy, ridesharing, competition, duopoly supply chain, marketing effort, pricing.

| Abbreviations | Definitions |
|---|---|
| *SP* | *Sharing platform* |
| *B2B* | *Business-to-business* |
| *B2C* | *Business-to-consumer* |
| *SC* | *Supply chain* |

| | |
|---|---|
| *SCM* | *Supply chain Management* |
| *B2B2C* | *Business-to-business-to-consumer* |
| *P2P* | *Peer-to-peer* |
| *RS* | *Ride sharing* |
| *SC* | *Supply chain* |
| *SE* | *Sharing economy* |

## 1. Introduction

Over the last decade, several digital start-ups have emerged focusing on sharing. This digital platform allows different parties to share, exchange and share information. Further, these companies have created cutting-edge business models that rely on sharing and collaboration and have changed the way people access goods and services. Consumers now have more flexibility and choice when spending and can benefit through sharing of resources. In addition, the emergence of this 'new' economy, facilitated by online platforms, is predicted to have a radical effect on consumer behavior and disrupt business as usual (Cheng, 2016). For example, Uber, Ola, TaxiForSure, etc., are sharing platforms that are leveraging smartphones, mobile payments, and other digital technologies to provide more diverse and differentiated services. Because of this, in recent years, academicians, practitioners, policymakers, and individuals have paid considerable attention to the sharing platform (SP) (Hossain, 2020; Anand et al., 2023).

The sharing platform may be an old practice, but it brings new opportunities to various sectors such as accommodation, healthcare, household, transportation, food, and grocery (Weitzman, 1986; Biswas & Pahwa, 2015; Guan et al., 2020; Laczko et al., 2020). However, previous studies found transportation to be the most critical sector for the SP and considered in the form of ridesharing platforms (Hossain, 2020; Li & Chung, 2020; Nyamekye, et al., 2022). Several companies such as Airbnb, Ola, and Uber have become well-known names in the travel industry due to the ridesharing platform phenomenon. Furthermore, implementing a ridesharing platform powered by service enablers in the private transportation industry is most motivating and impactful; promoting greater convenience for individual commuters (Biswas & Pahwa, 2015; Goel & Haldar, 2020; Wang et al., 2023). However, sometimes Ola or Uber compete with local taxi service providers in providing services to customers (Gururaj, 2015). Thus, sharing platforms play a vital market strategy role in the supply chain in the competitive environment (Li et al., 2019; Chen et al., 2020).

A supply chain consists of a network of companies that supply raw materials, produce goods, and deliver products at the right place and time (Simchi-Levi et al., 2008). Various supply chain management (SCM) techniques have been devised to improve the efficiency of different value chain activities in the manufacturing and service sectors (Fisher, 1997; Cachon, 2003). Supply chain management is closely linked to the platform economy, which is emerging as an important source of innovation for SCM (Brettel et al. 2014). Furthermore, digital technology has emerged as the core organizational form for informational transformation, leading to the emergence of the platform economy (Liu et al., 2022). Due to the increasing significance of sharing platforms (circular economies, ridesharing, and platform economies), understanding the supply chain process has become more important (Cachon et al., 2017; Sassanelli et al., 2020; Li et al., 2021; Zhang & Zhao, 2021). The shared platform is a market model that enables and facilitates the sharing of goods and services (Chen et al., 2019). Ridesharing (RS) is an excellent example of shared platforms where assets are shared. For instance, Ola and Uber cars are shared by passengers when in demand. "*Ridesharing refers to the common use of a motor vehicle by a driver and one or several passengers, in order to share the costs (non-profit) or to compensate the driver (i.e., paid service) using billing information provided by the participants (for profit)*" (Mitropoulos et al, 2021). More recently, business/supply chain researchers and experts have recognized the importance of online platforms in attracting customers and users. Both supply chain systems and sharing platforms use pricing mechanisms that include the decision regarding the entity that sets the price (Surie & Koduganti, 2016; Cachon, et al., 2017; Zhang & Zhao, 2021). All members in both sharing platforms and supply chain cases want to maximize their profits (Jena & Meena, 2019; Özkan, 2020). The sharing platform provides a service that is intangible, simultaneously produced and consumed by each customer, while the supply chain focuses more on the value chain for both products and services (Cusumano et al., 2015; Chen et al., 2020).

Ride-sharing business models can broadly be classified into two types based on demand, namely instant ridesharing/carpooling and planned ridesharing/carpooling (Lembcke et al., 2020). Ola and Uber are service enablers of on-demand RS, serving as an intermediary between suppliers of services (e.g., private taxi service) and passengers who demand instant services that are under-utilized. In planned RS /carpooling, the service providers offer pre-planned travel journeys, and provide 'fixed' services to cover the operational costs of their assets (Mitropoulos et al., 2021). This study aims to examine the former business model of RS. In addition to aggressively investing in developing countries, Ola and Uber offer driver incentives to attract customers and accustom them to low fares (Das, 2015). India is Uber's second-biggest market after the United States (Surie & Koduganti, 2016). While the organized taxi industry is still in its infancy in terms of the number of vehicles, it is worth noting that service enablers like Ola and Uber only represent 4–5% of the market. Meanwhile, around 90% of taxi services are unorganized (i.e., local service providers) across the country[1]. They provide services directly to passengers without relying on a service enabler (Surie & Koduganti, 2016; Li & Chung, 2020). Meanwhile, service enablers also focus their marketing campaigns on attracting new customers by emphasizing the benefits of their service. Because of this, supply chains compete with one another. This is referred to as a duopoly supply chain. Moreover, service enablers like Ola and Uber claim that 12% of all trips undertaken globally take place in India (Busvine, 2016).

A service enabler invests in marketing campaigns designed to promote its quality, pricing, discounts, and other promotions to attract customers. This triadic supply chain model has several advantages over the traditional B2B2C model. A triadic platform-based B2B partnership is formed between three participants in the ridesharing platform: service providers (for example, drivers, hosts, valets), service enablers (for instance, Ola, Uber, Airbnb) and customers (for example, passengers, riders, guests, users) (Kumar et al., 2018; Nourinejad & Ramezani, 2020). Here, the customer may either be a business (B2B) or an entity (B2C). In addition, partners in the supply chain add value to both dyads. In the context of transportation, for instance, service providers and passengers are not required to interact. A service enabler provides a lower fare for passengers who avail of the service via an online platform. Service enablers incur service assistance costs by hiring knowledgeable drivers and managers, using dedicated software, and investing in service training; in addition to providing additional service information (such as offers) to passengers through marketing efforts. "*Note that the information service in the advertisement is a kind of marketing effort"* (Cachaon, 2003; Kumar et al., 2018; Wang et al., 2020; Asl-Najafi et al., 2022). As a result, some taxi drivers view them as a threat to their market share (Surie & Koduganti, 2016; Mesa et al., 2021). Additionally, Uber can replace low-demand transit services with lower overall costs (Zhou, 2019). Therefore, Delhi, Bombay, and a number of other Indian cities are strongly opposed to app-based taxi services. Furthermore, some taxis compete with online platforms such as Uber

[1] https://medium.com/wearedrife/taxis-in-india-the-history-geography-and-economics-of-it-7b673421384f.

and Ola (Gururaj 2015; Surie & Koduganti 2016) to increase their market share. Here, the service enabler's service assistance costs include hiring knowledgeable drivers and managers, the use of dedicated software, and expending on service training programs; the service enabler can deliver additional service information to passengers by marketing effort. "*Note that the information service in the advertisement is a kind of marketing effort"* (Cachaon, 2003; Kumar et al., 2018; Wang et al., 2020; Asl-Najafi et al., 2022).

In the ridesharing platform, service enabler (such as Uber and Ola) companies set the transaction price (a ride price) and commission fee for a service, whereas service providers (for example, taxi driver) deliver that high quality of service to the customer (Das 2015; Fang et al., 2018; Hossain 2020). By comparison, HK taxi, a taxi-hailing app, enables passengers in Hong Kong to bid for taxi rides (Yau, 2020). Because of the on-demand nature and heterogeneity of the user groups, it is important to understand the impact of the price-setting power mechanism on supply chain profit. Therefore, this article focuses on the service enabler price setting and service provider price-setting power with and without price competition. However, the ride-hailing platform companies have faced numerous challenges and complaints from customers, competitors, and drivers who make up their fleet (Nourinejad & Ramezani, 2020). For example, without providing clarity, they differentiated their pricing into a 'peak hours charge' and 'normal hours charge'. Thus, some customers use conventional taxis during the peak hours of the day, which tends to lose to the ride-hailing platform companies (Kumar et al., 2018; Benjaafar et al., 2020; Chen et al., 2020; Hossain, 2020). Therefore, most studies to date focus on optimal pricing decisions of the ridesharing platform in supply chain management (e.g., Kumar et al., 2018.; Guan et al., 2020; Meng et al., 2019; Gupta and Ivanov, 2020). To the best of our knowledge, however, none of the literature on the business model for ridesharing platforms within a supply chain under price competition has addressed the issue of ridesharing platforms as a business model. Motivated by the gap between industrial implementation and academic research, a supply chain (SC) model considering the ridesharing platform under a competitive environment is presented in this paper. **This study aims to explore operational decisions involved in a ridesharing platform under price competition scenarios in a duopoly SC.** Here are the research questions we seek to answer:

- RQ1: Which price-setting power mechanism has the highest profit in the SP supply chain under price competition and without competition?

