Advances in Industrial Engineering, June 2026, 60(1): 93-123
DOI: 10.22059/aie.2026.397478.1948
RESEARCH PAPER

Service Price Optimization in Ride-Hailing Company and Its Coordination with Insurance Company by Revenue-Sharing Contract

Hamideh Bahrami[1], Saeed Yaghoubi[2*] and Maryam Ghanbarzadeh-Roudbaraki[3]

[1] *Ph.D. Candidate, School of Industrial Engineering, Iran University of Science and Technology, Tehran, Iran.*
[2] *Professor, School of Industrial Engineering, Iran University of Science and Technology, Tehran, Iran.*
[3] *M.Sc., School of Industrial Engineering, Iran University of Science and Technology, Tehran, Iran.*

Received: 22 June 2025, Revised: 27 January 2026, Accepted: 10 February 2026

Abstract

This article proposes a mathematical model to examine service pricing in ride-hailing companies and the relationship between ride-hailing and insurance companies, in which insurance is viewed as a competitive advantage. The ride-hailing company insures its drivers, customers, and cars with the insurance company, ensuring that the insurance company will compensate the affected parties in the event of an accident during travel. This study addresses the importance of hygiene in ride-hailing cars, given the impact of epidemics such as COVID-19 on transportation service prices. The interaction between the ride-hailing and insurance companies is modeled using a Stackelberg game in three scenarios: decentralized, centralized, and a coordination game under revenue-sharing contracts. The ride-hailing company decides on insurance and hygiene-level, while the insurance company determines the base entrance premium to interact with the ride-hailing company. This model allows ride-hailing companies to optimize their profitability and decision-making, and provide safe and reliable services to their customers. The study is validated using information from Lyft. The result shows that the revenue-sharing contract between the ride-hailing company and the insurance company increases the profits of both companies. This article provides a framework for ride-hailing companies to gain a competitive advantage by coordinating with insurance companies and ensuring the safety and hygiene of services.

Keywords:
Pricing,
Game Theory,
Hygiene,
Covid-19,
Coordination.

1. Introduction

Over time, due to the development of the internet and the increase in intra-city and inter-city travel of passengers and goods, companies have emerged that provide online transportation services to customers (Dailey et al., 1999; Rajabzadeh et al., 2023). Their primary goal is to offer timely service to customers with appropriate quality, minimizing wait times (Taylor, 2018). These companies provide applications that allow customers to log in and share their location (Bistaffa et al., 2017). Customers can choose their destination, view the travel cost, and register their travel request. These requests are then sent directly to drivers near the customer's origin, and upon acceptance, coordination between the customer and driver is

* Corresponding author: (Saeed Yaghoubi)
Email: yaghoubi@iust.ac.ir

established. Companies facilitating this coordination are known as ride-hailing or ride-sharing companies, and this approach helps improve the speed of connection between customers and drivers (Dong and Leng, 2021; Yang et al., 2020; Waqas and Najmi, 2023). Leading companies in the ride-hailing industry include Uber and Lyft, founded in 2010 and 2012, respectively. These companies provide mobile apps that allow users to connect with their nearest drivers. Uber operates in 71 countries, including the United States, Brazil, and Mexico, while Lyft operates in the United States and Canada. Combined, these two companies have over 116 million users and 16.5 million drivers, with total revenue of approximately $8.234 billion by 2020[†].

Depending on the time and budget, customers are considering travel they can choose different types of transportation such as buses, online transportation, personal vehicles, and passenger trains. One of the reasons cause to customers choose the ride-hailing company for transportation is the cost of travel. The cost of travel in online transportation services is often cheaper than traditional taxis which have fixed rates for each route (Hosni et al., 2014; Fang & Yuan, 2018; Peng et al., 2024) because the ride-hailing company calculates the cost of transportation in a variable way. This cost consists of two parts: the first part is the entrance fee of the travel which the ride-hailing company determines and the second part is the variable price which depends on factors such as duration of travel and distance traveled. Therefore, the ride-hailing company is competing with traditional taxis and other ride-hailing companies in the travel service and price (Akbari et al., 2021).

Although the cost of travel in ride-sharing companies is lower than traditional taxis, concerns over safety and liability have become prominent. Notably, road accidents involving ride-hailing vehicles have seen a concerning rise, with studies indicating a 2-3% increase in such incidents since 2011[‡]. Taking action by the ride-hailing company can lead to more and better support for the services they provide. One of these measures is financial support for those damaged by transport accidents through insurance for drivers, customers, and cars during travel, which increases the company's popularity and increases the company's demand by increasing customer satisfaction. The ride-hailing company can insure them through the insurance company and achieve a competitive advantage.

While insurance mitigates financial risks from accidents, the COVID-19 pandemic introduced a new dimension of safety concerns—health and hygiene. In the post-pandemic era, customers increasingly prioritize health precautions alongside financial security. Another action that a ride-hailing company can take to support customers and drivers is hygiene-related measures. As we know Covid-19 has been a rapid outbreak worldwide since 2019. Widely transmission via larger respiratory droplets or direct contact with infected people or contaminated surfaces or inhaling small airborne droplets are recognized as transmission ways of COVID-19 (Morawska et al., 2020). Recent studies indicate that over 70% of passengers now consider cleanliness and hygiene as decisive factors when choosing ride-hailing services (Li et al., 2023). Since the car is an enclosed space, observance of hygiene in the car is one of the most important factors during the Covid-19 pandemic. The ride-hailing company decides on the level of hygiene and reduces the risk of disease for drivers and customers by applying hygiene level in the cars. Customers can use the company's service with the trust of car hygiene, and drivers can keep on working with more confidence and safety because observing hygiene items, the possibility of getting the disease is reduced for both of them. Therefore, observing hygiene items like encouraging sick drivers to rest in his/her course of the disease, disinfection of high-contact surfaces of the car, taking actions for less contact between driver and customer,

[†] https://backlinko.com/lyft-users, https://backlinko.com/uber-users

[‡] https://www.technologyreview.com/2018/10/25/139300/uber-and-lyft-are-behind-a-sharp-rise-in-us-traffic-deaths/

for example using the shield to separate the car space between the driver and the customer, the possibility of online payment instead of using paper money, etc. are important.

These safety measures—insurance for accidents and hygiene for health risks—are not isolated; rather, they interact dynamically, as investments in one area can influence the affordability and effectiveness of the other. The decisions regarding insurance levels and hygiene standards are intertwined. Investment in hygiene measures influences and is influenced by the insurance coverage provided. For instance, the level of insurance coverage impacts the extent of hygiene practices that a company can afford, while enhanced hygiene protocols can affect the overall cost structure and insurance needs.

Although prior research has made meaningful progress in analyzing various aspects of ride-hailing operations, a significant research gap remains unaddressed: no existing model simultaneously addresses pricing, hygiene levels, and insurance coverage within a unified framework that captures the strategic interplay between ride-hailing platforms and insurance providers. Pricing-hygiene studies (e.g., Choi and Shi, 2022; Srinivas and Marathe, 2023) overlook insurance's role in mitigating both accident and health risks, which empirical data shows are intertwined—e.g., enhanced hygiene reduced COVID-19 claims by up to 30% in ride-hailing fleets (Mathai et al., 2021; Cueva et al., 2023), yet increased costs necessitate coordinated insurance premiums. Insurance coordination literature (e.g., Shen, 2020; Shr and Chang, 2024) focuses on unilateral or regulatory mechanisms, overlooking the interaction between decision makers or coordination contracts that could align incentives in a post-pandemic market.

Our study proposes the first integrated model of the interaction between the ride-hailing company and the insurance company by applying the hygiene level of the ride-hailing company in the cars under the framework of the Stackelberg game. In this approach, drivers, customers, and cars are insured on each travel by the ride-hailing company, and the ride-hailing company applies hygiene in the cars to protect drivers and customers against Covid-19 disease. To gain a competitive advantage, the ride-hailing company and the insurance company are trying to increase the number of their customers by taking measures. In this competitive environment that occurs between the two companies, the ride-hailing company is considered a leader, and the insurance company is a follower. We have strengthened the justification for assigning the leader role to the ride-hailing company and the follower role to the insurance company, based on observed market dynamics, scale, and bargaining power asymmetry in the real-world industry. This structure accurately reflects the significant leverage held by large ride-hailing platforms over the insurance providers they partner with, given the platforms' massive market valuations, extensive user bases, and substantial annual revenues. For instance, Uber and Lyft have achieved extraordinary scale, with Uber operating in over 10,500 cities across 70 countries and reporting approximately $37.3 billion in revenue for 2023[§], while Lyft generated $4.4 billion in 2023[*] , primarily in North America. In contrast, some specialized auto insurers, such as Mobilitas (a subsidiary of Swiss Re), have significantly smaller market shares and reported revenues of approximately $0.035 billion in 2023[†] . This vast disparity in market footprint and revenue generation grants ride-hailing platforms considerable leverage in negotiations.

On the other hand, ride-hailing companies own and control the primary interface with both drivers and passengers, setting service terms, prices, and safety protocols that effectively determine the operational environment and risk profile for which insurance is required. This gatekeeper position allows them to dictate fundamental parameters, such as the desired level of

---

[§]https://s23.q4cdn.com/407969754/files/doc_financials/2025/Stockholders2025/2024-Annual-Report.pdf
[*] https://s27.q4cdn.com/263799617/files/doc_financials/2023/q4/02/Lyft-2023-12-31-Press-Release-Annual.pdf
[†] https://www.fslso.com/docs/default-source/uploadedfiles/reports/insurer-financial-reports/2q24-insurer-financial-reports/mobilitas-insurance-company_16392_2q2024.pdf?sfvrsn=179977f4_3

coverage, to which insurance providers must respond.

Additionally, the lucrative, high-volume business presented by a major ride-hailing platform attracts competition among multiple insurance carriers, diminishing the pricing power of any single insurer and reinforcing the ride-hailing company's role as the agenda setter. Insurers thus act as followers, optimizing their premiums in response to the coverage levels and other terms set by the platform to win or retain the business. Therefore, modeling the ride-hailing company as the Stackelberg leader—who first decides on insurance level, hygiene level, and price, with the insurance company subsequently setting the base premium—accurately captures this observed power dynamic and sequential decision-making process in the industry. In the interaction between the ride-hailing company and the insurance company, the ride-hailing company decides on the level of insurance and the level of hygiene, and the insurance company decides on the base entrance premium. Furthermore, the ride-hailing company pays the insurance costs of drivers, customers, and cars to the insurance company according to the base entrance premium and insurance level. With the insurance of drivers, customers, and cars by the ride-hailing company, in the event of an accident, the insurance company pays part of the compensation to drivers and customers. Depending on the level of insurance that the ride-hailing company considers to insure them, the maximum and minimum cost paid by the insurance company to drivers and customers varies. This study examines interactions between the ride-hailing company and the insurance company under decentralized, centralized, and coordination contract scenarios.

The main contributions of this article, which distinguish it from other similar articles, are presented as follows:

- Proposing a novel mathematical model for the interplay between the ride-hailing company and the insurance company with a Stackelberg game theory approach—extending beyond pricing-hygiene models (e.g., Choi and Shi, 2022) by incorporating insurance as a core decision variable.
- Examining the application of hygiene levels in ride-hailing company cars and its impact on demand.
- Decision making about insurance level by the ride-hailing company to insure drivers, customers, and cars, unlike prior insurance studies (e.g., Zou, 2017) that lack coordination mechanisms.
- Proposing a revenue-sharing contract to analyze the coordination game between the ride-hailing company and the insurance company's performance—filling the void in channel coordination for mobility services.

The rest of the paper is as follows. Section 2 presents the literature review. In Section 3, problem descriptions are provided and the mathematical models are formulated in this section. Section 4 numerical evaluation and several sensitivity analyses are implemented to state the applicability of the proposed models. In Section 5 managerial insights are discussed and finally, in Section 6 concluding remarks and future research directions are provided.

2. Literature Review

The rapid expansion of the ride-hailing industry has garnered significant academic interest, particularly in the pricing strategies of these services. Before presenting our model, we provide a brief literature review to highlight the key distinctions between our work and related studies. Given that this study examines the interaction between ride-hailing companies and insurance providers, where demand is influenced by factors such as service pricing, insurance coverage, and hygiene standards, this section reviews relevant research across three main areas: (1) pricing strategies for ride-hailing services, (2) Examining the interaction between ride-hailing companies and insurance companies, and (3) The incorporation of hygiene standards in the services offered by ride-hailing companies.

Asghari and Shahabi (2017) have examined a rational pricing mechanism for ride-hailing through the provision of a hidden space transfer model on sharing platforms in which, in this study, drivers can increase their revenue by using the data provided by this model. Sun et al. (2019b) have examined the reasonable price strategy to maximize profits for drivers and customers. Their model focuses solely on pricing and commission rates and completely abstracts away hygiene standards and any form of insurance coverage or interaction with insurance companies. Ma et al. (2020) have investigated the problem of customer balance using a source-destination pricing strategy to ensure justice and fairness. Özkan (2020) has provided optimization of compliance decisions and pricing simultaneously to increase ride-hailing system performance. Hong and Liu (2022) have investigated the pricing mechanism for the ride-hailing company that offers both a basic ride service via general vehicles powered by fossil fuel and a green ride service via electric vehicles. Although methodologically sophisticated, their analysis excludes hygiene considerations and insurance decisions entirely, limiting its applicability in a post-COVID environment. Hu et al. (2022) examined surge pricing on ride-hailing platforms from a temporal perspective, analyzing the strategic behavior of both riders and drivers. They introduced two types of equilibrium pricing strategies: the first involves an initial sharp price increase followed by a lower price, while the second features a low initial price followed by a higher price. Yang et al. (2022) have analyzed the effect of price regulation on the platform's pricing decision in the competition between a taxi service and an on-demand ride-hailing service. They have examined a Nash equilibrium game model, with two types of on-demand ride-hailing services and price constraints. Xu et al. (2022) utilized a Stackelberg game model to study pricing strategies in ride-hailing and aggregation platforms, focusing on how platforms set prices and drivers choose service levels in both unbundled and bundled scenarios. Ravula (2022) examined two types of savings for consumers: monetary savings from lower prices by sharing economy providers and hassle savings from reduced effort in transactions. The study showed that for trips under 6.64 miles, consumers prefer yellow taxis for hassle savings, while for longer distances, they choose Uber for monetary savings. Siddiq and Taylor (2022) analyzed how access to autonomous vehicle (AV) technology reverses traditional pricing and fleet management strategies in ride-hailing platforms under competitive conditions. Their forward-looking model does not address driver/passenger insurance or post-pandemic hygiene requirements, which are central to our contribution. Xu et al. (2022) explored pricing strategies for ride-hailing platforms using a game-theoretic framework, where platforms lead and drivers follow in a Nash game. They analyzed the impact of service costs and pricing on platform profits, without considering factors like hygiene and insurance. Zhong et al. (2022) analyzed pricing strategies for on-demand ride-hailing platforms compared to traditional taxis under both regulated and unregulated scenarios. They found that prices and profits are higher in unregulated settings and recommended that the government encourage competition between the two. Afifah and Guo (2022) investigated spatial pricing strategies for ride-sourcing services within a Stackelberg framework, considering traffic congestion. They identified optimal pricing strategies to minimize locational imbalances and proposed algorithms with reliable convergence properties. Despite using the same game structure, their model does not include hygiene or insurance decisions and does not consider coordination contracts with third-party insurers. Tripathy and Heese (2023) used a game-theoretic model to analyze how driver collusive can trigger surge pricing on ride-hailing platforms, shifting focus from pricing optimization to strategic driver behavior. Their focus is exclusively on driver strategic behavior and pricing dynamics, with no treatment of hygiene standards or insurance-related decisions, making it complementary but distinct from our integrated approach. Xu et al. (2024) developed a Stackelberg game model to analyze pricing strategies in a ride-hailing platform with multiple travel modes. Their study focused on pricing without considering hygiene and insurance aspects for drivers and passengers.

Existing ride-hailing pricing models during the COVID-19 era have primarily focused on hygiene as a response to demand shifts, but often without integrating insurance or strategic coordination. For instance, Choi and Shi (2022) model pricing and hygiene levels using a queuing-game approach with blockchain for compliance, showing that hygiene investments can increase fares by 10–20% while boosting demand. Similarly, Srinivas and Marathe (2023) optimize pricing and hygiene under pandemic constraints, highlighting autonomous vehicles' role in cost reduction, yet neither incorporates insurance coverage as a decision variable.

Another focus of this study is the interaction between ride-hailing companies and insurance companies, for which we review the relevant literature. Insurance plays a crucial role in enhancing job satisfaction and security, which increases drivers' sense of belonging and loyalty to the company (Nugroho and Bandono, 2023; Fielbaum and Tirachini, 2021). A larger pool of insured drivers helps reduce service delays, improving customer satisfaction and ultimately increasing the profitability of the ride-hailing company (Sun et al., 2019a). Zou (2017) explored the legal aspects of contracts between drivers and ride-hailing companies, highlighting the responsibility to insure drivers but without detailing the interaction model. The study remains purely legal-descriptive and does not propose any analytical interaction model between ride-hailing and insurance companies, nor does it treat insurance level as a decision variable or explore coordination contracts—core contributions of our work. Teo et al.(2018) conducted a study to identify factors influencing passenger preference for ride-hailing services. Using data from interviews with a manager of an e-hailing company, they found that providing insurance for both passengers and drivers, which enhances travel safety, is a significant factor in the marketing of these companies. Another study has examined the factors affecting the driver's expenses without mathematical modeling, which includes insurance (Henao and Marshall 2019). However, this study is descriptive and lacks mathematical modeling of insurance decisions, pricing, hygiene, or strategic interaction with an insurance provider. Hong et al. (2020) highlighted that driver satisfaction and willingness to work for ride-hailing platforms improve when companies offer a minimum wage guarantee, a benefits plan, and insurance features that protect driver privacy. Shen (2020) analyzed how mergers and acquisitions affect corporate strategies in ride-hailing, including changes in driver insurance policies. Again, the study is qualitative and strategic in nature and does not develop any game-theoretic model for joint decision-making on insurance coverage, hygiene, or revenue-sharing coordination with an insurance company. A study on labor relations in the ride-hailing industry, based on questionnaire data, found that platforms should provide comprehensive insurance and essential benefits to ensure drivers' livelihood, job stability, and satisfaction (Li et al. 2022). Lu et al (2021) presented an identity system for ride-hailing that protects user privacy and ensures drivers' qualifications through a safety guarantee insurance model. It allows riders to verify driver credentials before trips and receive incentives for reporting unqualified drivers. Shr and Chang (2024) analyzed the impact of Taiwan’s government-mandated Multipurpose Taxi Program on taxi drivers’ operations, including passenger insurance. Their study found that the program significantly improves customer protection, with participating drivers being at least 44% more likely to purchase passenger insurance. Despite its valuable policy insights, the work remains empirical and regulatory-focused and does not model insurance as an optimizable decision variable within a bilateral Stackelberg game or revenue-sharing contract, as we do. Parvasi et al. (2024) used Stackelberg game theory for pricing decisions in a competitive retail setting with imported products and crowdfunding options. Although methodologically close, their work remains entirely outside the ride-hailing and mobility-as-a-service context and does not address hygiene or transportation insurance. Most studies focus on legal aspects, marketing strategies, or driver satisfaction without delving into strategic interactions or mathematical modeling. This research addresses these gaps by introducing a Stackelberg game model that considers these factors, providing a comprehensive analysis of the interaction under various scenarios.

Several recent studies have incorporated hygiene considerations into ride-hailing operations, primarily motivated by the COVID-19 pandemic. Choi and Shi (2022) developed a game-theoretic model to jointly optimize pricing and hygiene levels in ride-hailing vehicles, further examining the role of blockchain technology in ensuring compliance. While their work explicitly treats hygiene as a decision variable and captures its positive effect on demand during pandemics, it does not consider any form of insurance coverage for drivers or passengers, nor does it model strategic interaction or coordination with an external insurance company—two core elements of our study.

Li et al. (2023) empirically demonstrated through survey data that perceived COVID-19 risk and hygiene measures significantly affect post-pandemic ridesourcing usage. While providing strong behavioral justification for including hygiene in demand functions (which we adopt), their study is purely empirical and does not propose any analytical pricing, insurance, or coordination model.

Zhao (2022) employed a game-theoretic framework to study the enforcement of health protocols between ride-hailing platforms and drivers during the epidemic, treating hygiene behavior monitoring as the central issue. However, the study excludes both pricing and insurance decisions entirely, limiting its scope to regulatory compliance. Li et al. (2023) empirically demonstrated through survey data that perceived COVID-19 risk and hygiene measures significantly affect post-pandemic ridesourcing usage. While providing strong behavioral justification for including hygiene in demand functions (which we adopt), their study is purely empirical and does not propose any analytical pricing, insurance, or coordination model. Srinivas and Marathe (2023) also investigated optimal pricing and hygiene decisions for e-hailing services under COVID-19, emphasizing the potential role of autonomous vehicles in improving hygiene standards. Their model completely abstracts away insurance mechanisms and any bilateral relationship with insurance providers, focusing instead on technology-driven hygiene solutions. Agyemang and Yaro (2023) assessed COVID-19 knowledge, attitudes, and practices among ride-hailing operators in Ghana. Their survey of 1,014 participants indicated high adherence to hygiene measures such as mask-wearing and personal hygiene. However, as a purely empirical survey-based analysis, the study does not develop any analytical framework for optimizing hygiene as a decision variable, nor does it integrate pricing strategies, insurance coverage, or coordination mechanisms with external partners like insurance companies—gaps that our Stackelberg game model addresses through joint optimization of hygiene, price, and insurance levels. Sinha (2024) analyzed factors influencing customer satisfaction in ride-hailing services using Porter's Five Forces and SWOT analysis. The findings revealed that car hygiene is a significant factor contributing to customer satisfaction, based on customer response. While providing valuable strategic insights into external market forces and internal strengths/weaknesses, this work remains descriptive and qualitative, without proposing a mathematical model for decision-making on hygiene levels or linking it to insurance interactions and revenue-sharing contracts.

While studies have explored various aspects of hygiene and its impact on customer satisfaction, pricing, and the introduction of technologies like blockchain and autonomous vehicles, they often overlook critical factors such as insurance coverage for drivers and customers. There is a need for research that combines hygiene standards with comprehensive insurance considerations and examines their joint effects on ride-hailing services, particularly through integrated models like game theory approach. Table 1 offers a comprehensive overview of the more related literature reviewed, highlighting the position of our work within the existing ones.

Table 1. The Summary of the literature review

Study	Pricing decision	Hygiene level as decision variable	Insurance as coverage decision variable	Game theory type	Considers driver & passenger insurance
Zou (2017)			✓		✓
Sun et al. (2019b)	✓				
Henao and Marshall (2019)			✓		✓
Shen (2020)			✓		✓
Hong and Liu (2022)	✓				
Choi and Shi (2022)	✓	✓		Mixed-leadership game	
Yang et al. (2022)	✓			Nash	
Xu et al. (2022)	✓			Nash-Stackelberg	
Zhong et al. (2022)	✓	✓		Stackelberg	
Afifah and Guo (2022)	✓			Stackelberg	
Tripathy and Heese (2023)	✓			Stackelberg	
Srinivas and Marathe (2023)	✓			Stackelberg	
Parvasi et al. (2024)	✓			Stackelberg	
Shr and Chang (2024)			✓		✓
Present study	✓	✓	✓	Stackelberg	✓

As illustrated in Table 1, while prior research has made significant strides in individual components of ride-hailing operations—such as pricing decisions, hygiene levels, and insurance considerations—these elements are typically examined in isolation or through limited game-theoretic models. Critically, no existing study simultaneously integrates pricing, hygiene as a decision variable, insurance coverage optimization, and dual protection for drivers and passengers within a unified Stackelberg framework that models the leader-follower dynamics between ride-hailing platforms and insurance providers.

Our work directly addresses these gaps by developing a novel mathematical model that jointly optimizes service pricing, hygiene levels, and insurance coverage under a Stackelberg game, while explicitly incorporating revenue-sharing contracts for coordination. This integrated approach fills the voids highlighted in Table 1 and provides a holistic, quantifiable framework for post-pandemic mobility services, enabling platforms to balance competitive differentiation, risk mitigation, and profitability in a coordinated ecosystem.

3. Mathematical Model

In this study, the ride-hailing company and the insurance company are considered a decision-maker. The ride-hailing company insures customers, drivers, and cars, and also by applying hygiene level in the cars, increases the quality of its service. The insurance company pays for part of the damages to insured customers, drivers, and vehicles caused by accidents. To better understand, we will introduce the notations used in this study in section 3.1 and also, we investigate three different scenarios between the ride-hailing company and the insurance company in section 3.2.

3.1. Notations

In this section, the notations used in the study are defined:

Parameters	
p_0	The basic entrance fee that the customer pays for each travel
p_2	The variable price depends on the duration of travel
τ_1	Sensitivity of customers to the entrance fee
τ_2	Sensitivity of customers to p_2
τ	Average travel time per every travel
α	Market base demand
β	Sensitivity coefficient of insurance level
u	Coefficient of hygiene level cost in the ride-hailing company profit function
θ	Sensitivity coefficient of the number of insured units to the base entrance premium
g	Percentage of travel revenue that the driver pays to the ride-hailing company
S	The probability of an accident in a day
t	Sensitivity coefficient of p_0 to the premium
k	Demand sensitivity of the ride-hailing company to insurance level
λ	Demand sensitivity of the ride-hailing company to hygiene level
m	Average hours of drivers' activity in the ride-hailing company on a day
q	The average cost of the driver for one hour of activity in the ride-hailing company on a day
C_{max}	The basic maximum compensation that pays by the insurance company to the customer and the driver in each accident
C_{min}	The basic minimum compensation that pays by the insurance company to the customer and the driver in each accident
L_1	The cost that the insurance company pays to the driver for an accident
L_2	The cost that the insurance company pays to the customer for an accident
Demand and profit function	
D_r^f	Demand function of the ride-hailing company in model f (hours)
D_i^f	Demand function of the insurance company in model f (unit)
π_y^f	Profit function of member y in model f($)
Decision variable	
w^f	The base entrance premium paid by the ride-hailing company to the insurance company for the insurance of each car in one day in model f
h^f	The hygiene level applied by the ride-hailing company for each car in each travel in model f
γ^f	The insurance level created by the ride-hailing company for each car in each travel in model f
p_1^f	Entrance fee dependent on γ^f, p_0 in model f

$y \in \{r, i, d, ic\}$ refers to the ridesharing company, insurance company, drivers and integrated company, respectively.

$f \in \{C, DC, RC\}$ indicates the centralized, decentralized, revenue sharing contract models.

3.2. Model formulation

In this article, we consider the reasons stated in the introduction, the customers choose the ride-hailing company for the travel. Since the ride-hailing company is looking for measures to increase the quality of the services it provides, it insures drivers, customers, and cars by the insurance company. In the event of an accident, part of the damage will be paid to them by the insurance company. This action will increase the number of customers and drivers of the ride-hailing company.