- RQ2: How will the commission fee impact the transaction price and SC profit under the RS platform business model?
- RQ3: How is the total supply chain affected by the service enabler's marketing effort when *service provider sets transaction price (Model S).and service enabler sets transaction price (Model E).*?

We developed an analytical model to address these questions considering the competition between a conventional service provider, ride-sharing service provider, and a service enabler. Here, the service enabler offers an online platform for service providers and puts marketing effort into promoting the service. In contrast, the conventional service provider offers their service directly to customers. Customers may check the quality of the service displayed in the promotion and avail the service online. We constructed an analytical model considering the service enabler's price-setting and service provider's price-setting mechanism under varying price competition scenarios.

The rest of the paper is arranged as follows. A summary of existing literature is presented in Section 2. Meanwhile, Section 3 explains essential notations and assumptions. Section 4 deals with mathematical models. A numerical example is given in Section 5 to demonstrate the model, discussion, and sensitivity analysis. Section 6 discussed the managerial implications. Finally, Section 7 presents a conclusion and future work.

## 2. Literature review

In the sharing platform, RS is the dominant feature, which matches drivers with passengers via smartphone apps (Chen et al., 2020; Sun et al., 2020). It involves two research streams, namely ride-sharing and platform competition. Here we discuss how our work compares to existing supply chain literature.

### *2.1. Ridesharing platform*

Uber and Ola are disruptive innovations in the sharing platform whose business model focuses on riding, which uniquely appeals to customers (Chen et al., 2020). Ridesharing services are categorized differently in the literature. It is also known as online taxi-hailing, real-time ridesharing, ride-hailing, on-demand rides, on-demand taxi, and taxi aggregator (Mouratidis et al., 2021). Antheaume et al. (2014) analyzed a model comprising 233 suppliers in four regions of the firm Carrefour. They compared various supply chain configurations for cost and carbon dioxide-equivalent emissions to determine when suppliers should switch to greener resource sharing. Xiong and Zhao (2016) studied the effect of a taxi-hailing app on professional driver's performance under a simulated driving environment. The study found that drivers who use one app perform better than those who use multiple apps. A ridesharing platform can directly coordinate passengers and cab drivers through communication technologies (Fang et al., 2018). As per Lee (2018), the quality and credibility of the source positively influence customers' continued usage of branded apps in accordance with the information adoption model. These papers do not investigate the transfer of demand from local service providers to organized service providers.

Further, Li et al. (2019) mention that ride-splitting adoption is low, and travel times and distances covered by shared rides are higher than single rides. Despite the growth of shared mobility, electrified vehicles, and vehicle automation, Spurlock et al. (2019) found that ride-hailing and adaptive cruise control have penetrated the market more than either electrified cars or car sharing. Peterson and Simkins (2019) analyzed a consumer's alternative transportation mode compared to commercial car-sharing. In their study, the authors examined consumers' value orientations and reasons for and against car-sharing by using behavioural reasoning theories and suggested that subjective norms (such as those of coworkers) play an important mediating role. More recently, Using Benjaafar & Hu's (2020) model, the authors examined how RS is organized and how introducing a platform that chooses seat rental prices to maximize revenue or welfare will affect traffic and ownership. How RS is organized depends on ownership and usage costs. Peer-to-peer(P2P) ride sharing is offered when this ratio is low.

Whereas Chen et al. (2020) proposed a new research direction to understand the price-setting impact on the sharing platform business model, Nourinejad and Ramezani (2020) developed a dynamic non-equilibrium ride-sourcing model that accounts for changing rider numbers, vacant ride-sourcing vehicles, and occupied ride-sourcing vehicles. When customer demand is high, myopic loss may lead to higher profits. Meng et al. (2020) examined the appropriate refuelling level through a data-driven approach. To improve accessibility and environmental sustainability, they suggested a recommendation scheme for on-demand refuelling in free-floating car-sharing services. At the same time, Sun et al. (2020) discussed platform allocation by considering maximum customer matching requests with the minimum waiting time. They found that the optimal radius is 1-3 kilometers. Mouratidis et al. (2021) studied ride-hailing and tele-activities considering app development and discovered that tele-activities might substitute some trips, while ride-hailing may increase vehicle miles travelled.

In summary, the existing research mainly focuses on sharing platforms' performance and transaction prices at the empirical level. These studies are lacking at the theoretical model level. Therefore, our study can fill the gap in this field by simultaneously considering the optimal decision of transaction price and marketing effort.

### *2.2. Competition in the sharing platform*

New online platforms bring competition between online service enablers or service providers, resulting in a conflict between service providers and resulting in reduced supply chain performance (Basak et al. 2017). An analysis by Zhong et al. (2019) examined ride sharing platforms where permanent agents were involved, and subsidies were being offered by the service enablers. Additionally, they found that workers may be offered lower wages and gain lower surpluses when the ridesharing market becomes a duopoly from a monopoly. According to Berstein et al. (2020), platforms are competing in the sharing economy (SE), which impacts prices. The study found that drivers and customers have an advantage when platforms raise prices in response to a surge in demand rather than if platforms were forced to charge the same prices regardless of demand. Fang et al. (2020) evaluated the performance of loyalty programs in economy sharing under optimality and competition. Additionally, Ye et al. (2020) found that team competition can increase drivers' productivity, job satisfaction, and retention, as well as increase revenue over cost on a ridesharing platform. Moreover, customer satisfaction is a measure of how well a ridesharing experience meets their expectations (Elmeguid et al., 2018). Furthermore, customers' satisfaction is influenced by service and performance, and performance is influenced by work plans. Companies should focus on providing quality services, as well as creating efficient work plans, in order to ensure customer satisfaction. This can be achieved by developing customer-oriented strategies and nurturing customer relationships. In heterogeneous markets, loyalty programs with multiple thresholds can succeed. Li et al. (2021) studied ride sharing under a competitive game model considering customized bus services and optimal pricing. Platform-owned vehicles are positively correlated with profits from customized bus services and ride sharing. Chang & Sokol (2022) examined how

Airbnb affects hotel demand and incumbent hotels' responses to Airbnb's prices and non-price responses.

*2.3. Research gaps and contributions*

Based on broad research attributes, Table 1 compares our research with existing research. However, none of these studies have discussed ridesharing in the SC considering different price-setting power between offline and online service providers under price competition.

**Table 1:** Comparative analysis of previous research

| Study | Ride-sharing | Price-setting by service provider | Price-setting by service enabler | Commission-price | Marketing effort | Competition |
|---|---|---|---|---|---|---|
| Benjaafar et al. (2017) | √ | √ | | √ | √ | |
| Kumar et al. (2018) | √ | √ | | √ | √ | |
| Li & Szeto (2019) | √ | √ | | | | |
| Zhong et al. (2019) | √ | | √ | | | √ |
| Fang et al. (2020) | | √ | | √ | | √ |
| Nourinejad &Ramezani (2020) | √ | √ | | √ | | |
| Vivoda et al. (2020) | √ | √ | √ | | | |
| Martin et al. (2021) | √ | √ | | | | |
| Wang et al., (2022) | √ | | | √ | | |
| Wu et al., (2022) | √ | √ | √ | | | |
| Wang et al., (2023) | √ | | | √ | | |
| **This study** | √ | √ | √ | √ | √ | √ |

Following is a list of research gaps identified from the literature review.

(1) Prior research on online advertising in the SC has primarily focused on the pricing strategies of the service provider (Benjaafar et al., 2017; Kumar et al., 2018; Vivoda et al., 2020; Yan et al., 2021) or enabler (Wang et al., 2016; Benjaafar et al. 2017; Kumar et al., 2018) and the driver's performance (Stiglic et al., 2015; Benjaafar & Hu, 2020). Further, very few researchers have studied online platform competition considering the pricing strategies of the service enabler (Zhong et al., 2019; Fang et al., 2020), while the impact of marketing

effort and transaction price on SC profit and platform players' profit, considering service enabler and service provider simultaneously under a competitive environment, has not been addressed in SCs (see Table 1). To bridge this gap, we investigate the effect of marketing effort and pricing strategy under local service provider and online platforms competition.

(2) Most prior studies work on ride sharing by considering the commission price (Benjaafar et al. 2017; Kumar et al. 2018; Fang et al., 2020; Nourinejad & Ramezani, 2020). However, there are no studies available on marketing effort that show which platform (online platform or offline platform) will benefit SCs in a competitive environment. Further, it is important to understand the impact of the commission fee and marketing effort on supply chain profit. Thus, this study addresses this gap by considering the marketing effort and commission fee platforms in competitive environments. Additionally, we compare the transaction price, marketing effort, and SC profit in two competitive scenarios (for instance, case 1: service provider sets transactions price (Model S); and case 2: service enabler sets transactions price (Model E).

(3) Moreover, this paper considers a price- and marketing effort-dependent demand function. Accordingly, we developed a mathematical model based on Stackelberg game theory to consider marketing effort and pricing sensitivity demand under Model S and Model E and proposed the best possible decisions for service providers and service enablers to maximize their profit.

(4) We investigate the effect of market size, marketing effort, and commission fee on supply chain partners' decisions regarding optimal service. In the ridesharing platform, the total profit, service provider profit, and service enabler's profit are highest when price competition is present, and the lowest when it is not. When the Model S operates in a competitive environment, transaction prices are the lowest, as they are determined by the service providers who compete and deliver service to customers. Furthermore, we found that transaction price and total SCs profit increase as market size and marketing effort increase respectively.

## 3. Model

In a ridesharing supply chain involving a service enabler (Uber or Olla) and two service providers (taxi or car), we developed a model under competition to capture the optimal channel competition strategy (Fig.1). The ride service is provided by one of the service providers through a service enabler. We call the service provider 1(2) that provides the service1(2). For example, in a developing country like India, a local taxi driver (unorganized) at the railway station or bus station engages in RS by offering traditional rides in conjunction with online sharing platforms. While Uber uses real-time location information to coordinate rides between customers and taxi drivers. Service enablers are established as online P2P platforms that charge commission fees per transaction (Wang et al., 2016; Kumar et al., 2018). When a passenger requests a service, the service enabler assigns that request to the service provider who will take the least time to reach the passenger. The service enabler decides the transaction price based on the time and distance. Then, the service provider delivers higher service quality (service provider provides the best service as per the passenger's requirement) since service provider has a face-to-face interaction with the passenger. Here, we assume that the service enabler's service assistance costs include hiring knowledgeable drivers and managers, the use of dedicated software, and expending on service training programs; the service enabler can deliver additional service information to passengers by marketing effort. The overall quality of service provides to passengers, encompassing advertising, feedback collection, packaging, and delivery, is referred to as marketing effort (Wang et al., 2020; Asl-Najafi et al., 2022; Jena, 2022,). The service enabler makes information available for service provider 1, and the cost of providing the information service at level $h$ ($0 \leq h \leq 1$) can be denoted as $f(h)$, where $f(0) = 0$, $f'(h) > 0$, and $f''(h) > 0$. Following Ofek et al. (2011) and Zhang et al. (2020), we assume that the information service cost is quadratic in $h$, i.e., $f(h) = \frac{1}{2} m h^2$, where $m$ is a cost factor. This is well expressed in retailing, where higher service levels mean substantially higher prices. Here, we denote *he* and *she* for service provider and service enabler respectively throughout the paper.

Depending on the section of each ridesharing platform format by the service provider and service enabler, there are two alternatives' models under competition, as illustrated in Fig.1:

- *Service provider sets transaction price (Model S):* Under this model, service provider 1 sets their tour transaction price (a ride) and the service enabler provides online platforms to passengers for availing the service. Further service enabler is responsible for the marketing effort for the product service enabler wishes to sell. For example, The Ice

Enabler online platform is structured as a P2P platform that charges a commission per transaction. In this model, service providers set prices.

- *Service enabler sets transaction price (Model E).* Under this model, the service enabler sets the transaction price without competition and competition and the service provider delivers the service to the passenger. A service enabler uses this model to set up an online P2P platform that charges commissions per transaction and makes marketing efforts. In this model, the service enabler has price-setting power.

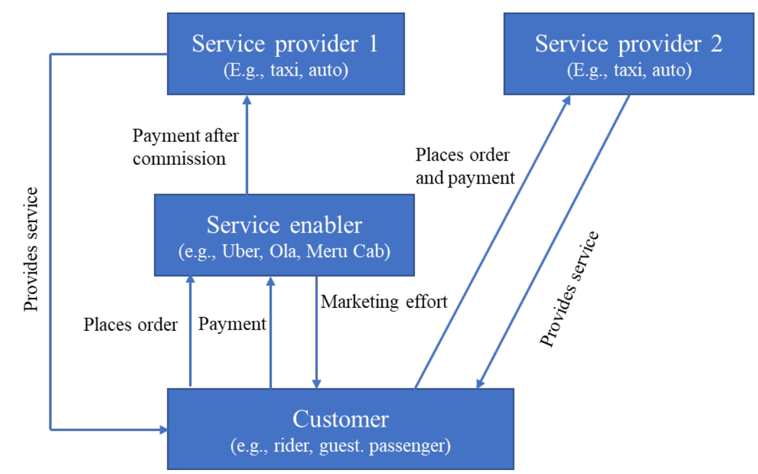


**Figure 1.** The ridesharing platform business model

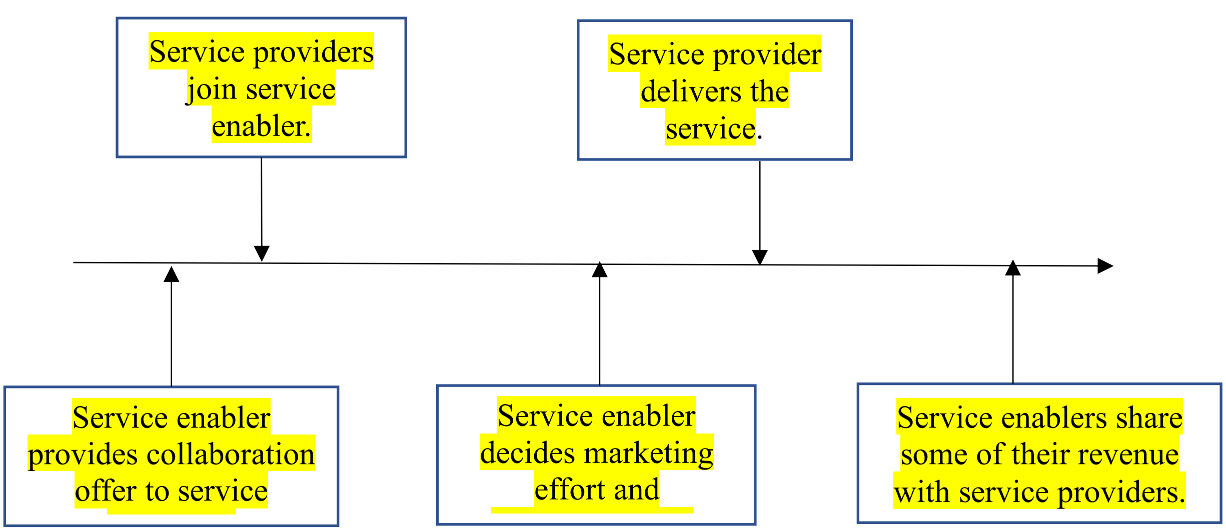


Fig 2. Sequence of the event

We assume that as service provider 1 provides services through Olla and Uber, it is considered an organized service provider. Conversely, we assume that service provider 2 is an unorganized service provider. Due to online service provider 1's effective payment system, providing bills, and doorstep service, some passengers switched from service provider 2 to service provider 1, even though the transaction price is higher. For example, Uber launched a wallet-based system in India. As a result, customers can essentially pay via debit card or net banking account, as well as via a credit card. This system has made it easier for customers to pay for their Uber rides. It also provides customers with an additional layer of security, as all sensitive information is handled by a third-party payment processor. This has resulted in increased customer satisfaction and loyalty. This study also explores the impact of price-setting power on supply chain profit considering the sharing platform. Thus, we considered deterministic demand for a better understanding of the power decision. In the traditional economy, demand is mainly affected by the price; in contrast, demand in a service enabler is affected by price, service, and capacity (Cachon et al., 2017; Bai et al., 2018; Benjaafar & Hu, 2020). Our demand model does not consider capacity since we assumed that the capacity between a local provider who provides direct service to passengers and a provider who provides services through a service enabler is the same service provider (Like, Fang et al., 2020; Gu et al., 2023). Furthermore, for understanding the impact of transaction price and commission price on supply chain, we assume that service providers have enough capacity for providing service to passengers (similar types of assumption taken by Fang et al., 2020; Wu et al., 2022; Guo et al., 2023). In addition, we assume that they increase transaction prices to compensate for demand and supply. In India, the transaction price is higher during peak hours (especially during office hours) (Surie et al., 2016; Kashyap and Bhatia, 2018, Shah, 2021). Finally, we assume that the service providers will choose their optimal price to maximize their profits. Here, service enablers enjoy more bargaining power than service providers where service enablers determine marketing effort and commission fee by using the response function of the service providers (Kumar, V., 2018; Fang et al., 2020; Hossain, 2020). The event of sequence of the model is shown in Fig. 2.