As mentioned, the ride-hailing company's action can be to support customers and drivers, is about hygiene. The disease is transmitted through direct contact with infected people or by inhaling small air droplets or through large respiratory droplets and a car as an indoor place is one of the places that increases the possibility of transferring this disease (Mathai et al., 2021), applies the hygiene in the cars reduce the risks of disease outbreaks between customers and drivers. Studies have shown that health and safety measures are critical in customer decision-making. For instance, Cueva et al. (2023) found that experts rated these measures highest in importance for the sharing economy. Additionally, research by Li et al. (2023) indicated that health measures in ride-hailing services reduce COVID-19 transmission risk, fostering public trust and boosting market performance. Srinivas and Marathe (2023) further supported this by demonstrating that increased hygiene levels directly correlate with higher demand for ride-hailing services.

Ride-hailing companies like Uber offer substantial insurance policies, including liability coverage for accidents and personal injury protection, which ensures financial security for drivers and passengers[‡] . This significantly reduces concerns about physical harm and financial loss, as highlighted by Vayouphack (2020), fostering trust and reassurance among customers. The ride-hailing company considers the car with its driver and the customer inside it, as a unit in each travel, and to insure them, it insures the unit of the car. The cost that the ride-hailing company pays for the insurance of each car unit depends on w^f and γ^f and follows the relation $c = w^f(1 + \beta\gamma^f)$ that w^f is the base entrance premium amount that is determined by the insurance company as the base cost of insurance. Depending on the level of insurance, the cost of insurance also varies and they are directly related to each other. According to Uber's pricing structure studies conducted in this field, such as the article by Hu et al. (2022), the travel cost charged by ride-hailing companies to their customers is based on factors such as demand during that period, travel duration, and additional services provided[§] . Given this reality, the travel cost is made of two parts and is calculated according to the relationship $(\tau_1 p_1^f + \tau_2 p_2)$ for the customers. Since p_1 is the entrance fee for the travel, the ride-hailing company by applying insurance for each car unit, makes it dependent on the level of insurance and is calculated: $p_1^f = p_0(1 + t\gamma^f)$. p_2 is the variable price, which is considered dependent on the duration of travel in this study. The proportion of g from the cost paid by customers belongs to the ride-hailing company and the proportion $(1 - g)$ belongs to the driver. Therefore, in this paper, the ride-hailing company decides on the travel entrance fee (p_1^f), the hygiene level (h^f), and the insurance level (γ^f) that it is going to apply for its services. On the other hand, the insurance company covers the drivers, customers, and cars in exchange for receiving the insurance fee per unit of car, and pays $C_{min}(1 + \beta\gamma^f)$ and $C_{max}(1 + \beta\gamma^f)$ for part of the minimum and the maximum damage caused in the accident, respectively, and decides on the base entrance premium (w^f). This compensation, which depends on the level of insurance, increases as the level of insurance increases. We examine 3 different scenarios between the ride-hailing company and the insurance company, taking into account the hygiene level applied in the cars by the ride-hailing company: 1. Decentralized, 2. Centralized, and 3. Coordination game under revenue-sharing contract.

3.2.1. Decentralized (DC)

In this paper, it is assumed that the ride-hailing company can accept all requests for travel (D_r^{DC}). According to the mentioned cases about the importance of supporting each travel, the ride-hailing company insures the customers, drivers, and cars on each travel by the insurance company. Furthermore, since the level of hygiene affects the demand of this company, by applying hygiene level by the ride-hailing company in the cars and observance of more hygiene items by the driver, demand increases linearly. The demand functions of the ride-hailing company and the insurance company are calculated as Equation (1) and Equation (2):

$$D_r^{DC} = (a - \tau_1 p_1^{DC} - \tau_2 p_2) + \lambda h^{DC} + k\gamma^{DC} \tag{1}$$

$$D_i^{DC} = \left(\frac{D_r^{DC}}{m}\right)(1 - \theta w^{DC}) \tag{2}$$

‡ https://www.uber.com/us/en/drive/insurance/

§ https://www.vatech.com/manuals/379746

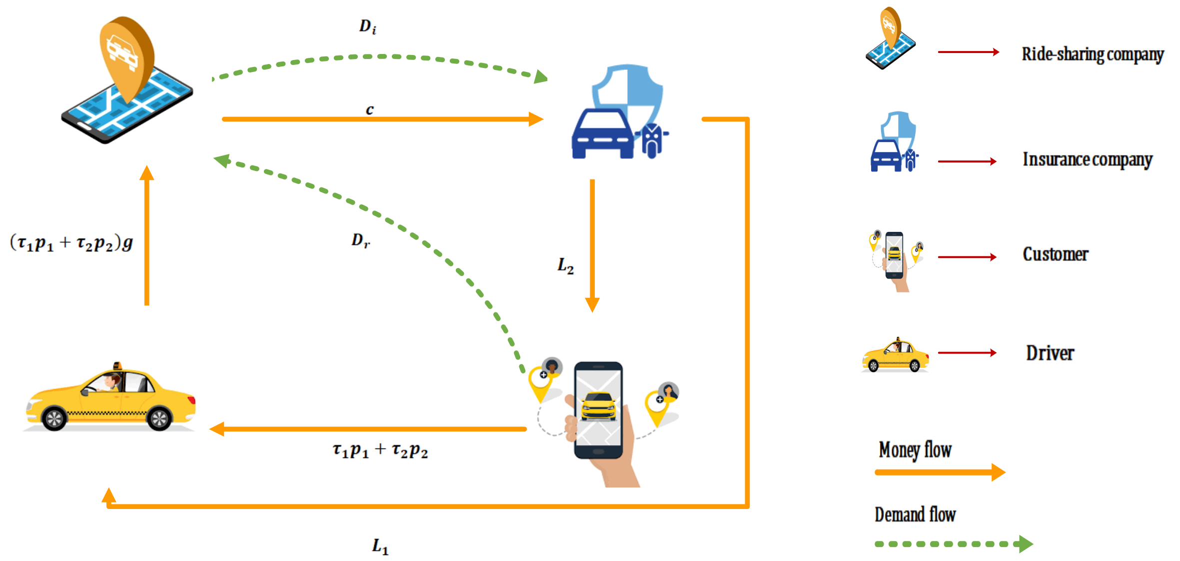

Figure 1. The structure of the interactions among the ride-hailing company, the insurance company, driver, and customer

The linear demand function for the ride-hailing company (Equation 1) is grounded in standard microeconomic and consumer utility-maximization theory (Chow, 1966; Rosen, 1974), where demand depends on key service attributes, including price, perceived safety, and service quality. The negative coefficients on the entrance fee and the travel-time–dependent price follow the classical downward-sloping demand principle, reflecting that higher costs reduce the utility and attractiveness of the service. In contrast, the positive sensitivities to hygiene and insurance levels are consistent with behavioral risk-aversion theory, whereby passengers place a higher value on reduced financial risk of accidents and lower exposure to health hazards. The inclusion of hygiene level (h) as a positive sensitivity factor in the ride-hailing demand functions modeled to quantitatively capture how investments in hygiene actions translate into customer utility and demand increases. Theoretically, hygiene enhances service utility by reducing perceived health risks in an enclosed vehicle environment, aligning with consumer choice theory where demand rises with attribute quality (Lancaster, 1966; Rosen, 1974). Specifically, each increment in h (e.g., from basic online payments to comprehensive disinfection and barriers) is assumed to linearly boost demand via a sensitivity coefficient, approximating empirical elasticities; quadratic costs in the profit function (Equation 3) account for diminishing returns on escalating investments.

Empirical studies conducted during the COVID-19 pandemic show that passengers' perception of the effectiveness of preventive and hygiene measures—such as disinfection protocols, provision of sanitizing products, and health-focused guidelines—significantly influences their intention to engage in protective behavior and their choice of transport mode. For example, research on ride-hailing users during the pandemic finds that perceived effectiveness of preventive measures positively affects passengers' confidence and their self-protective intentions, which in turn increases their willingness to use these services when appropriate hygiene protocols are present (Nguyen-Phuoc et al., 2022). Additional evidence comes from studies in related travel and service contexts showing that passengers value enhanced hygiene. In shared mobility and other transport modes, a considerable proportion of users express a preference for increased cleanliness and sanitization, and many are willing to accept or even pay for improved hygiene features (Li et al., 2023; Agyemang and Yaro, 2023). For instance, Li et al. (2023) found through U.S. surveys that hygiene measures increase ride-hailing usage intentions by 40–60% among risk-averse users; Agyemang and Yaro (2023) reported 95% adherence to hygiene in Ghanaian operators, correlating with sustained demand.

Reports from Uber and Lyft further indicate that hygiene initiatives (masks, sanitization) mitigated 75% demand drops in 2020, enabling 55.6% market growth projections by 2021(Wang et al., 2022). Accordingly, the hygiene-sensitivity parameter captures demand responsiveness to health-safety measures, while the insurance-sensitivity parameter reflects users' valuation of financial protection, consistent with findings in Henao and Marshall (2019). The chosen linear form is also widely used in transportation pricing literature (Sun et al., 2019b; Hong and Liu, 2022), offering analytical tractability while capturing the key behavioral mechanisms influencing demand in ride-hailing markets.

The insurance demand function (Equation 2) is grounded in derived demand theory from economics, where the ride-hailing platform's insurance requirements scale proportionally with its own demand volume (e.g., number of trips needing coverage) but decrease inversely with the base premium, reflecting price elasticity in B2B services. Behaviorally, this structure captures the platform's cost-benefit analysis: elevated premiums deter coverage due to budget limits and risk preferences, while higher ride demand amplifies operational exposure, necessitating more insured units (e.g., more trips equate to more vehicles requiring protection). The ride-hailing company insures its drivers, cars, and customers on a daily basis. To determine the insurance demand function, it is necessary to calculate the number of cars that the ride-hailing company insures each day. The number of cars required is directly proportional to the ride-hailing demand; as demand for rides increases, more cars are needed. If each driver works an average of m hours during the day, D_r^{DC}/m represents the number of cars required per day. For example, if the total daily demand is 2000000 hours and each driver works an average of 8 hours per day, the ride-hailing company needs $2000000/8 = 250000$ cars during the day. The demand function of the insurance company is directly related to the demand of the ride-hailing company and is also inversely related to the base cost of insurance, because as w^{DC} increases, the ride-hailing company can insure a less percentage of the car units. As mentioned, the number of units insured by the ride-hailing company is inversely related to w^{DC}, the ratio $(1 - \theta w^{DC})$ is multiplied by D_r^{DC}/m and the ride-hailing company insures $\frac{D_r^{DC}}{m}(1 - \theta w^{DC})$ the car units. The lower w^{DC}, the higher the ratio $(1 - \theta w^{DC})$ and the higher the number of insured units. The cost that customers pay for each travel is variable and follows the relationship $(p_1^{DC} + p_2 \times (duration\ of\ travel))$. p_1^{DC} is the entrance fee per travel, which depends on the level of insurance that the ride-hailing company considers $p_1^f = p_0(1 + t\gamma^{DC})$ and p_2 is the price per unit in the duration of travel. The profit functions of the ride-hailing company (Equation (3)) and the insurance company (Equation (4)) are as follows:

$$\pi_r^{DC} = \left((D_r^{DC} p_2) + (D_r^{DC} \frac{p_1^{DC}}{\tau})\right) g - (\frac{uh^{DC^2}}{2}) - (w(1 + \beta\gamma^{DC})) \left(\frac{D_r^{DC}}{m}(1 - \theta w^{DC})\right) \tag{3}$$

$$\pi_i^{DC} = (w^{DC}(1 + \beta\gamma^{DC})) \left(\frac{D_r^{DC}}{m}(1 - \theta w^{DC})\right) - \left(\frac{C_{max}+C_{min}}{2}\right)(1 + \beta\gamma^{DC})\, S \left(\frac{D_r^{DC}}{m}(1 - \theta w^{DC})\right) \tag{4}$$

In Equation (3), the first term indicates the revenue received by the ride-hailing company per day, in which the g ratio of the travel cost is given as a commission to the ride-hailing company and $(1 - \mathrm{g})$ is the ratio for the driver for each travel during the day. The second term stems from the investment required for different levels of hygiene measures in ride-hailing services. Basic hygiene measures, such as enabling online payments, incur minimal costs. However, as hygiene levels increase, so do the measures and associated costs. Comprehensive hygiene actions, including vehicle disinfection, mandatory masks, hand sanitization, installation of barriers, regular health checks, and encouraging sick drivers to rest, require significantly higher investments. According to Srinivas and Marathe (2023), these costs increase at a quadratic relationship as the hygiene level rises from basic to comprehensive, due to the cumulative and interconnected nature of these measures. The third part shows the cost that the ride-hailing company pays to the insurance company for insurance $\frac{D_r^{DC}}{m}(1-\theta w^{DC})$units. The insurance cost is modeled as a linear function of the insurance level because commercial fleet insurance pricing follows actuarial expected-loss principles, where total cost scales proportionally with exposure and coverage. In practice, insurance premiums are calculated as a base rate per insured unit, adjusted linearly with coverage level, reflecting constant marginal cost under economies of scale in bulk contracting. This structure is consistent with standard insurance economics and industry practice, where higher coverage levels command proportionally higher premiums rather than escalating marginal costs (Goldburd et al., 2016; Ohlsson and Johansson, 2010). Accordingly, the linear cost form accurately represents insurance as an externally procured financial service rather than an internal effort-based investment. In Equation (4), the first term indicates the revenue received of the insurance company for the number that the ride-hailing company insures. The second part indicates the payment of the insurance company to the insured person. The accident cost the insurance company must cover is calculated by multiplying the following three factors; average damage per accident, probability of an accident for each car per day, and number of insured vehicles. As mentioned, the number of insured cars is given by $\frac{D_r}{m}(1-\theta w^{DC})$. The probability of an accident per car per day is denoted by S. Additionally, the damage that each vehicle incurs in an accident follows a uniform distribution with a minimum of C_{min} and a maximum of C_{max}, with an average value of $\frac{C_{max}+C_{min}}{2}$. Since the insurance company has committed to paying more if a higher insurance level is chosen, this average is multiplied by $(1+\beta\gamma^{DC})$ to reflect that with an increase in the insurance level, the payment by the insurance company for each vehicle's damage increases.