Moreover, prices are the only way to control capacity indirectly (Benjaafar & Hu, 2020). Another difference is that most of the literature considers traditional demand is static, while the sharing platform considers time-based demand (Banerjee et al., 2015; Zhang et al., 2017; Wang et al., 2022). In addition, we aim to understand the impact of marketing effort and transaction price on the SC's profit when there is competition between two service providers. Like other researchers, we have used a linear and deterministic approach for simplicity (Choi, 1991; Benjaafar et al., 2017; Bai et al., 2018, Zhong et al., 2019; Jena & Meena, 2022). The demand function is sensitive to price and service (i.e., marketing effort) during mathematical modelling and assumed to be in the following form:

Under competition

*Service provider 1*: $D_1 = (\alpha_1 - \beta_1 p_1 + \gamma_1(p_2 + h - p_1) + \theta h),$ (3.1)

*Service provider 2*: $D_2 = \big((\alpha_1 - \beta_2 p_2 + \gamma_2(p_1 - h - p_2)\big).$ (3.2)

Without competition (Benchmarking case):

$D = (\alpha_1 - \beta_1 p_1 + \theta h),$ where $\gamma_1 = 0$ (3.3)

Where $D_i$, $i$ =1, 2 and $p_i$, $i$ =1, 2 are the market demand and transaction prices for the different services of the service provider $i$ (= 1, 2), respectively. We can think of $\alpha_i$, $i$ =1, 2 as a parameter giving total potential market size (if prices were zero) for service provider 1 and provider 2, $\beta$ is the transaction price elasticity of the ride service. In contrast, γ represents the substitutability coefficient (cross-price elasticity) of the two services between two service providers. Based on Jeuland and Shugan (1988), it is assumed that $\alpha_{i,} > 0,\ \beta_{i,} > \ \gamma_i > 0,$ $i$ =1, 2, in the parameters of (3.1-3.3). Furthermore, the linear demand function is common in the economics and supply chain management literature (Choi, 1991; Asl-Najafi et al., 2022; Jena & Meena, 2022; Liu et al., 2023).

When service provider 2 enters the market and competes with service provider 1, new passengers (those who do not currently use service 1) will likely join service 1 and service 2. Therefore, service provider 1 has the same market share without and with competition. Different researchers have discussed this general assumption (Kumar et al., 2018; Alaei et al., 2020; Li & Szeto 2019;). Additionally, parameter $h$ measures the cost of providing information on the P2P platform, while parameter $\theta$ represents the marketing effort coefficient.

We also assumed that service provider 1 is more systematic and provides a better service (in terms of pick-up timing) through the service enabler than service provider 2. In developing countries like India, 90% of the local taxi services, such as unorganized taxi services, offer their service to customers (Kashyap & Bhatia, 2018; Goel & Haldar, 2020).

Subscripts $s_i$, $e$, and $N$ respectively indicate service provider i, ($i$ =1, 2), service enabler, and without competition, where $i$ =1, 2 are used throughout the paper. Mathematical models are developed using the following notation in Table 2.

**Table 2:** Summary of the model's notation

| **Notations** | **Description** |
|---|---|
| *Indices* | |
| $i$ | Indexing service providers 1 and 2 ($i$=1,2) |
| $S$ | Index of service provider sets transactions price (Model S) |
| $E$ | Index of service enabler sets transactions price (Model E) |
| $D_i$ | Market demand of service 1 (i=1,2) |
| $\pi_e$ | The profit of the service enabler |
| $\pi_{si}$ | Profit of the service provider i, (i= 1,2) |
| $\pi_T$ | Total supply chain profit |
| Wj and Cj | Represent without competition (W) and competition (C) for Model j, where j= S, E |
| *Parameters* | |
| $\alpha_i$ | Market share of the service provider i (i= 1,2) |
| $\beta_i$ | The coefficient of transaction price per ride service by service provider i |
| $\gamma_i$ | Services with cross-price elasticity |
| $\theta$ | Market effort per unit of service |
| $m$ | Given constant |
| $k_1$ | Servicing cost of the service provider 1 |
| $k_2$ | Servicing cost of the service enabler |
| $k_3$ | Servicing cost of the service provider 2 |
| $\theta$ | Cost factor for providing marketing effort |
| $N$ | Without competition |
| $\eta$ | Commission per transaction, $0 \leq \eta \leq 1$ |
| *Decision variables* | |
| $p_1$ | Transactions price of service provider 1 per ride |
| $p_2$ | Transactions price of service provider 2 per ride |
| $h$ | Marketing effort level for offering an online platform |

## 4. Model development

This section has developed mathematical models considering the following two situations: (a) *Model S* and (b) *Model E* without competition and with competition. The model is as follows:

*For Model S*:

*Without competition*

Service enablers have the following profit function:

$$\pi_e{}^W = D(\eta p_1 - k_2) - \frac{mh^2}{2} . \tag{4.1}$$

Service provider 1's profit function is as follows:

$$\pi_{s1}{}^W = D\big((1-\eta)p_1 - k_1\big). \tag{4.2}$$

In this model, the producer decides on the transaction price, demand, and marketing effort to maximize the nonlinear profit function. Equation 4.1 shows the first term represents the overall ride service revenue for the service enabler. The second term calculates the total service cost invested by service providers and the third term presents the overall marketing cost for passengers to use their service. For equation 4. 2, the first term represents the total revenue of the rider, while the second term indicates the total servicing costs invested by the service provider 1.

*Under competition:*

Service enablers have the following profit function:

$$\pi_e{}^C = D_1(\eta p_1 - k_2) - \frac{mh^2}{2}. \tag{4.3}$$

The profit function of service provider 1 can be written as:

$$\pi_{s1}{}^C = D_1\big((1-\eta)p_1 - k_1\big). \tag{4.4}$$

The profit function of service provider 2 can be written as:

$$\pi_{s2}{}^C = D_2\big((1-\eta)p_2 - k_3\big). \tag{4.5}$$

Equation 4.5 shows the first term represents the overall ride service revenue for the service provider 2. The second term calculates the total service cost invested by the service. Here we assumed that the service provider 2 (local driver) takes the cars/taxies on rent and provides a commission to the owners on a daily/monthly basis. In India, some businessmen, police officials, and professionals provide cars on rent and collect commissions from the drivers (Surie & Koduganti, 2016; Kashyap & Bhatia, 2018).

*For Model E:* In this case, the service enabler decides the transaction price considering the service cost of service provider 1. The service provider bears the cost of delivering a higher quality service to the passengers, including oil, payment, maintenance, etc. We considered the service provider's service cost is greater than the service enabler's service cost per ride (i.e., $k_1 > k_2$). Thus, the service enabler considers the service provider's cost($k1$) in their profit function while optimizing service enabler's profit function. This type of assumption has been discussed by many researchers (Kumar et al., 2018; Fang et al., 2020; Shah, 2021). Here, we assume that the service enabler considers competitors' market price (traditional service provider's transaction price) while deciding the transaction price. Therefore, the profit function of the service enabler can be written as:

$$\pi_e{}^W = D(\eta p_1 - k_1) - \frac{mh^2}{2}, \tag{4.6}$$

$$\pi_e{}^C = D_1(\eta p_1 - k_1) - \frac{mh^2}{2}. \tag{4.6a}$$

### *4.1. Without competition*

In this situation, there is no competition between service providers considered. The model reduces only to profit maximization concerning the service provider and the service enabler.

*4.1.1. Model S*

"Service provider 1 sets their transaction price and the service enabler provides online platforms to passengers for availing the service and puts marketing effort for providing information about their services. Here, the service enabler is set up as an online P2P platform that charges a commission per transaction. In this model, the service enabler can maximize service enabler's profit by calculating the corresponding marketing effort given the reaction function of the service provider."

Here, the service provider reaction function, given marketing effort $h,$ can be derived from the first-order condition of Eqn. (4.2)."

$$p_1 \in \arg \max_{p_1} \pi_{s1}{}^{WS}(p_1|h). \tag{4.7}$$

Since $\pi_S$ is concave (proof is given in Appendix A), it is solved by the first-order condition and the value of the price is as follows:

$$p_1{}^{WS} = \frac{1}{2}\left(-\frac{k_1}{-1+\eta} + \frac{h\theta+\alpha_1+(h+p_2)\gamma_1}{\beta_1+\gamma_1}\right). \tag{4.8}$$

The service enabler reaction function, given a transactions price $p_1{}^{WS}$ can be derived from the first-order condition of (4.1)."

$$h \in \arg\max_{h} \pi_e{}^{WS}(h|p_1). \tag{4.9}$$

Appendix B shows that $\pi_E$ is concave. Using the reaction function Eqs. (4.9), the service enabler's equilibrium marketing effort level can be derived following the first-order conditions of the respective service enabler's profit maximization problem of Eqn. (4.1).

$$h^{WS} = \frac{\theta(-(-1+\eta)\eta\alpha_1(\beta-\beta_1)+((-1+\eta)(\alpha\eta+k_2(\beta-2\beta_1))+\eta k_1(\beta-\beta_1))\beta_1)}{(-1+\eta)(\beta\eta\theta^2-2\eta\theta^2\beta_1+2m\beta_1^2)}. \tag{4.10}$$

Solving Eqns. (4.8 and 4.10) simultaneously, the optimal solution of $p_1{}^*$ and $h^*$can be determined.

$$h^{WS*} = \frac{\theta(-(-1+\eta)\eta\alpha_1(\beta-\beta_1)+((-1+\eta)(\alpha\eta+k_2(\beta-2\beta_1))+\eta k_1(\beta-\beta_1))\beta_1)}{(-1+\eta)(\beta\eta\theta^2-2\eta\theta^2\beta_1+2m\beta_1^2)}, \tag{4.11}$$

$$p_1{}^{WS*} = \frac{\alpha(-1+\eta)\eta\theta^2+(-1+\eta)\theta^2k_2(\beta-2\beta_1)-(\eta\theta^2-2m\beta_1)((-1+\eta)\alpha_1-k_1\beta_1)}{2(-1+\eta)(\beta\eta\theta^2-2\eta\theta^2\beta_1+2m\beta_1^2)}. \tag{4.12}$$

Finally, the demand, quantized for manufacturers*,* can be determined as:

$$D_1{}^{WS*} = (\alpha_1 - \beta_1 p_1{}^* + \theta h^*). \tag{4.13}$$

*4.1.2. Model E*

"The service enabler sets the transaction price considering the service cost of service provider 1, provides online platforms to passengers for availing the service and also puts marketing effort for providing information about their services.

Here, service enabler reaction function, given a marketing effort *h* and transaction price $p_1$ can be derived from the first-order condition of Eqn. (4.6).""

$$p_1, h \in \arg\max_{h,p_1} \pi_e{}^{WE}(h, p_1). \tag{4.14}$$

Since $\pi_E$ is concave (proof is given in Appendix C), it is solved by the first-order condition and the value of $p_1$ and *h* are as follows:

$$p_1{}^{WE} = \frac{1}{2}\left(\frac{k_1}{\eta} + \frac{h\theta+\alpha_1}{\beta_1}\right), \tag{4.15}$$

$$h^{WE} = \frac{-\theta(k_1-\eta p_1)}{1+m}. \tag{4.16}$$

Solving Eqns. (4.15and 4.16) simultaneously, the optimal solution of $p_1{}^*$ and $h^*$can be determined.

$$p_1{}^{WE*} = \frac{-(1+m)\eta\alpha_1 + k_1(\eta\theta^2 - (1+m)\beta_1)}{\eta(\eta\theta^2 - 2(1+m)\beta_1)}, \tag{4.17}$$

$$h^{WE*} = \frac{-\eta\theta\alpha_1 + \theta k_1\beta_1}{\eta\theta^2 - 2(1+m)\beta_1}. \tag{4.18}$$

Finally, the demand quantity for service enablers can be determined as:

$$D_1{}^{WE*} = (\alpha_1 - \beta_1 p_1{}^* + \theta h^*). \tag{4.19}$$

**Proposition 1**: *The rate of change in the service provider's price of a ride with the market size is half under model S and model E, when β=1.*

"In Proposition 1, the transaction price of service increases by half to improve passenger service, when the rate of increase in demand is one. It is important for the service provider to spend more on quality in order to attract quality-conscious and price-sensitive passengers. Furthermore, service enablers and service providers spend more on marketing and technology (such as mobile apps) to provide the best service to customers (Hossain et al., 2017; Cheng et al., 2020). For example, customers should have no difficulty accessing the app (Shah, 2021). Additionally, customers can book the cars in advance at anytime and anywhere with the ride fare information. The app allows customers to track their ride in real-time and provides them with an estimate of their arrival time. It also offers the option to pay for their rides in cash or with their debit/credit card.

**Proposition 2**: *When k >0, and* $\eta \in [0,1)$, *the rate of transaction price with commission fee increases under Model S, whereas the rate of transaction price with commission fee under model E decreases, when k >0, and* $\eta > 0$.

Proposition 2 states that the rate of change in the transaction price of service increases with commission fee under Model S when commission fee is less than 1. Since the service provider sets the transaction price and the service enabler sets the commission price. If the commission fee increases, the service provider increases the transaction price to compensate for the cost and maintain the balance of profit (Kumar.V et al., 2018; Li et al., 2019; Shah, 2021). However, under model E, the rate of transaction price with commission fee decreases as $\eta$ increases. Since service enabler wants to attract all types of passengers, that tends to increase the demand."

**Proposition 3**: *The rate of marketing effort under Model S and Model E with commission fee increases when k >0 and* $\eta > 0$.

“Proposition 3 states that the rate of change in the marketing effort of service increases with commission fee under both models since the service provider sets the transaction price and offers an online platform to passengers for obtaining a better service. As the commission fee increases, the service enabler takes more responsibility to handle the uneven demand. Ride-sourcing firms have the ability to adjust their fares according to demand, unlike local cars, which are set at preapproved prices by the government. Estimates are based on the place, type of taxi, distance, time of day, and number of days and nights (Hossain, 2020; Shah, 2021). In addition, service enablers inform the customer about their services' benefits through marketing efforts as commission price increases.

### *4.2. Competition*

In this situation, there is competition between service providers. The model reduces only profit maximization for the service providers and the service enabler. Here, the service enabler considers the service provider’s transaction price function while determining the marketing effort and riding price of service enabler’s service.

#### *4.2.1. Model S*

Service provider 1 sets their transaction price and the service enabler provides online platforms to passengers for availing the service. Here, the service enabler is set up as an online P2P platform that charges a commission per transaction. In this model, the service enabler can maximize service enabler’s profit by calculating the corresponding marketing effort given the reaction function of service provider 1 and 2.

Here, service providers 1 and 2 reaction function, given marketing effort *h* can be derived from the first-order condition of Eqn. (4.4 and 4.5).”

$$p_1 \in \arg\max_{p_1} {\pi_{s1}}^{CS}(p_1|h, p_2), \quad (4.20)$$

$$p_2 \in \arg\max_{p_2} {\pi_{s2}}^{CS}(p_2|h, p_1). \quad (4.21)$$

Since $\pi_{s1}$ and $\pi_{s2}$ are concave (proof is given in Appendix D), it is solved by the first-order condition and the value of price is as follows:

$$p_1{}^{CS} = \frac{1}{2}\left(-\frac{k_1}{-1+\eta} + \frac{h\theta+\alpha_1+(h+p_2)\gamma_1}{\beta_1+\gamma_1}\right), \tag{4.22}$$

$$p_2{}^{CS} = \frac{\alpha_2+k_3\beta_2+(-h+k_3+p_1)\gamma_2}{2(\beta_2+\gamma_2)}. \tag{4.23}$$

"Solving (4.22-4.23) simultaneously, one can determine the equilibrium value of $p_1$ and $p_2$. The service enabler reaction function, given a transaction price $p_1$ and $p_2$ can be derived from the first-order condition of (4.3)."

$$h \in \arg\max_h \pi_e{}^{CS}(h|p_1, p_2). \tag{4.24}$$

"Appendix E shows that $\pi_E$ is concave. Using the reaction function Eqs. (4.24), the service enabler's equilibrium marketing effort level and transactions price can be derived following the first-order conditions of the respective service enabler's profit maximization problem of Eqn. (4.3)."

$$h^{CS} = \frac{A+\eta\gamma_1(-2(-1+\eta)\alpha_2+k_1\gamma_2-2(-1+\eta)k_3(\beta_2+\gamma_2))+(-1+\eta)k_2(4\beta_1(\beta_2+\gamma_2)+\gamma_1(4\beta_2+3\gamma_2)))}{B(2\eta\theta^2-4m\beta_1+C+(-9m+8\eta\theta+2\eta\beta_1)\gamma_1^2+2\eta\gamma_1^3)\gamma_2^2)}. \tag{4.25}$$

$$A = (\beta_1+\gamma_1)(2\beta_2(\theta+\gamma_1)+(2\theta+\gamma_1)\gamma_2)(-4(-1+\eta)\eta\alpha_1(\beta_2+\gamma_2)$$
$$B = (-1+\eta)(8\beta_2^2(\beta_1+\gamma_1)(\eta\theta^2-2m\beta_1+\gamma_1(-2m+2\eta\theta+\eta\gamma_1))+8\beta_2(\beta_1+\gamma_1)$$
$$C = 8\beta_1(\eta\theta^2-2m\beta_1)+8(\eta\theta^2+(-3m+\eta\theta)\beta_1)\gamma_1$$

Solving Eqns. (4.22, 4.23, and 4.25) simultaneously, the optimal solution of $p_1{}^{CS*}$, $p_2{}^{CS*}$ and $h^{CS^*}$ can be determined. Finally, the demand quantized for manufacturer*s* can be defined as:

$$D_1{}^{CS*} = \alpha_1 - \beta_1 p_1{}^{S^*} + \gamma_1(p_2{}^{S^*} + h^{S*} - p_1{}^{S*}) + \theta h^{S*} \tag{4.26}$$

*4.2.1. Model E*

The service enabler sets the transaction price considering the service cost of the service provider, provides online platforms to passengers for availing the service, and puts marketing effort into providing information about their services.