In this section, we seek to gain the optimal values of each of the variables, and for this purpose, we apply the backward induction method. In this method, the leader first checks what the follower's best response to each decision will be, and based on that, chooses a strategy that maximizes his profit. Next, the follower, who has been informed of the leader's decision, gives the best response (Barron 2013). In this model, the ride-hailing company is positioned as the Stackelberg leader and the insurance company as the follower, reflecting real-world market dynamics where platforms like Uber and Lyft hold significant leverage due to their scale and control over user networks, while insurers (e.g., Mobilitas) compete for partnerships and respond to platform-set terms. Given that h^{DC}, γ^{DC}, and p_1^{DC} are the decision variables of the ride-hailing company, first, the ride-hailing company decides on the optimal amount of these variables and then the insurance company as a follower, determines its decision variable w^{DC}, according to the optimal values of h^{DC}, γ^{DC}, and p_1^{DC}.

Proposition 1. The profit function of the ride-hailing company is concave on h^{DC} and γ^{DC}. Therefore, the unique and optimal answer h^{DC} and γ^{DC} is obtained by optimizing the expected profit of the ride-hailing company.

Proof. The proof of proposition 1 and all the propositions written in this article are given in Appendix B.

Theorem 1. Due to the concavity of the ride-hailing company's profit function, the optimal values of h^{DC} and γ^{DC} under the decentralized scenario are obtained as follows:

$$h^{DC*}=\frac{\lambda A_1}{mA_2+\beta A_3} \tag{5}$$

$$\gamma^{DC*}=-\frac{\tau^2 A_4+mA_5}{(A_6(\theta A_7+\beta A_8))} \tag{6}$$

The values of A_j are indicated in Appendix A.

Proof. The proof of Theorem 1 and all the Theorems written in this article are given in Appendix B.

Proposition 2. The profit function of the insurance company is concave on w^{DC}. Therefore, the unique and optimal answer w^{DC} is obtained by optimizing the expected profit of the insurance company.

Theorem 2. Regarding Proposition 2, the optimal values of w^{DC} under the decentralized scenario is obtained as follows:

$$w^{DC*} = \frac{2+SA_9}{4\theta} \tag{7}$$

3.2.2. Centralized (C)

In the centralized scenario, we assume that the ride-hailing company and the insurance company have been merged into one integrated company. Since in this scenario, we want to consider one integrated company, the drivers, as a dependent group to the ride-hailing company, is merged with the ride-hailing company and the insurance company. The drivers' profit function is also as follows:

$$\pi_d = \left(D_r^C p_2 + D_r^C \frac{p_r^C}{\tau}\right)(1-g) + \left(\frac{C_{max}+C_{min}}{2}\right)(1+\beta\gamma^C)S\left(\frac{D_r^C}{m}(1-\theta w^C)\right) - (qD_r^C) \tag{8}$$

In Equation (8), the first term indicates the driver's revenue per day and the second part represents the amount received from the insurance company in the event of an accident. The third term shows the cost of car activity in one day. The average cost of the driver for one-hour activity in the ride-hailing company on the day is q and the average hours of drivers' activity in the ride-hailing company on the day is m also the number of car units are $(\frac{D_r^C}{m}(1-\theta w^C))$. The multiplication of these three expressions is equal to qD_r^C. By merging players, the cost of insurance per car unit is not exchanged between the ride-hailing company and the insurance company, in other words, w^C is eliminated, as a result the exchange of costs due to damages between the insured and the insurance company is also eliminated. The profit function of the integrated company from combinations Equations (3), (4), and (8) with the variables of decision γ^C and h^C as follows:

$$\pi_{ic}^C = \left(\frac{(a+k\gamma^C+h^C\lambda)(p_0+p_0t\gamma^C+(p_2-q)\tau)}{\tau}\right) - \left(\frac{{h^C}^2 u}{2}\right) - \left(\frac{(p_0+p_0t\gamma^C+(p_2-q)\tau)\left((p_0+p_0t\gamma^C)\tau_1+p_2\tau_2\right)}{\tau}\right) \tag{9}$$

Proposition 3. The profit function of the integrated company under the centralized scenario is concave with respect to h^C and γ^C.

Proof. See Appendix B.

Theorem 3. The optimal amount of h^C and γ^C under the centralized scenario are determined as follows:

$$h^{C*} = \frac{p_0A_{10}+kA_{11}}{tA_{12}+2ku\tau} \tag{10}$$

$$\gamma^{C*} = \frac{\tau A_{13} - p_0^2 t\lambda^2}{p_0 t A_{14}} \tag{11}$$

3.2.3. Coordination Game under Revenue-Sharing Contract (RC)

In this scenario, a coordination game is played between the ride-hailing company and the insurance company in which the insurance company cooperates with the ride-hailing for having more customers and pays a fraction of its revenue to the ride-hailing company, also the ride-hailing company cooperates with the insurance company for raising the quality of its service to increase demand. Under the coordination game through the revenue-sharing contract, the ride-hailing company receives a fraction of the insurance company's revenue φ. Thus, Equations. (12) and (13) calculate the profit functions of the ride-hailing company and the insurance company under the cooperative game through the revenue-sharing contract, respectively.

$$\pi_r^{RC} = \left(D_r^{RC} p_2 + D_r^{RC} \frac{p_1^{RC}}{\tau}\right) g - (u\frac{h^{RC^2}}{2}) - (w^{RC}(1+\beta\gamma^{RC}))\left(\frac{D_r^{RC}}{m}(1-\theta w^{RC})\right) + \varphi\left(\left(\frac{D_r^{RC}}{m}(1-\theta w^{RC})\right) w^{RC}(1+\beta\gamma^{RC})\right) \tag{12}$$

$$\pi_i^{RC} = (1-\varphi)(w^{RC}(1+\beta\gamma^{RC}))\left(\frac{D_r^{RC}}{m}(1-\theta w^{RC})\right) - (\frac{C_{max}+C_{min}}{2})(1+\beta\gamma^{RC})S\left(\frac{D_r^{RC}}{m}(1-\theta w^{RC})\right) \tag{13}$$

In Equation (12) similar to the first scenario, the first term indicates the ride-hailing company's revenue received on a day. The ratio of g of the cost of the travel is given as a commission to the ride-hailing company and its ratio is $(1-g)$ for the driver, for each travel during the day. The second term represents the cost of applying a hygiene level in the car. The third part shows the cost that the ride-hailing company pays to the insurance company for insurance $\frac{D_r^{RC}}{m}(1-\theta w^{RC})$ units. The fourth part shows a fraction of the insurance company's revenue that is shared with the ride-hailing company.

In Equation (13), the first term indicates the insurance company's revenue received for the number that the ride-hailing company insures that a fraction of it shares with the ride-hailing company and ratio of $(1-\varphi)$ belongs to the insurance company. The second part represents the payment of the insurance company to the insured person. We assume that the cost that the insurance company pays for part of the loss has a uniform distribution function with a minimum of C_{min} and a maximum of C_{max}, so its average is $\left(\frac{C_{max}+C_{min}}{2}\right)$.

In this scenario similar to the previous scenario, the Stackelberg game is adopted between decision makers, and the ride-hailing company is the leader and the insurance company is the follower. Given that h^{RC}, γ^{RC}, and p_1^{RC} are the decision variables of the ride-hailing company, at first, the ride-hailing company obtains h^{RC}, γ^{RC}, and p_1^{RC} such that its profit function, Equation (12), is maximized and then the insurance company as a follower, determines its decision variable w^{RC}, according to the optimal values of h^{RC}, γ^{RC}, and p_1^{RC}. Firstly, the concavity of the ride-hailing company's profit function is proved through the following proposition.

Proposition 4. The profit function of the ride-hailing company under coordination game under the revenue-sharing contract is concave with respect to h^{RC} and γ^{RC}.

Proof. See Appendix B.

Theorem 4. The optimal amount of h^{RC} and γ^{RC} under the coordination game under the revenue-sharing contract are determined as follows:

$$h^{RC*} = \frac{p_0 A_{10} + k A_{11}}{t A_{12} + 2ku\tau} \quad (14)$$

$$\gamma^{RC*} = \frac{\tau A_{13} - p_0^2 t \lambda^2}{p_0 t A_{14}} \quad (15)$$

Proposition 5. The profit function of the insurance company under the cooperative game under the revenue-sharing contract is concave with respect to w^{RC}.

Proof. See Appendix B.

Theorem 5. Regarding Proposition 5, the optimal values of w^{RC} under the cooperative game under the revenue-sharing contract is obtained as follows:

$$w^{RC*} = \frac{2 + A_{15}}{4\theta - 4\theta\phi} \quad (16)$$

3.3. Interaction Effects Between Insurance Level and Hygiene Level

In this section, to further analyze the obtained relationships, we examine the interaction effects between the insurance level and the hygiene level. For each scenario, the cross-partial derivative of the relevant profit function with respect to these two decision variables is derived. A positive value indicates synergy (i.e., the two decisions are complementary), a negative value indicates a trade-off, and a zero value implies that the two decisions are independent. Specifically, Equations (17)–(19) analyze the interaction between the hygiene level and the insurance level on the ride-hailing company's profit under the decentralized and revenue-sharing scenarios, as well as on the total system profit under the centralized scenario.

$$\frac{\partial^2 \pi_r^{DC}}{\partial \gamma^{DC} \partial h^{DC}} = \frac{\beta((C_{\max} + C_{\min})^2 S^2 \theta^2 - 4)\lambda}{16 m\theta} + \frac{g t \lambda p_0}{\tau} > 0 \text{ if } \beta + \frac{16 g m t \theta p_0}{(-4 + (C_{\max} + C_{\min})^2 S^2 \theta^2)\tau} < 0 \quad (17)$$

$$\frac{\partial^2 \pi_{ic}^{C}}{\partial \gamma^{C} \partial h^{C}} = \frac{t \lambda p_0}{\tau} > 0 \quad (18)$$

$$\frac{\partial^2 \pi_r^{RC}}{\partial \gamma^{RC} \partial h^{RC}} = \frac{\beta\lambda((C_{max} + C_{min})S\theta + 2(\varphi - 1))(2 + (C_{max} + C_{min})S\theta - 2\varphi)}{16 m\theta(1 - \varphi)} + \frac{g t \lambda p_0}{\tau} > 0 \text{ if}$$
$$\beta < \frac{16 g m t \theta(-1 + \varphi) p_0}{\tau((C_{max} + C_{min})S\theta + 2(-1 + \varphi))(2 + (C_{max} + C_{min})S\theta - 2\varphi)} \quad (19)$$

In the centralized scenario, hygiene and insurance are always complementary (synergistic)—increasing one enhances the marginal profitability of the other. In the decentralized and revenue-sharing contract scenarios, they are complementary under certain conditions, meaning that a higher insurance level (γ^f) amplifies the positive impact of investing in hygiene (h^f), and vice versa.

From the derived analysis, the following managerial insights can be inferred:

Customer Value Proposition: The synergy implies that customers perceive combined hygiene and insurance measures as more valuable than each one separately. Marketing campaigns should highlight this "Safe & Secure Ride" offering to differentiate from competitors and justify premium pricing.

Policy and Partnership Implications: For insurance companies, this synergy suggests that partnering with platforms that maintain high hygiene standards can increase demand and improve the insurer's profitability. Insurers may offer premium discounts or customized products for platforms with certified hygiene protocols.

4. Experiment Analysis

In this section, a real example is given to better understand the model given in the previous section. In the next part, we will analyze the numerical results of an example, by using some of the diagrams.

4.1. Numerical Examples

In this section, a real example is presented in order to analyze the performance of the described model, for this purpose we use data from Lyft company for parameters p_0 and p_2. The numerical example parameters are given in Table 2. Lyft operates in the United States and Canada and has more than 23 million users. In 2020, it had an average of 13.5 million drivers, and the company generated a net revenue of $2.364 billion * . *

Table 2. The values of parameters used in numerical example

Parameters	Values
The basic entrance fee (p_0)	0.505
The variable price (p_2)	1
Sensitivity of customers to the entrance fee (τ_1)	1200000
Sensitivity of customers to p_2 (τ_2)	12000
Average travel time per every travel (τ)	0.3
Market base demand (α)	12000000
Sensitivity coefficient of insurance level (β)	0.8
Coefficient of hygiene level cost in the ride-hailing company profit function (u)	20000
Sensitivity coefficient of the number of insured units to the base entrance premium (θ)	0.1
Percentage of travel revenue that the driver pays to the ride-hailing company (g)	0.25
The probability of an accident in a day (S)	0.002
Sensitivity coefficient of p_0 to the premium (t)	0.6
Demand sensitivity of the ride-hailing company to insurance level (k)	3000
Demand sensitivity of the ride-hailing company to hygiene level (λ)	7000
Average hours of drivers ' activity (m)	9
The average cost of the driver for one hour of activity in the ride-hailing company (q)	2.5
The basic maximum compensation (C_{max})	1000
The basic minimum compensation (C_{min})	20

From the information provided on the Lyft Company website, we see that the cost of travel is calculated by adding the cost per mile, cost per minute, entrance fee, and service cost. We assumed $p_0 = 0.505$ as the basis entrance fee and since in this study we have considered the costs in minutes, we have converted the cost in miles and the cost of services into the cost in minutes, then we are adding these costs to the cost in minutes and approximately we have reached $p_2 = 1$. All costs brought are related to the Monterey area of California† . †

To ensure the reproducibility and practical relevance of our numerical analysis, Table R.1 in Appendix A outlines the empirical estimation method and data source for each key parameter used in the Lyft-based case study. The parameters are not assumed arbitrarily; they are derived through a combination of direct extraction from Lyft's public pricing data, calibration from established academic studies on ride-hailing demand and driver behavior, and inference from industry reports on insurance and safety. This structured approach provides a transparent foundation for the simulation, validatingthe model's outputs against real-world operational and financial benchmarks.