Here, the service enabler takes service provider 2's reaction function into consideration of their respective price decisions. Here, service provider 2's reaction function, given $h$ and $p_1$ can be derived from the first-order condition of (4.5)."

$$p_2 \in \arg\max_{p_2} \pi_{s2}{}^{CE}(p_2|h, p_1). \tag{4.27}$$

Since $\pi_{s2}{}^{CE}$ is concave (proof is given in Appendix D), it is solved by the first-order condition and the value of the price is as follows:

$$p_2{}^{CE} = \frac{\alpha_2+k_3\beta_2+(-h+k_3+p_1)\gamma_2}{2(\beta_2+\gamma_2)}. \tag{4.28}$$

The service enabler reaction function, given transaction price $p_2$ can be derived from the first-order condition of (4.6a)."

$$p_1, h \in \arg\max_{h} \pi_e{}^{CE}(h|p_1, p_2). \tag{4.29}$$

"    Appendix F shows that $\pi_E$ is concave. Using the reaction function Eqs. (4.29), the service enabler's equilibrium marketing effort level and transaction price can be derived following the first-order conditions of the respective service enabler's profit maximization problem."

$$p_1{}^{CE} = \frac{\eta\alpha_2\gamma_1+\beta_2(2h\eta\theta+2\eta\alpha_1+\eta(2h+k_3)\gamma_1+2k_1(\beta_1+\gamma_1))+(2h\eta\theta+2\eta\alpha_1+\eta(h+k_3)\gamma_1+k_1(2\beta_1+\gamma_1))\gamma_2}{4\eta\beta_1(\beta_2+\gamma_2)+2\eta\gamma_1(2\beta_2+\gamma_2)}, \tag{4.30}$$

$$h^{CE} = \frac{-(k_1-\eta p_1)(2\beta_2(\theta+\gamma_1)+(2\theta+\gamma_1)\gamma_2)}{2m(\beta_2+\gamma_2)}. \tag{4.31}$$

Solving Eqns. (4.28, 4.30, and 4.32) simultaneously, the optimal solution of $p_1{}^{CE*}$, $p_2{}^{CE*}$, and $h^{CE^*}$ can be determined.

**Proposition 4.** In an equilibrium condition**,** the ordinal relationship between the transaction price under both models is as follows: $p^E > p^S$. Whereas $p^E < p^S$ while $\eta \geq 0.5$. In both models, the marketing effort level for providing service information about a ride is correlated as follows: $h^E < h^S$.

Proof: See the Appendix.

Proposition 4 shows that the transaction price is higher in *Model E* compared to *Model S* since the service provider interacts with passengers directly and knows the market value better when compared to the service enabler. Further, the service enabler becomes unclear concerning price setting because of the heterogeneity of passengers and does not have direct control over resources. However, the service enabler sets the commission fee and provides an online platform to attract the right users. When the commission fee exceeds 0.5, the transaction price is higher in *Model S* than *Model E*. This means that the service provider sets a higher price to compensate the cost as well as to generate more profit, though the service enabler offers extra bonuses to drivers if the number of rides exceeds a certain threshold (Kumar et al., 2020). Comparatively, the marketing effort is higher in *Model S* compared to *Model E*. This means the service enabler tries to exert higher marketing effort because of lower involvement in price setting and boosting passenger loyalty.

**Proposition 5.** *Under equilibrium conditions, both models have the following ordinal relationship between total supply chain profit:* ${\pi_T}^S > {\pi_T}^E$.

Proof: See the Appendix.

“ It is clear from Proposition 5 that Model S makes a better profit for the entire supply chain, but it is worse off in *Model E* since the service provider and service enabler generate a higher profit in Model S than Model E. This happens because of the lower price, better service quality, and higher market effort, which leads to higher demand. Moreover, the higher market efforts and lower commission fee encourage service providers to make a collaboration business. For example, in India service providers are businesspersons, police officials and professionals who have a car and work with Uber and Ola by paying a fixed salary to the driver (Kashyap & Bhatia, 2018). As a result, service providers make more money due to higher revenue and lower ride costs. Therefore, *Model S* creates a win-win situation compared with *Model E*.

**Proposition 6.** In a competition scenario, transaction prices $p_i, i = 1, 2,$ of service providers 1 and 2 increase as market size, $\alpha_i, i = 1, 2,$ increases.

Proof: See the Appendix.

It is observed that the transaction price increases as the market size increases. As the market grows, demand for the service also increases. This leads to service providers receiving more requests than they can handle (Kashyap & Bhatia, 2018; Shah, 2021; Yan et al., 2021). Consequently, they increase transaction prices to compensate for demand and supply. In India, the transaction price is higher during peak hours (especially during office hours) (Surie et al., 2016; Kashyap and Bhatia, 2018, Shah, 2021). This encourages service providers to work during peak hours, resulting in better customer service. This arrangement has improved the quality of service and increased customer satisfaction (Shah, 2021). In addition, service enablers inform the customer about their services' benefits through marketing efforts. Therefore, the demand for the service increases, resulting in increased profits for SCs.

## 5. Numerical Example and Results

An illustration of the model is provided in this section through a numerical study. Since real-time data on the multi-attribute variables was difficult to find, we used hypothetical but relevant data. We validate the models by initializing most parameters by referring to the existing literature (Kashyap & Bhatia, 2018; Li. et al., 2019; Gupta & Ivanov, 2020). The experts' opinions (managers and supervisors having minimum 10 years' experience) are used to generate some parameters, such as those that relate to $m$ and $\eta$. These parameters are set as follows, $\alpha_1 = 15, \alpha_2 = 10, \beta_1 = 2.5, \beta_2 = 1, \gamma_1 = 1, \gamma_2 = 0.5, \theta = 1, k_2 = 0.05, k_1 = 0.2, k_3 = 0.6, m = 50, \eta = 0.2$.

**Table 3:** Summary results of Model S and E under with and without competition

| | ***Without competition*** | | ***With competition*** | |
|---|---|---|---|---|
| ***Model*** | ***Model S*** | ***Model E*** | ***Model S*** | ***Model E*** |
| $p_1$ | 3.12 | 3.501 | 2.860 | 3.299 |
| $p_2$ | …… | ….. | 4.106 | 4.180 |
| $h$ | 0.011 | 0.009 | 0.019 | 0.016 |
| $\pi_e$ | 4.130 | 3.127 | 4.759 | 3.518 |
| $\pi_{s1}$ | 16.550 | 16.275 | 19.075 | 18.701 |
| $\pi_{s2}$ | ---- | …… | 18.445 | 19.228 |
| $\pi_T$ | **20.690** | **19.402** | **42.281** | **41.448** |

**Table 4:** Impact of θ and η on SCs profit under competition

| Total SCs profit | | | | | | | |
|---|---|---|---|---|---|---|---|
| $\theta$ | Model S | Model E | % change | $\eta$ | Model S | Model E | % Change |
| 0.8 | 42.270 | 41.438 | 1.968 | 0.2 | 42.281 | 41.448 | 1.970 |
| 1.0 | 42.281 | 41.448 | 1.970 | 0.4 | 42.281 | 41.448 | 1.970 |
| 1.2 | 42.291 | 41.458 | 1.969 | 0.6 | 42.281 | 41.448 | 1.970 |
| 1.4 | 42.301 | 41.468 | 1.969 | 0.8 | 42.281 | 41.448 | 1.970 |
| 1.6 | 42.311 | 41.478 | 1.968 | 1.0 | 42.281 | 41.448 | 1.970 |

The results in Table 3 show that the total profit, service provider and service enabler's profit in the ridesharing platform are highest under price competition, whereas they are least without price competition. Table 3 shows that transaction prices are lowest in *Model S* under a competitive environment since it is determined by the service providers, who compete and deliver the service to passengers. Further, with Model E, the service enabler sets the price and commission price in order to reduce the friction between demand and supply during peak hours. Due to this, some passengers prefer to use the traditional process. Further, it is observed that when commission prices increase from 0.2 to 1.0, Model S is 1.9 times higher than Model E (see Table 4). This indicates that Model E is less attractive, even when the commission price is lower. Therefore, Model S may be more suitable when demand is high, as it can provide flexibility and better returns for the service enabler. Therefore, the ratio of total SC profit in Model S to Model E remains unchanged, while the commission price does not affect SC profit. In this case, service enablers' profits may decline in proportion to their increased service providers' profits as commissions increase, causing SC profits to remain unchanged. It is also observed that the profit of the service enabler and service provider obtains higher profit in Model S compared to Model E under both situations (see Table 3). This happens because of the lower transaction price and higher market effort, which causes higher demand. Hence, they attract more price-sensitive passengers. Consequently, the service provider creates more value by using their price-setting power. The service provider has superior information about the quality of the service and can assess the value better than the service enabler. Our result provides similar insights to Chen et al. (2020), and Kumar et al. (2020) who claim that the service provider price-setting mechanism is most effective."