For the case study, the hygiene measures corresponding to the optimal value of h are categorized into five groups, with the intervals for each category defined as follows:

---

* https://backlinko.com/lyft-users *

† https://www.lyft.com/pricing/MRY †

[0,2)	Online payments
[2,4)	Online payments + Vehicle cleaning and disinfection
[4,6)	Online payments + Vehicle cleaning and disinfection + Mandatory mask usage
[6,8)	Online payments + Vehicle cleaning and disinfection + Mandatory mask usage+ Installation of barriers between passengers and drivers
$[8, \infty)$	Online payments + Vehicle cleaning and disinfection + Mandatory mask usage + Installation of barriers between passengers and drivers +Regular health checks for drivers and encouraging sick drivers to rest

The categorization into discrete groups serves to guide the specific hygiene actions that correspond to different ranges of hygiene levels.

We can observe the effect of these changes on the decision variables and profit of the ride-hailing company and the insurance company in Table 3 by using the parameters of Table 2.

Table 3. Values of decision variables and profit functions

Variables	First scenario	Second scenario	Third scenario
Fraction of the insurance company's revenue shared (φ)	-	-	0.06
The hygiene level (h^f)	0.24	5.63	5.63
The insurance level (γ^f)	9.70	15.74	15.74
The base entrance premium (w^f)	5.51	-	5.54
Entrance fee (p_1^f)	3.44	5	5
Profit function of the ride-hailing company (π_r^f)	5614680	-	6220290
Profit function of the insurance company (π_i^f)	15400000	-	16205600
Profit function of the drivers (π_d^f)	57650400		69650100
Members' integrated profit function (π_{ic}^f)	78655080	92076000	92076000

From Table 3, it can be seen that the level of insurance and hygiene in the second and third scenarios is higher than in the first scenario, and this is in the interest of the insurance company, drivers, and customers. In the first scenario, the ride-hailing company implements only the measures from the first category, which includes online payments. However, in the second and third scenarios, the company adopts the measures from the third category, which include online payments, vehicle cleaning and disinfection, and mandatory mask usage. The income of the ride-hailing company and the insurance company in the third scenario is higher than the first scenario so the third scenario is more profitable for both companies. The entrance fee in the second and third scenarios is higher than the first scenario and may not be to the liking of customers. If the coordination game plays between the ride-hailing company and the insurance company and a contract is signed, the profits of both companies will increase. This increase in profit in the case of a contract is equal to the merger of the two companies. Therefore, the final profit in the second scenario and the third scenario are equal.

4.2. Sensitivity Analysis

Some of the parameters are more effective in increasing or decreasing the profits of companies and in this section, to validate the model, the effects of important parameters on the model are analyzed. Figures 2 and 3 show the changes in the profit of the ride-hailing company and the insurance company in relation to the travel price (p_2).

Variable price analysis (p_2) in Figure 2 demonstrates the profit of the ride-hailing company in the decentralized model and revenue-sharing contract model is rising. By increasing p_2, the revenue of the ride-hailing company grows, and its demand decreases, but the profit chart is bullish because the effect of revenue growth is more than demand decrease. Due to the decrease in demand, in the contract model, the number of insured car units lessens and the profit of the insurance company is reduced. By decreasing the profit of the insurance company, the portion of the revenue given to the ride-hailing company is reduced and gradually increase the profit of the ride-hailing company in the contract model with a lower slope occurs. Figure 3 shows that with an increase of p_2, the insurance company's profit decreases in both decentralized and contract models. This downward trend occurs in the decentralized model with a steeper slope.

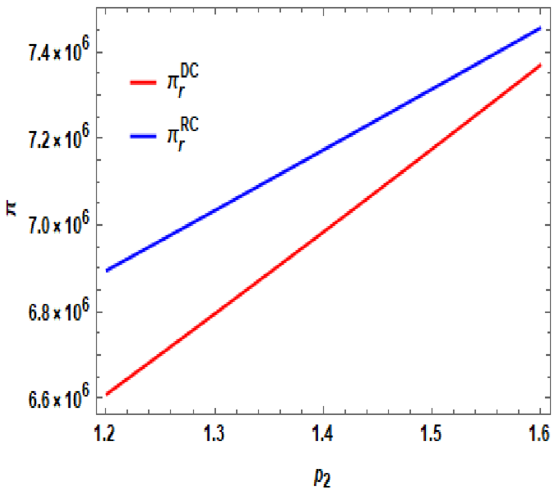

Figure 2. The effect of p_2 on the ride-hailing company's profit function

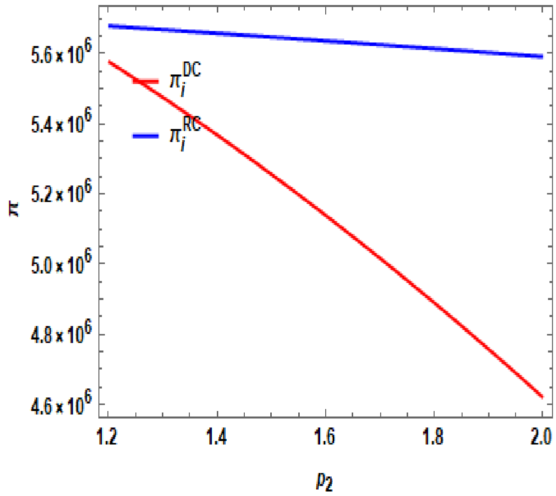

Figure 3. The effect of p_2 on the insurance company's profit function

The effect of change on the basis of maximum payment compensation (C_{max}) on the profit of the ride-hailing company and the profit of the insurance company are shown in Figures 4 and 5, respectively. As we can see in Figure 4, the profit chart of the ride-hailing company is upward because with an increase of C_{max}, the amount of payment of part of the damage to the insured increases, which satisfies customers and as a result, the demand of the ride-hailing company increases. Figure 5 shows that with an increase of C_{max}, the insurance benefit in both scenarios decreases because it has to pay more damages to the insured. In the centralized model, decreasing or increasing C_{max}does not affect the profit because, in the integrated company profit function, C_{max} is removed.

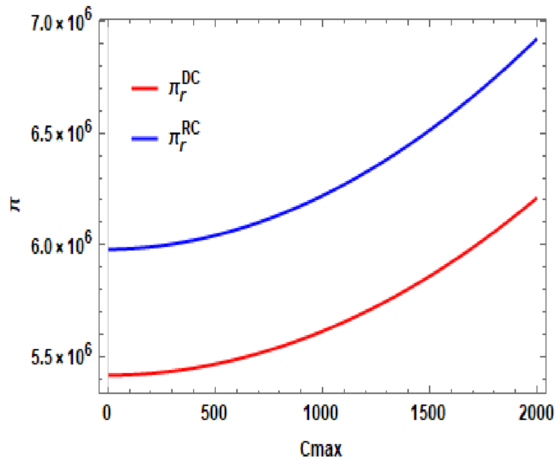

Figure 4. The effect of C_{max}on the ride-hailing company's profit function

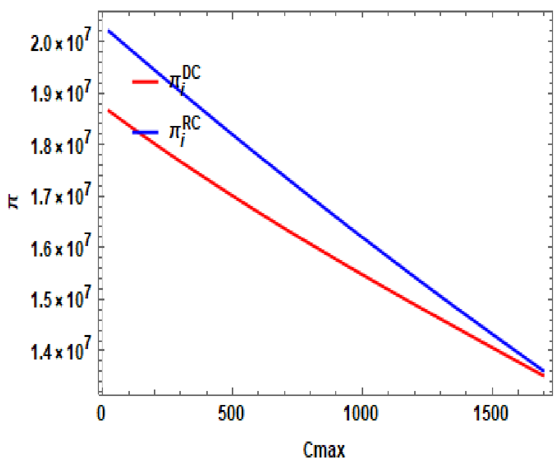

Figure 5. The effect of C_{max} on the insurance company's profit function

Changes in the sensitivity coefficient of the number of insured units to the base entrance premium(θ) are shown in Figures 6 and 7. We can see in Figure 6, that the profit of the ride-hailing company than θ is bullish because as θ increases, the number of car units insured by the ride-hailing company decreases, and as a result, it pays less to the insurance company. According to the following Figures, it can be seen that with increasing θ, the number of insured units decreases and as a result, the amount of compensation paid by the insurance company to the insured decreases and causes the insurance company's profit increases. In the centralized model, since all members of the game are one unit, there is no cost called insurance cost, and all car units are insured and decreasing or increasing θ has no effect on profit.

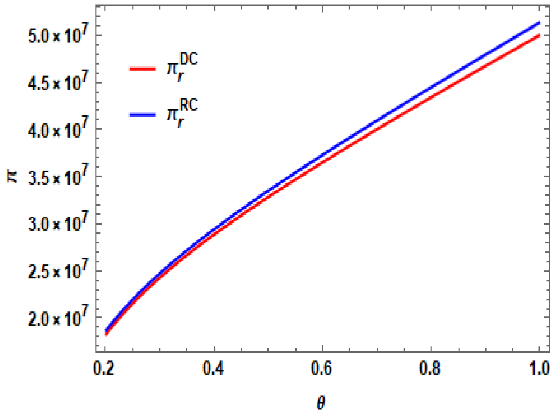

Figure 6. The effect of θ on the ride-hailing company's profit function

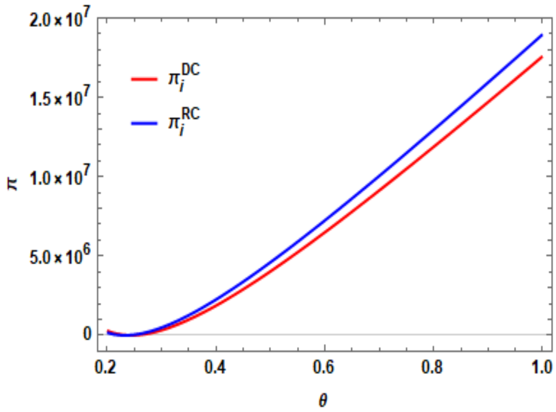

Figure 7. The effect of θ on the insurance company's profit function

Figures 8–12 illustrate the impact of the revenue-sharing fraction (φ) on the equilibrium outcomes under the coordination contract. Figure 8 demonstrates a non-monotonic relationship between φ and the insurance company's profit. Initially, as φ increases from a low value, the profit shows a slight upward trend, due to the demand-enhancing effect of better-coordinated services which expands the insured base. However, beyond a certain threshold, the direct financial impact of ceding a larger revenue share outweighs this benefit, leading to a decline in the insurer's profitability. In contrast, Figure 9 confirms that the ride-hailing company's profit increases monotonically with φ, as it directly benefits from a larger share of the insurance revenue in addition to the indirect gains from higher demand. Figures 10 and 11 reveal a significant insight: both the optimal hygiene level (h^{RC}) and the optimal insurance level (γ^{RC}) increase monotonically with φ. This indicates that a higher revenue share for the ride-hailing company incentivizes greater investment in both hygiene and insurance coverage. With a larger stake in the insurance revenue stream, the platform is motivated to enhance hygiene and insurance levels to further drive demand. Consequently, as shown in Figure 12, the insurance company responds to this higher insurance level (γ^{RC}) and its own altered profit structure by optimally adjusting the base entrance premium (w^{RC}), which also increases with φ.

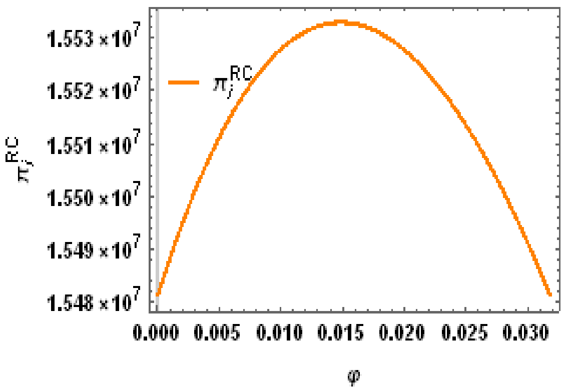

Figure 8. The effect of φ on the insurance company's profit function

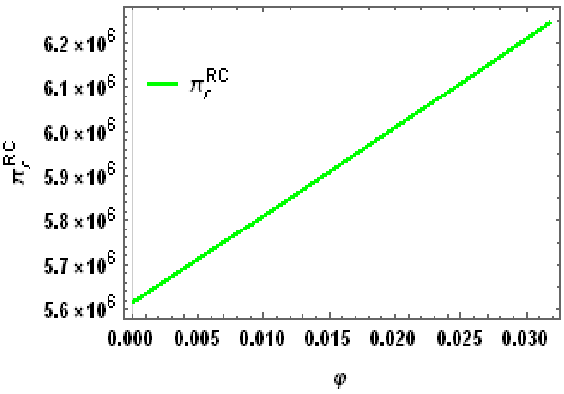

Figure 9. The effect of φ on the ride-hailing company's profit function

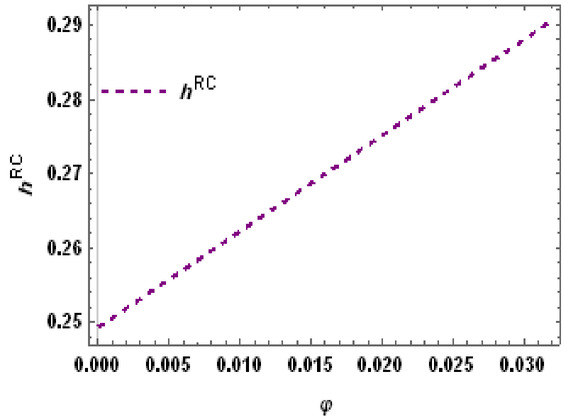

Figure 10. The effect of φ the optimal hygiene level

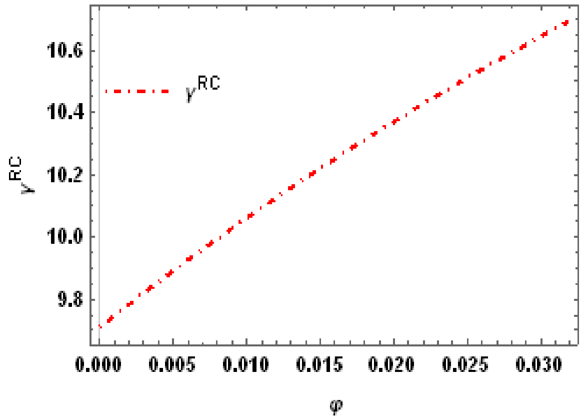

Figure 11. The effect of φ on the optimal insurance level

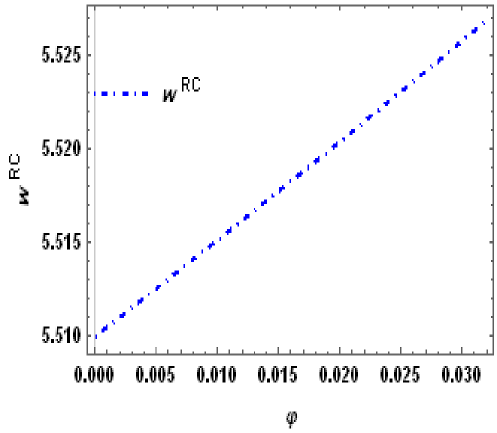

Figure 12. The effect of φ on the optimal base entrance premium

Figures 13–15 analyze the sensitivity of equilibrium decisions to the daily accident probability (S) under both the decentralized and coordination contract scenarios. Figure 13 shows that the optimal hygiene level (h^f) increases with S in both scenarios. As the operational risk rises, the ride-hailing company invests more in hygiene not only as a direct safety measure but also as a strategic complement to insurance, enhancing overall service safety and customer confidence in a higher-risk environment. Figure 14 demonstrates that the optimal insurance level (γ^f) also exhibits a strong positive relationship with S. The increase is sharp initially as the firm responds to the fundamental rise in risk, with the slope moderating at higher values of S, indicating a gradual approach to a practical coverage ceiling. Consequently, as shown in Figure 15, the insurance company rationally adjusts by charging a higher base entrance premium (w^f) in response to the increased accident probability and the corresponding rise in coverage level. The premium increases monotonically with S, reflecting the direct risk–premium relationship fundamental to insurance economics. Across all figures, the coordinated model (RC) yields higher optimal values for hygiene, insurance, and premium compared to the decentralized baseline, illustrating how the revenue-sharing contract fosters higher investment in safety and risk mitigation.

Figures 16 and 17 present an analysis examining the simultaneous effects of the accident probability (S) and the minimum compensation cost (C_{min}) on the profit functions of the insurance company and the ride-hailing company, respectively, under the decentralized scenario. Figure 16 demonstrates that insurance company's profit is more sensitive to variations in S than to C_{min}. The insurance company's profit increases with both higher S and higher C_{min}. This is because, in our model's equilibrium, the insurance company optimally adjusts the base premium (w^f) in response to heightened risk exposure. The increased premium revenue from a higher S and a higher C_{min} outweighs the associated rise in expected claim costs, leading to a net increase in profitability. This reflects the insurer's ability to price risk accurately in a controlled setting. Similarly, Figure 17 demonstrates that the ride-hailing company's profit also grows with increases in S and C_{min}. This occurs as the platform optimally responds to the increased risk environment by raising its insurance level (γ^f) and adjusting its pricing strategy. The consequent enhancement in perceived safety and service quality stimulates greater demand, while the coordinated adjustment of the insurance premium through the Stackelberg interaction ensures that a portion of the increased costs is managed within the supply chain dynamics.

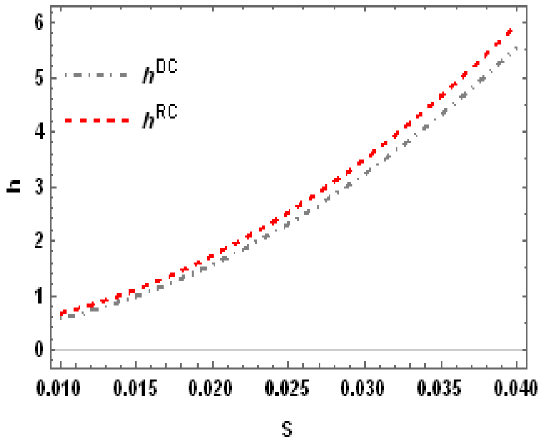

Figure 13. The effect of S the optimal hygiene level

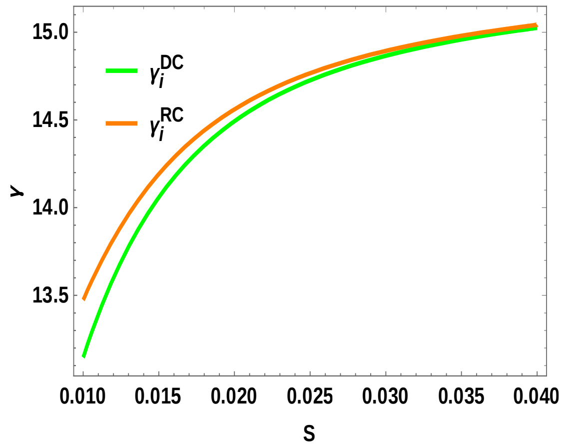

Figure 14. The effect of S on the optimal insurance level

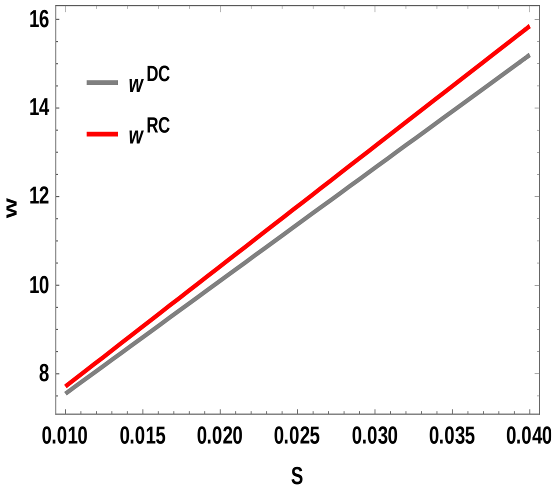

Figure 15. The effect of S on the optimal base entrance premium

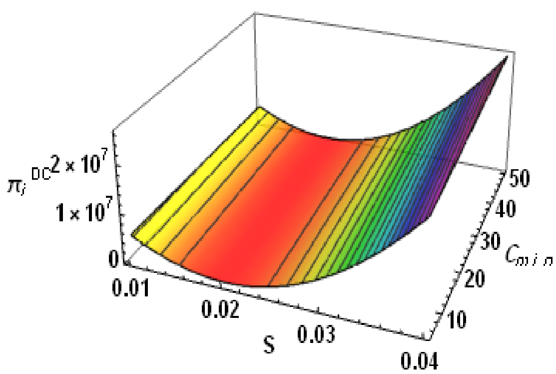

Figure 16. The synchronic effect of S and C_{min} on the insurance company's profit function

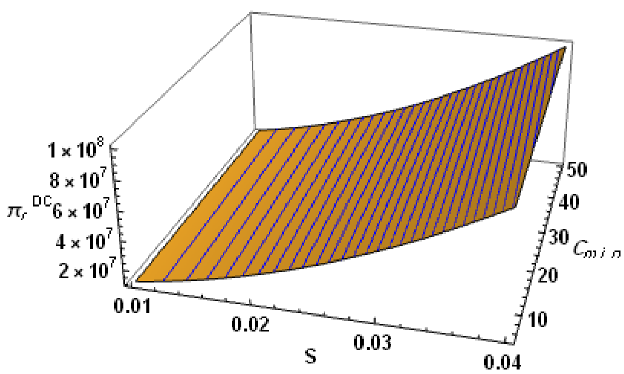

Figure 17. The synchronic effect of S and C_{min} on on the ride-hailing company's profit function

5. Managerial Insight

This article examines the ride-hailing company and the insurance company under the Stackelberg game by applying the level of hygiene in the cars. This game has been reviewed and analyzed under three scenarios and the optimal strategy has been identified. In the following, we will express the managerial insights and practical points:

- **Hygiene standards impact on market share and competitive advantage**

  The ride-hailing industry's rapid growth has made capturing and maintaining customer loyalty critical for companies. By implementing higher hygiene standards, ride-hailing companies can significantly differentiate themselves from competitors. The emphasis on hygiene, especially in a post-pandemic world, not only attracts new customers but also retains existing ones. This creates a competitive advantage that can lead to an increased market share, thereby positioning the company as a pioneer in the industry.

- **Customer and driver satisfaction:**

  When the ride-sharing company applies higher levels of hygiene and insurance, the entrance fee determined by the company will increase. However, given the emphasis on hygiene and safety, customers and drivers value these improvements, leading to increased demand up to a certain level. This balance ensures that the company does not experience a decrease in demand, and its profits increase as long as the added costs remain within the acceptable range for customers."

- **Mutual Benefits in the revenue-sharing contract:**

  The findings indicate that when ride-hailing and insurance companies enter into a coordination contract, it leads to mutual benefits. The ride-hailing company benefits from reduced risks and liabilities through insurance, while the insurance company gains from the increased business generated by the ride-hailing industry's growth. This collaboration not only enhances the profitability of both companies but also improves the overall service quality, making it a win-win situation.

- **Hygiene standards with considering coordination**

  When a ride-hailing company establishes a revenue-sharing contract with an insurance provider, it often leads to the adoption of stricter hygiene standards. This partnership allows the ride-hailing company to distribute the costs of upholding these higher hygiene levels, which in turn bolsters the company's financial sustainability.

- **The impact of insurance on the ride-hailing industry**

  Insuring both customers and drivers not only provides a sense of security but also reflects the ride-hailing company's commitment to responsibility and support. From a managerial standpoint, offering comprehensive insurance coverage can significantly enhance the company's reputation, leading to increased trust and loyalty among both customers and drivers. This sense of safety can be a powerful differentiator in a competitive market, attracting more users to the platform and retaining existing ones. As a result, the number of customers and drivers is likely to grow, which in turn can lead to higher service availability and increased revenue. In essence, the strategic decision to insure customers and drivers not only supports the company's social responsibility goals but also serves as a critical factor in driving long-term growth and financial success.

- **Enhancing level of insurance services through revenue-sharing contract**

  When a ride-hailing company partners with an insurance provider through a revenue-sharing contract, it secures higher-quality insurance services for both drivers and customers. This enhanced coverage increases trust and boosts demand for transportation services, ultimately leading to higher profits for the ride-hailing company. Additionally, the insurance provider benefits from the increased fees associated with the contract, resulting in greater profitability compared to situations without a revenue-sharing contract. This mutually beneficial contract strengthens service quality, customer satisfaction, and the long-term financial performance of both partners.

6. Conclusions and Future Research

In this article, we explore the concept of ride-hailing companies insuring their drivers, customers, and cars through insurance companies, which supports the services they provide. Additionally, we examine the importance of hygiene levels in ride-hailing cars to reduce the risk of Covid-19 transmission to protect customers and drivers. The ride-hailing company decides on the insurance and hygiene levels, while the insurance company determines the base entrance premium paid by the ride-hailing company. Using Stackelberg game theory, we model the interactions between ride-hailing and insurance companies under three scenarios: decentralized, centralized, and coordination game under revenue-sharing contracts. We evaluate the model by providing a real-world example from Lyft.

From a theoretical perspective, this research makes several contributions. First, it extends the existing ride-hailing and service-quality literature by introducing insurance coverage as an endogenous strategic decision variable, rather than treating insurance as an exogenous regulatory or background factor. This allows the model to capture the dual safety dimensions of health protection and financial risk protection within a unified decision framework. Second, by explicitly modeling hygiene investment and insurance coverage simultaneously, the study reveals that these two safety instruments can exhibit strong complementarity effects, particularly under centralized and coordinated contracts. This interaction effect has not been explicitly addressed in prior pricing–hygiene or insurance-only models and provides new insights into how multi-dimensional safety strategies shape consumer demand and firm profitability. Third, the proposed revenue-sharing contract contributes to the channel coordination literature in mobility services by demonstrating how contractual mechanisms can partially or fully restore system efficiency and enhance joint profitability in vertically related service ecosystems.