**Table 5:** Interpretation of the significant result from Table 3

| Decision Variable | Comparison result | Comments |
|---|---|---|
| Transaction price | ${p_1}^{CE} > {p_1}^{WE} > {p_1}^{WS} > {p_1}^{CS}$<br>${p_2}^{CE} > {p_2}^{CS}$ | *Model E* dominates *Model S* under both with and without competition. |
| Market effort level | $h^{CS} \geq h^{CE} > h^{WS} > h^{WE}$ | *Model S* dominates *Model E* under both with and without competition. |
| Service provider's profit | ${\pi_{s1}}^{CS} > \pi_{s1}C^{E} > {\pi_{s1}}^{WS} > {\pi_{s1}}^{WE}$<br>${\pi_{s2}}^{CE} > {\pi_{s2}}^{CS}, \pi_{s1} > \pi_{s2}$ | *Model S* is better than *Model E* for service provider 1, but reverse the case for service provider 2<br>Profit of service provider *1* > Profit of service provider *2* |
| Service enabler's Profit | ${\pi_e}^{CS} > {\pi_e}^{WS} > {\pi_e}^{CE} > {\pi_{s1}}^{WE}$ | The *Model S* generates a higher profit in both cases. |

| | | |
|---|---|---|
| Total SC Profit | $\pi^{CS} > \pi^{CE} > \pi^{WS} > \pi^{WE}$ | Competitive models generate higher profits than non-competitive models |

However, the total profit is substantially high in Model S compared to the other three models. When two service providers compete and choose different service formats, the service providers who collaborate with service enablers enjoy greater profits. Since Model S has a low transaction price and a higher market effort in comparison to Model E, it increases demand. Table 4 shows that the percentage change in profit between Model S and Model E is constant or slightly decreases depending on the marketing effort. In contrast, service providers who directly provide the service to customers make greater profits under Model E. We found similar insights to those offered by Zhong et al. (2019), Yan et al. (2021), and Kumar et al. (2020) that a service provider offering ridesharing should integrate with a service enabler to capture more market share. Table 5 summarizes the major findings. Accordingly, the preferred option for a price-sensitive customer would be to drive *Model S* on the ride sharing platform, instead of the other three.

### *5.1.Sensitivity analysis*

A sensitivity analysis was conducted to examine the impact of various parameters on the model.

#### *5.1.1.Impact of marketing effort coefficient*

Firstly, we analyze the effects of the marketing effort coefficient on the total SC profit for both models and determine how it affects them. It has been observed that profits increase with an increase in marketing effort across all channels (see figure 3), so that total profits increase. As the market size increases and marketing efforts increase, the demand for online-platform service in Model S will rise, resulting in a higher level of revenue for Model S than for the other model due to a higher level of market demand. In addition, as the marketing effort increases, the profit of the service enabler and the service provider rises as well. Furthermore, passengers perceive that online service maximizes their utility.

#### *5.1.2.Impact of commission fee*

First, we study the influence of commission fee ($\eta$) on SC profit for both models. It is observed that the total profit increases as the commission fee increases under Model E (See Fig. 4). Conversely, when the commission fee increases over a particular threshold value (0.5), the total profit for the *Model S* decreases significantly compared with that in the *Model E*. This happens because the higher transaction price and lower marketing effort cause lower market demand. Further, the service provider's profit decreases as the commission fee increases, though the service enabler's profit increases. The service enabler gains higher profit as commission fees exceeds certain threshold value 0.5, whereas the service provider 1 gains lower profit as commission fees increase in Model S. For increasing service provider's profit, service enablers spend more effort on advertising for capturing more customers. This shows that model E is more profitable for both service providers and service enablers when commission price exceeds a certain threshold value (0.5). Moreover, the increased effort in advertising can also help to increase the customer base and improve customer loyalty. This highlights the importance of finding the optimal commission fee, as it can significantly affect the total profit of the business.

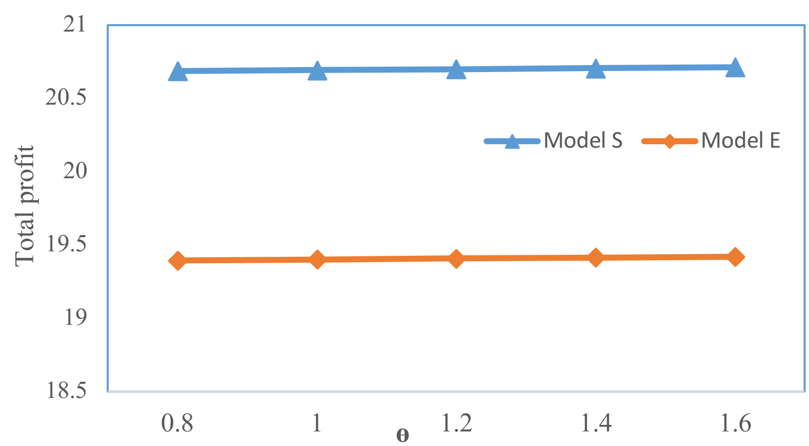


Fig.3.Total SC profit for different model with marketing effort co-efficient ($\theta$)

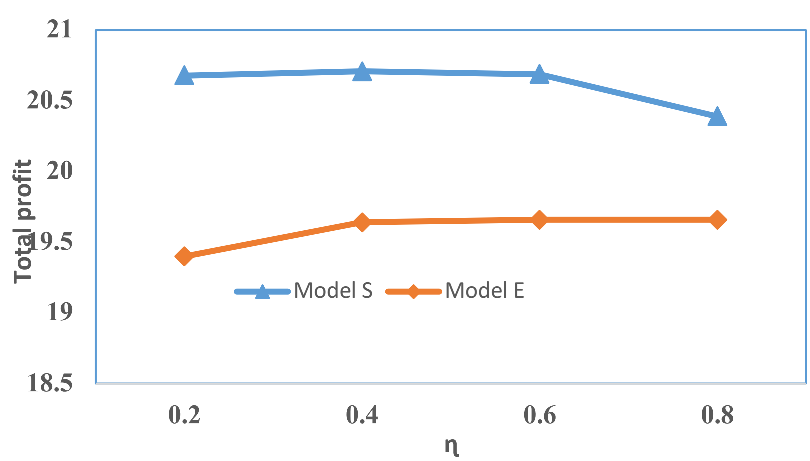


Fig.4.Total SC profit for different model with different value of commission fee (η)

## 6. Managerial Implications

This work provides managerial insights. Our model will allow managers of ride sourcing organisations (such as Ola, Ube) and service providers (taxi owner or taxi driver) to understand how they decide their commission fee and ride price when they compete with an unorganized service provider (local taxi service provider) and without competition. Additionally, our study helps both service providers and service enablers decide who sets the transaction price and commission fee to maximize supply chain profit. Moreover, our study provides insights into the optimal transaction pricing and commission fee structure to ensure that everyone in the supply chain is able to gain the highest possible value from the transaction. This helps to maximize profits for service providers and service enablers involved in the transaction. If the commission fee is higher than a certain threshold value, the profit of the service provider 1 will decrease whereas the profit of the service enabler will increase, which discourages service providers to continue the business with the service enabler. If service enablers charge the optimal commission fee and provide other benefits such as service freedom, health insurance, bonus etc. service enablers can collaborate with service providers through the sharing platform (Kumar, V, et al., 2018; Li et al., 2021; Jena & Meena, 2022).

Furthermore, micro and small service providers can also embrace the ride sharing process when facing a financial crisis. This is if they did not get an appropriate transaction price and on time. Service providers rely on frequent cash transactions in everyday life. For example, Uber and Ola cabs in India offer work for drivers every day of the week, but their payment intervals differ (Surie & Kodugaganti, 2016). Furthermore, it is observed that for a well-functioning business model on the ride sharing platform, concurrently developing customers and service providers is critical (Kumar et al., 2018). Thus, service enablers need to develop a marketing strategy to meet the channel's specific structure and passengers' expectations. It has been proven that transparency services can be effective strategies to encourage passengers to use the online service process, especially if they are hesitant to do so. This role of transparency services is also addressed by some previous studies (e.g., Surie & Kodugaganti, 2016, Kumar, 2018; Shah, 2021). Further, proposition 6 shows higher marketing effort and lower transaction prices create a larger market share. As a result, demand increases. This result helps sourcing managers invest more in the marketing effort to increase demand.

As mentioned in the previous section, a sensitivity analysis may provide insights into reducing marketing effort and commission fees. The sensitivity analysis unravels the impact of allotted marketing effort on overall SC profit. With increasing marketing effort and commission fee, total cost increases, but total SC profit decreases. So, if an organization only wants to increase total profit through marketing effort, then it will be smart to move for the channel integration process. Moreover, when service providers determine transaction price and commission fee, the profit of the whole supply chain is higher than when service enabler set the transaction price and commission price. That means, the manager of ride sourcing should collaborate with service providers to decide the commission fee and transaction fee. But when an organization only wants to increase profit with marketing effort and does not receive commissions, it allocates more resources for service quality. This is when marketing effort costs start to improve. When commission fees are low, the service enabler's ability to share commission is an effective threat to prevent the service provider from entering an offline platform. Depending on ridesharing quality, the service enabler's threat effectiveness will vary. Specifically, the service enabler's threat is valid if the commission fee is low, and the marketing effort is high. Consequently, this research recommends that marketing and operations managers of ride-sourcing companies implement optimal commission fees and marketing efforts.