The results also offer several important managerial and policy implications. For ride-hailing platforms, the findings highlight that investments in hygiene and insurance should be designed jointly rather than independently, as their combined effect on customer trust and demand can be significantly stronger than the sum of individual effects. This suggests that bundled "safe and secure ride" strategies—combining visible hygiene protocols with strong insurance guarantees—can serve as powerful tools for market differentiation, customer retention, and long-term platform growth. For insurance providers, the results indicate that partnering with platforms that actively invest in service quality and hygiene can increase demand for insurance products and improve portfolio stability, motivating the design of customized insurance contracts or premium incentives linked to certified hygiene standards. From a policy perspective, regulators and public transportation agencies may view coordinated safety standards and insurance requirements as complementary tools for improving service reliability, protecting users, and supporting sustainable urban mobility, especially in post-pandemic operating environments.

Moreover, the comparison across contractual structures demonstrates that revenue-sharing coordination can significantly improve both firm profitability and service quality outcomes relative to purely decentralized decisions. However, the effectiveness of such contracts depends critically on the sharing rate, which influences not only profit allocation but also the incentives to invest in hygiene and insurance. This highlights the importance of contract design in aligning private incentives with system-wide efficiency, particularly in platform-based service markets characterized by asymmetric bargaining power.

The problem addressed in this research is modeled using a single ride-hailing company and one insurance company, representing these entities. While this approach deviates from real-world scenarios, future studies could expand the model by incorporating multiple ride-hailing and insurance companies to analyze pricing strategies and competition among them. While the present study adopts a deterministic demand function to maintain analytical tractability and establish the first integrated framework for ride-hailing–insurance interactions, we fully acknowledge that real-world ride-hailing demand is inherently stochastic and time-varying. Several exogenous and endogenous factors—such as sudden weather changes, traffic congestion, special events, network connectivity issues, and, importantly, systematic intraday demand patterns—introduce significant volatility and predictability challenges into ride-hailing operations. For instance, empirical data consistently shows pronounced demand peaks during morning and evening commute hours, with considerable lulls during midday and late-night periods, leading to time-dependent pricing and service availability adjustments in practice.Including such stochastic and dynamic elements in the model would undoubtedly affect optimal decisions regarding pricing, hygiene investment, and insurance levels. For example, under high-demand volatility, the platform might adjust its insurance coverage dynamically or adopt flexible hygiene protocols to mitigate operational risks while managing costs. Similarly, insurance premium settings could be adapted based on time-varying accident probabilities linked to traffic density or weather conditions. In some countries, including the U.S., public transportation agencies have partnered with ride-hailing companies to enhance their services. This aspect could also be considered in future research models.

Appendix A

$$A_1 = ((k - a\beta)(-2 + (C_{max} + C_{min})S\theta)(2 + (C_{max} + C_{min})S\theta)\tau + 16gm\theta(-ap_0t + k(p_0 + p_2\tau)) + p_0(4t - 4\beta - 16gmp_2t\theta - (C_{max} + C_{min})^2S^2(t - \beta)\theta^2)\tau\tau_1 + p_2(16gmp_0t\theta - 4\beta\tau + (C_{max} + C_{min})^2S^2\beta\theta^2\tau)\tau_2) \quad (A.1)$$

$$A_2 = 16gp_0t\theta\lambda^2 + 32ku\theta\tau - 32p_0tu\theta\tau\tau_1 \quad (A.2)$$

$$A_3 = (-2 + (C_{max} + C_{min})S\theta)(2 + (C_{max} + C_{min})S\theta)\lambda^2\tau) \quad (A.3)$$

$$A_4 = (-2 + (C_{max} + C_{min})S\theta)(2 + (C_{max} + C_{min})S\theta)(16mu(k + a\beta)\theta + \beta(-2 + (C_{max} + C_{min})S\theta)(2 + (C_{max} + C_{min})S\theta)\lambda^2) \quad (A.4)$$

$$A_5 = 256g^2mp_0t\theta^2\lambda^2(p_0 + p_2\tau) + 16g\theta\tau(16amp_0tu\theta + 16kmu\theta(p_0 + p_2\tau) + (-4 + (C_{max} + C_{min})^2S^2\theta^2)\lambda^2(p_0(t + \beta) + p_2\beta\tau)) - 16u\theta\tau(p_0((t + \beta)(-2 + (C_{max} + C_{min})S\theta)(2 + (C_{max} + C_{min})S\theta)\tau + 16gmt\theta(2p_0 + p_2\tau))\tau_1 + p_2(16gmp_0t\theta - 4\beta\tau + (C_{max} + C_{min})^2S^2\beta\theta^2\tau)\tau_2) \quad (A.5)$$

$$A_6 = (16gmp_0t\theta - 4\beta\tau + (C_{max} + C_{min})^2S^2\beta\theta^2\tau) \quad (A.6)$$

$$A_7 = 16gmp_0t\lambda^2 + 32kmu\tau - 32mp_0tu\tau\tau_1 \quad (A.7)$$

$$A_8 = (-2 + (C_{max} + C_{min})S\theta)(2 + (C_{max} + C_{min})S\theta)\lambda^2\tau) \quad (A.8)$$

$$A_9 = \theta(C_{max} + C_{min}) \quad (A.9)$$

$$A_{10} = \lambda((k - at) + (-p_2 + q)t\tau\tau_1 + p_2t\tau_2) \quad (A.10)$$

$$A_{11} = (p_2 - q)\tau\lambda \quad (A.11)$$

$$A_{12} = p_0\lambda^2 - 2p_0u\tau\tau_1 \quad (A.12)$$

$$A_{13} = k(-p_2 + q)u\tau + p_0tu((2p_0 + (p_2 - q)\tau)\tau_1 + p_2\tau_2) - p_0(ku + atu + (p_2 - q)t\lambda^2) \quad (A.13)$$

$$A_{14} = (p_0t\lambda^2 + 2ku\tau - 2p_0tu\tau\tau_1) \quad (A.14)$$

$$A_{15} = S\theta(C_{max} + C_{min}) - 2\phi \quad (A.15)$$

A summary of the parameter estimation methods and data sources used for the Lyft-based numerical analysis is provided in Table R.1.

Table R.1. Parameter Estimation and Data Source

Parameter	Estimation Method	Data Source/Reference
p_0	Direct from Lyft regional pricing	https://www.lyft.com/
p_2	Derived from Lyft's per-minute and per-mile rates, converted to an hourly equivalent using average urban speed data, and normalized to model units.	https://www.lyft.com/

τ_1	Calibrated using price elasticity of demand estimates from ride-hailing studies, applied to Lyft's demand scale to yield realistic percentage changes (2-5%) for observed price variations.	
τ_2	Estimated via regression on past sales panel data and passenger surveys.	
τ	Industry standard average trip duration for urban ride-hailing services.	https://lyft.com/impact/economic-impact-report
α	Derived from Lyft's active rider count and assumed average ride frequency, scaled to total ride-hours.	https://investor.lyft.com/sec-filings/annual-reports
β	Calibrated from commercial auto insurance premium structures, reflecting sub-linear premium increases for higher coverage tiers.	https://www.actuary.org/sites/default/files/2021-03/AutoInsurData.IB_.3.21.pdf
u	Calibrated from reported platform investments in COVID-19 safety measures, scaled to Lyft's operational size and demand.	Uber safety investment report (2020)[‡] ; scaled for Lyft.
θ	Estimated based on structured interviews with ride-hailing industry experts and calibrated to response of insurance purchasing to premium changes. The value is scaled to be consistent with the demand units employed in the model.	
g	Direct from Lyft's commission (take-rate) model, representing the platform's share of the ride fare.	https://www.lyft.com/
S	Calibrated from NHTSA vehicle crash rates, adjusted for ride-hailing vehicle mileage and claim frequency.	https://crashstats.nhtsa.dot.gov/
t	Estimated based on structured interviews with ride-hailing industry experts and calibrated to quantify the impact of insurance coverage levels on customer entrance fees. This value is scaled to be consistent with the demand units used in the model.	
k	Estimated based on structured interviews with ride-hailing industry experts and calibrated to quantify the effect of insurance coverage levels on users' willingness to use ride-hailing services. The value is scaled to be consistent with the demand units employed in the model	
λ	Estimated based on structured interviews with ride-hailing industry experts and calibrated using post-COVID empirical studies that quantify the effect of health and hygiene measures on users' willingness to use ride-hailing services. The value is scaled to be consistent with the demand units used in the model.	
m	Based on driver survey data reporting average active platform time per day.	Driver behavior studies (e.g., Chen et al., 2019).
q	Estimated from driver operating cost per mile, converted to an hourly cost using average speed.	Henao & Marshall (2019); operating cost per mile estimates.
C_{min}	Calibrated using industry data on average costs of minor claims in ride-hailing operations, including small vehicle damages and low-severity medical expenses. The value is scaled to the model's monetary units to ensure numerical tractability.	Insurance Research Council[§]
C_{max}	Calibrated based on reported average costs of severe claims involving bodily injury and major property damage in ride-hailing accidents. This parameter is also scaled to match the monetary units used in the model for computational consistency.	Insurance Research Council

‡ https://www.uber.com/us/en/about/reports/us-safety-report/

§ https://www.insurance-research.org/

Appendix B

Proof of Proposition 1. The Hessian matrix of the ride-hailing company profit function as follows: h^{RC}, γ^{RC}, and p_1^{RC}

$$\begin{pmatrix} -u & \frac{w^{DC}\beta(w^{DC}\theta-1)\lambda}{m}+\frac{gp_0t\lambda}{\tau} \\ \frac{w^{DC}\beta(w^{DC}\theta-1)\lambda}{m}+\frac{gp_0t\lambda}{\tau} & \frac{2(gmp_0t+w^{DC}\beta(w^{DC}\theta-1)\tau)(k-p_0t\tau_1)}{m\tau} \end{pmatrix} \quad \text{(B.1)}$$

As we know, if the Hessian matrix is negative, the profit function of the ride-hailing company is concave on h^{DC}, γ^{DC}.

According to the Hussein matrix obtained from this profit function, the first principal minor is negative $(-u<0)$ and the second principal minor is positive $(\frac{-2u(gmp_0t+w^{DC}\beta(w^{DC}\theta-1)\tau)(k-p_0t\tau_1)}{m\tau}>0)$ under the following conditions:

$$m^2\tau^2(gmp_0t+w^{DC}\beta(w^{DC}\theta-1)\tau)(gmp_0t\lambda^2+2kmu\tau+w^{DC}\beta(w^{DC}\theta-1)\lambda^2\tau-2mp_0tu\tau\tau_1)<0 \quad \text{(B.2)}$$

Therefore, the profit function of the ride-hailing company is concave on h^{DC}, γ^{DC}.

Proof of Proposition 2. To proof that the insurance company profit function is concave on w^{DC}, we can observe that the second derivative of the insurance company profit function is negative.

$$-\frac{2(1+\beta\gamma^{DC})\theta(a+k\gamma^{DC}+h^{DC}\lambda-(p_0+p_0t\gamma^{DC})\tau_1-p_2\tau_2)}{m} \quad \text{(B.3)}$$

Proof of Proposition 3. The Hessian matrix of the integrated company profit function as follows:

$$\begin{pmatrix} -u & \frac{p_0t\lambda}{\tau} \\ \frac{p_0t\lambda}{\tau} & \frac{2p_0t(k-p_0t\tau_1)}{\tau} \end{pmatrix} \quad \text{(B.4)}$$

We can observe from the Hussein matrix obtained that the first principal minor is negative $(-u<0)$ and the second principal minor is positive $(\frac{-2up_0t(k-p_0t\tau_1)}{\tau}-(\frac{p_0t\lambda}{\tau})^2>0)$ under the following conditions:

$$p_0t\tau^2(-p_0t\lambda^2-2ku\tau+2p_0tu\tau\tau_1)>0 \quad \text{(B.5)}$$

Therefore, the profit function of the integrated company under the centralized scenario is concave on h^C, γ^C.

Proof of Proposition 4. Since that h^{RC}, γ^{RC}placed in the cooperative game under the revenue-sharing contract are the optimal value of the integrated company, the concave of the integrated company profit function relative toh^{RC}, γ^{RC} is shown in proof of proposition 3**.**

Proof of Proposition 5. The second derivative of the insurance company under the cooperative game under the revenue-sharing contract profit function is concave under following conditions:

$$p_0 t(p_0 t\lambda^2 + 2ku\tau - 2p_0 tu\tau\tau_1)\left(p_0^2 t\lambda^2 + p_0(ku + atu + (p_2 - q)t\lambda^2)\tau + k(p_2 - q)u\tau^2 - p_0 tu\tau\left((2p_0 + (p_2 - q)\tau)\tau_1 + p_2\tau_2\right)\right) < 0 \tag{B.6}$$

Thus, the profit function of the insurance company under the cooperative game through the revenue-sharing contract is concave on w^{RC}.

Proof of Theorem 1 and Theorem 2. To derive the optimal decisions in the decentralized scenario, we follow a backward induction approach consistent with the Stackelberg game structure, where the ride-hailing company acts as the leader and the insurance company as the follower.