## 7. Conclusion and Future scope

“This paper investigated the impact of the price-setting power mechanism and competition on total supply chain profit in dual service providers and single service enablers under the ridesharing platform. We developed and solved four models where different decisions were considered: (1) service provider sets transaction price (*Model S*); and (2) service provider sets transaction price (*Model E*). Five main contributions have been made to the existing literature. Firstly, this paper incorporates the ridesharing platform in an SC context. Secondly, it applies the price-setting game between the service provider and service enabler under a competitive environment (Furuhata et al., 2013; Martins et al.,2021; Yan et al., 2021). Thirdly, the paper addresses the impact of a marketing effort on supply chain profit under the different price-setting mechanisms. Fourthly, it was found that the total profit, service provider and service enabler’s profit in the ridesharing platform are highest under price competition. Lastly, unlike Agatz et al. (2012) and Yan et al. (2021), our work combines the ridesharing and marketing effort into a competitive SC and reveals that when service providers set their tour transactions price (a ride), the total SC profit increases as the commission fee increases."

Comparisons of equilibrium profits across models has provided important new results. We find that the service provider's profit, service enabler's profit, and total SC profit under price competition are higher than the scenario without price competition. Furthermore, *Model S* is beneficial to supply chain players compared to *Model E* under price competition and without price competition. This means that when service providers set the ride price and the service enabler puts in marketing effort, both players in the supply chain realize higher profit (this addresses RQ1). Again, it is found that the total profit increases as the commission fee increases under both models. However, it decreases in Model S as commission fees exceed a certain threshold (0.5). Therefore, the service provider and service enabler should prefer Model S when the commission fee is less than a certain threshold value. Thus, when the commission fee increases over a particular threshold value (0.5), the total profit for *Model S* decreases significantly compared with that in *Model E* (this addresses RQ2). Furthermore, we developed the equilibrium strategy for service providers and service enablers. Moreover, it is observed that the total supply chain profit increases as marketing effort increases in both price power settings. However, Model S generates a higher profit as marketing efforts increase (this addresses RQ3). Here it is observed that the profit of the service enabler and service provider is higher in Model S than Model E in both situations. Further, the service provider creates more value by using price-setting power. The service provider has superior information about the service quality and can assess the value better than the service enabler. Our result provides similar insights to Chen et al. (2020), and Kumar et al. (2020) who claim that the service provider price-setting mechanism is most effective. We conclude that the service provider has the most effective pricing power when it comes to creating value. It is essential for service providers to leverage this power to maximize their profits and keep customers satisfied.

Considering the problem-solution approach explored in this paper, this work has some limitations. First, we considered a price, capacity, and service sensitive demand function. In reality, demand for some goods is uncertain and dynamic and does not follow this rule. Therefore, understanding dynamic pricing under various price-setting mechanisms is critical. Furthermore, while this article focuses on the price competition between service providers, it is essential to understand the impact of price competition between service enablers on supply chain profit. We have assumed in this study that the service enabler considers the service cost of service provider 1 when setting the price, which may not always be feasible. Therefore, it is important to understand how the ridesharing platform impacts the SC profit when considering her own costs in the profit function. Further, for simplifying the model and understanding the transaction price and service impacts on the supply chain, we have not considered capacity constraints in our model. However, it is interesting to consider the capacity constraint and its impact on supply chain profits. In this study, we have discussed the competition between organised service providers and unorganised service providers considering ridesharing platforms. Furthermore, we have analysed the impact of marketing effort cost and commission fee impact on the total profit. However, it is interesting to understand the impact of service enabler service on service providers' profit. Another interesting research direction would be to examine how surge pricing affects supply and demand in the ridesharing platform."

**Appendix**

Appendix A

$$\frac{\partial^2 \pi_{s1}}{\partial {p_1}^2} = 2(-1+\eta)\beta_1 < 0$$

Accordingly, the service provider's profit function is strictly concave in $p_1$.

Appendix B

$$\frac{\partial^2 \pi_E}{\partial h^2} = -m + \frac{\eta\theta\left(\theta - \frac{\beta\theta}{2\beta_1}\right)}{\beta_1} < 0$$

Accordingly, the service provider's profit function is strictly concave in *h*.

Appendix C

$$H(p_1, h) = \begin{pmatrix} \frac{\partial^2 \pi_E}{\partial {p_1}^2} & \frac{\partial^2 \pi_s}{\partial p_1 \partial h} \\ \frac{\partial^2 \pi_s}{\partial h \partial p_1} & \frac{\partial^2 \pi_E}{\partial h^2} \end{pmatrix} = \begin{pmatrix} -2\eta\beta_1 & \eta\theta \\ \eta\theta & -m \end{pmatrix}$$

Here, $-2\eta\beta_1 < 0$ and $H(p_1, h) < 0$. Hence, the Hessian matrix is negative definite. Thus, the service provider's profit function is strictly concave in $p_1$ and *h*.

Appendix D

$$\frac{\partial^2 \pi_s}{\partial {p_1}^2} = 2(1-\eta)(-\beta_1 - \gamma_1) < 0$$

Accordingly, the service provider's profit function is strictly concave in $p_1$

$$\frac{\partial^2 \pi_{s2}}{\partial {p_2}^2} = -2\beta_2 - 2\gamma_2 < 0$$

Accordingly, the service provider's profit function is strictly concave in $p_2$.

Appendix E

Like *Appendix B*, here, the Hessian matrix is negative definite. Accordingly, the service enabler's profit function is strictly concave in $h$.

Appendix F

$$H(p_1, h) = \begin{pmatrix} \frac{\partial^2 \pi_E}{\partial {p_1}^2} & \frac{\partial^2 \pi_s}{\partial p_1 \partial h} \\ \frac{\partial^2 \pi_s}{\partial h \partial p_1} & \frac{\partial^2 \pi_E}{\partial h^2} \end{pmatrix} = \begin{pmatrix} \eta(-2\beta_1 + \gamma_1(-2 + \frac{\gamma_2}{\beta_2 + \gamma_2})) & \eta(\theta + \gamma_1(1 - \frac{\gamma_2}{2(\beta_2 + \gamma_2)})) \\ \eta(\theta + \gamma_1(1 - \frac{\gamma_2}{2(\beta_2 + \gamma_2)})) & -m \end{pmatrix}$$

Here, $\eta(-2\beta_1 + \gamma_1(-2 + \frac{\gamma_2}{\beta_2+\gamma_2})) < 0$ and $H(p_1, h) < 0$. Thus, the Hessian matrix is negative definite. Thus, the service provider's profit function is strictly concave in $p_1$ and *h*.

**Proposition 1**

*For Model S*

$\frac{\partial p_1}{\partial \alpha_1} = \frac{1}{2}$ when $\beta = 1$

*For Model E*

$\frac{\partial p_1}{\partial \alpha_1} = \frac{1}{2}$ when $\beta = 1$

**Proposition 2**

*Model E*

$\frac{\partial p}{\partial \eta} = -\frac{\mathrm{k}}{2\eta^2} < 0$

*Model S*

$\frac{\partial p}{\partial \eta} = \frac{k}{2(-1+\eta)^2} > 0$, when $k$ >0, and $\eta \in [0,1)$

**Proposition 3**

*For Model S*

$$\frac{\partial h}{\partial \eta} = \frac{\beta\theta(2m\alpha - \theta^2 k)}{(-2m\beta + \eta\theta^2)^2}$$

*Model E*

$$\frac{\partial h}{\partial \eta} = \frac{\theta(-\theta^2 k + 2(1+m)\alpha)\beta}{(\eta\theta^2 - 2(1+m)\beta)^2}$$

**Proposition 4:**

$h^s - h^E = \frac{2\beta(-k\beta+\alpha\eta)\theta}{(2m\beta-\eta\theta^2)(2(1+m)\beta-\eta\theta^2)} > 0$, as $.m > \alpha > \beta > \eta > 0$

$p^s - p^E = \frac{2m(\alpha+k\beta-\alpha\eta)-k\theta^2}{2(-1+\eta)(-2m\beta+\eta\theta^2)} + \frac{(1+m)(k\beta+\alpha\eta)-k\eta\theta^2}{\eta(-2(1+m)\beta+\eta\theta^2)} < 0$ , when $\eta < 0.5$, k > 0

**Proposition 5**

$\pi_T{}^s - \pi_T{}^E = \frac{2(1+m)^2\beta(k\beta-\alpha\eta)(\alpha(-2+\eta)\eta}{2\eta^2(-2(1+m)\beta+\eta\theta^2)^2} > 0$

**Proposition 6:**

$\frac{\partial p_1{}^S}{\partial \alpha_1} = \frac{1}{2(\beta_1+\gamma_1)} > 0$, Because $\beta_1 > \gamma_1 > 0$. $\frac{\partial p_2{}^S}{\partial \alpha_2} = \frac{1}{2(\beta_2+\gamma_2)} > 0$, Because $\beta_2 > \gamma_2 > 0$.
$\frac{\partial p_1{}^E}{\partial \alpha_1} = \frac{\beta_2+\gamma_2}{2\beta_1(\beta_2+\gamma_2)+\gamma_1(2\beta_2+\gamma_2)} > 0$, Because $\beta_1 > \gamma_1 > 0$. $\frac{\partial p_2{}^E}{\partial \alpha_2} = \frac{1}{2(\beta_2+\gamma_2)} > 0$, Because $\beta_2 > \gamma_2 > 0$.

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