First, Equations (1) and (2) are substituted into the insurance company's profit function (Equation (4)).

$$\pi_i^{DC} = \frac{((C_{amx}+C_{imn})S-2w^{DC})(1+\beta\gamma^{DC})(w^{DC}\theta-1)(a+k\gamma^{DC}+h^{DC}\lambda-p_1^{DC}\tau_1-p_2\tau_2)}{2m} \tag{B.7}$$

The resulting profit function is then differentiated with respect to w^{DC}, and the corresponding first-order condition is solved to obtain the insurer's optimal premium, given in Equation (7) ($\frac{d\pi_i^{DC}}{dw^{DC}} = 0$). Next, this optimal response of the insurance company is substituted into the ride-hailing company's profit function (Equation (3)).

$$\pi_r^{DC} = \frac{gp_1^{DC}(a+k\gamma^{DC}+h^{DC}\lambda-p_1^{DC}\tau_1-p_2\tau_2)}{\tau} - \frac{1}{2}h^{2DC}u + \frac{((1+\beta\gamma^{DC})(-4+(C_{amx}+C_{imn})^2S^2\theta^2)+16gm\theta p_2)(a+k\gamma^{DC}+h^{DC}\lambda-p_1^{DC}\tau_1-p_2\tau_2)}{16m\theta} \tag{B.8}$$

The ride-hailing company's profit is then differentiated with respect to its decision variables, namely the hygiene level h^{DC} and the insurance level γ^{DC}. By solving the first-order derivative of the profit function with respect to each of the variables ($\frac{d\pi_r^{DC}}{dh^{DC}} = 0 \; and \; \frac{d\pi_r^{DC}}{d\gamma^{DC}} = 0$), the optimal values of the ride-hailing company's decision variables, presented in Equations (5) and (6), respectively, are obtained.

Proof of Theorem 3. By solving the first-order derivative of the profit function of the integrated company with respect to each of the variables ($\frac{d\pi_{ic}^{C}}{dh^{C}} = 0 \; and \; \frac{d\pi_{ic}^{C}}{d\gamma^{C}} = 0$), the optimal values of the integrated company's decision variables under the centralized scenario, presented in Equations (10) and (11), respectively, are obtained.

Proof of Theorem 4 and Theorem 5. To derive the optimal decisions in revenue-sharing contract, we follow a backward induction approach consistent with the Stackelberg game structure, where the ride-hailing company acts as the leader and the insurance company as the follower.

First, Equations (1) and (2) are substituted into the insurance company's profit function (Equation (13)).

$$\pi_i^{RC} = \frac{(1+\beta\gamma^{RC})(-1+w^{RC}\theta)((C_{amx}+C_{imn})S+2w^{RC}(-1+\varphi))(a+k\gamma^{RC}+h^{RC}\lambda-p_1^{RC}\tau_1-p_2\tau_2)}{2m} \tag{B.9}$$

The resulting profit function is then differentiated with respect to w^{RC}, and the corresponding first-order condition is solved to obtain the insurer's optimal premium, given in Equation (16) ($\frac{d\pi_i^{RC}}{dw^{RC}} = 0$). Next, this optimal response of the insurance company is substituted into the ride-hailing company's profit function (Equation (12)).

$$\pi_r^{DC} = \frac{(1+\beta\gamma^{RC})((C_{amx}+C_{imn})S\theta+2(-1+\varphi))(2+(C_{amx}+C_{imn})S\theta-2\varphi)(a+k\gamma^{RC}+h^{RC}\lambda-p_1^{RC}\tau_1-p_2\tau_2)}{16m\theta(-1+\varphi)^2} - -\frac{1}{2}h^{2RC}u + \frac{gp_1^{RC}(a+k\gamma^{RC}+h^{RC}\lambda-p_1^{RC}\tau_1-p_2\tau_2)}{\tau} + gp_2(a + k\gamma^{RC} + h^{RC}\lambda - p_1^{RC}\tau_1 - p_2\tau_2) + \frac{(1+\beta\gamma^{RC})((C_{amx}+C_{imn})S\theta+2(-1+\varphi))(2+(C_{amx}+C_{imn})S\theta-2\varphi)\varphi(a+k\gamma^{RC}+h^{RC}\lambda-p_1^{RC}\tau_1-p_2\tau_2)}{16m\theta(-1+\varphi)^2} \tag{B.10}$$

The ride-hailing company's profit is then differentiated with respect to its decision variables, namely the hygiene level h^{DC} and the insurance level γ^{DC}. By solving the first-order derivative of the profit function with respect to each of the variables ($\frac{d\pi_r^{RC}}{dh^{RC}} = 0 \; and \; \frac{d\pi_r^{RC}}{d\gamma^{RC}} = 0$), the optimal values of the ride-hailing company's decision variables, presented in Equations (14) and (15), respectively, are obtained.

References

Afifah, F., & Guo, Z. (2022). Spatial pricing of ride-sourcing services in a congested transportation network. Transportation Research Part C: Emerging Technologies, 142, 103777.

Agyemang, E., & Yaro, J. A. (2023). Knowledge, attitudes, and perception as predictors of COVID-19 safety practices of ride-hailing operators in Ghana: a cross-sectional study. International Journal of Environmental Research and Public Health, 20(5), 4529.

Akbari, M., Moradi, A., SeyyedAmiri, N., Zúñiga, M. Á., Rahmani, Z., & Padash, H. (2021). Consumers' intentions to use ridesharing services in Iran. Research in Transportation Business & Management, 41, 100616.

Asghari, M., & Shahabi, C. (2017, November). An on-line truthful and individually rational pricing mechanism for ride-sharing. In Proceedings of the 25th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems (pp. 1-10).

Barron, E. N. (2013). Game theory: an introduction (Vol. 2): John Wiley & Sons.

Castro, A., et al. (2022). "Floquet engineering the band structure of materials with optimal control theory." arXiv preprint arXiv:2203.03387.

Bistaffa, F., Farinelli, A., Chalkiadakis, G., & Ramchurn, S. D. (2017). A cooperative game-theoretic approach to the social ridesharing problem. Artificial Intelligence, 246, 86-117.

Chen, M. K., Rossi, P. E., Chevalier, J. A., & Oehlsen, E. (2019). The value of flexible work: Evidence from Uber drivers. Journal of political economy, 127(6), 2735-2794.

Choi, T. M., & Shi, X. (2022). On-demand ride-hailing service platforms with hired drivers during coronavirus (COVID-19) outbreak: Can blockchain help?. IEEE Transactions on Engineering Management, 71, 737-752.

Chow, G. C. (1966). On the long-run and short-run demand for money. Journal of Political Economy, 74(2), 111-131.

Cueva, A., Akhmedova, A., & Marimon, F. (2023). Effect of COVID on the sharing economy: Delphi analysis confirms that quality plays a key role in customers' satisfaction. International Journal for Quality Research.

Dailey, D. J., Loseff, D., & Meyers, D. (1999). Seattle smart traveler: dynamic ridematching on the World Wide Web. Transportation Research Part C: Emerging Technologies, 7(1), 17-32.

Dong, Z., & Leng, M. (2021). Managing on-demand ridesharing operations: Optimal pricing decisions for a ridesharing platform. International Journal of Production Economics, 232, 107958.

Fang, X., & Yuan, F. (2018). The coordination and preference of supply chain contracts based on time-sensitivity promotional mechanism. Journal of Management Science and Engineering, 3(3), 158-178.

Fielbaum, A., & Tirachini, A. (2021). The sharing economy and the job market: the case of ride-hailing drivers in Chile. Transportation, 48(5), 2235-2261.

Goldburd, M., Khare, A., Tevet, D., & Guller, D. (2016). Generalized linear models for insurance rating. Casualty Actuarial Society, CAS Monographs Series, 5, 77.

He, Y., Ni, J., Wang, X., Niu, B., Li, F., & Shen, X. (2018). Privacy-preserving partner selection for ride-sharing services. IEEE Transactions on Vehicular Technology, 67(7), 5994-6005.
Henao, A., & Marshall, W. E. (2019). An analysis of the individual economics of ride-hailing drivers. Transportation Research Part A: Policy and Practice, 130, 440-451.
Hong, J. H., & Liu, X. (2022). The optimal pricing for green ride services in the ride-sharing economy. Transportation Research Part D: Transport and Environment, 104, 103205.
Hong, S. J., Bauer, J. M., Lee, K., & Granados, N. F. (2020). Drivers of supplier participation in ride-hailing platforms. Journal of management information systems, 37(3), 602-630.
Hosni, H., Naoum-Sawaya, J., & Artail, H. (2014). The shared-taxi problem: Formulation and solution methods. Transportation Research Part B: Methodological, 70, 303-318.
Hu, B., Sun, Y., Sun, H., & Dong, X. (2020). A contrastive study on travel costs of car-sharing and taxis based on GPS trajectory data. International journal of environmental research and public health, 17(24), 9446.
Li, X., Lamadrid, R. L., & Zhou, L. (2022). Labour relations in the online ride-hailing industry: evidence from China. Labor History, 63(5), 652-668.
Li, X., Yang, Y., Guo, Y., Souders, D., & Li, J. (2023). Understanding the role of risk perception and health measures in ridesourcing usage in the post-COVID-19 era. Transportation Research Part A: Policy and Practice, 178,103877.
Lu, Y., Zhang, J., Qi, Y., Qi, S., Li, Y., Song, H., & Liu, Y. (2021). Safety warning! Decentralised and automated incentives for disqualified drivers auditing in ride-hailing services. IEEE Transactions on Mobile Computing, 22(3), 1748-1762.
Ma, J., Xu, M., Meng, Q., & Cheng, L. (2020). Ridesharing user equilibrium problem under OD-based surge pricing strategy. Transportation Research Part B: Methodological, 134, 1-24.
Mathai, V., Das, A., Bailey, J. A., & Breuer, K. (2021). Airflows inside passenger cars and implications for airborne disease transmission. Science advances, 7(1), eabe0166.
Morawska, L., et al. (2020). How can airborne transmission of COVID-19 indoors be minimised? Environment international 142: 105832.
Nguyen-Phuoc, D. Q., Su, D. N., Dinh, M. T. T., Newton, J. D. A., & Oviedo-Trespalacios, O. (2023). Passengers' self-protective intentions while using ride-hailing services during the COVID-19 pandemic. Safety Science, 157, 105920.
Nugroho, S. H., & Bandono, A. (2023). The Effect of Compensation, Labor Insurance, and Old Age Guarantee on Employee Satisfaction in Government Institutions. International Journal of Professional Business Review: Int. J. Prof. Bus. Rev., 8(5), 94.
Ohlsson, E., & Johansson, B. (2010). Non-Life insurance pricing. In Non-Life Insurance Pricing with Generalized Linear Models (pp. 1-14). Berlin, Heidelberg: Springer Berlin Heidelberg.
Özkan, E. (2020). Joint pricing and matching in ride-sharing systems. European Journal of Operational Research 287(3): 1149-1160.
Parvasi, S.P., A.A. Taleizadeh, and P. Thaichon. (2024). Price optimization for manufacturers in a competitive retail market: Imported products and online crowdfunding option. Journal of Revenue and Pricing Management. https://doi.org/10.1057/s41272-023-00471-5.
Peng, Z., Wang, W., Wang, C., & Yu, B. (2024). Designing stable ride-sharing for commuting trip chain with role flexibility. Transportation, 1-33.
Rajabzadeh, H., Altmann, J., & Rasti-Barzoki, M. (2023). A game-theoretic approach for pricing in a closed-loop supply chain considering product exchange program and a full-refund return policy: a case study of Iran. Environmental Science and Pollution Research 30(4): 10390-10413.
Ravula, P. (2022). Monetary and hassle savings as strategic variables in the ride-sharing market. Research in Transportation Economics: 101184.
Rosen, S. (1974). Hedonic prices and implicit markets: product differentiation in pure competition. Journal of political economy, 82(1), 34-55.
Shen, K. J. (2020). The rise of monopolistic rideshare companies in Asia: how ride hailing companies' market control impacts drivers. Penn Libraries: Scholarly Commons.
Shr, Y. H., & Chang, H. H. (2024). The effects of participating in digital ride-hailing on taxi drivers' business operations. Transportation Research Part A: Policy and Practice, 187, 104167.
Siddiq, A., & Taylor, T. A. (2022). Ride-hailing platforms: Competition and autonomous vehicles. Manufacturing & Service Operations Management, 24(3), 1511-1528.
Sinha, D. (2024). Customer Satisfaction in the Ride-Hailing Market: A Case Study Research in Delhi, India.
Srinivas, S. S., & Marathe, R. R. (2023). Towards sharing economy 2.0 with autonomous vehicles? Modeling the impact of COVID-19 on the e-hailing taxi service industry. Annals of Operations Research, 1-32.
Sun, H., Wang, H., & Wan, Z. (2019a). Model and analysis of labor supply for ride-sharing platforms in the presence of sample self-selection and endogeneity. Transportation Research Part B: Methodological, 125, 76-93.

Sun, L., Teunter, R. H., Babai, M. Z., & Hua, G. (2019b). Optimal pricing for ride-sourcing platforms. European Journal of Operational Research, 278(3), 783-795.

Taylor, T. A. (2018). On-demand service platforms. Manufacturing & Service Operations Management 20(4): 704-720.

Teo, B. C., Mustaffa, M. A., & Rozi, A. M. (2018). To grab or not to grab?: Passenger ride intention towards e-hailing services. Malaysia Journal of Consumer and Family Economics, 21, 153-163.

Tripathy, M., Bai, J., & Heese, H. S. (2023). Driver collusion in ride-hailing platforms. Decision Sciences, 54(4), 434-446.

Vayouphack, S. (2020). Ridesharing in Developing Countries: Perspectives from India and Thailand, Thesis, Auckland University of Technology.

Wang, W., Miao, W., Liu, Y., Deng, Y., & Cao, Y. (2022). The impact of COVID-19 on the ride-sharing industry and its recovery: Causal evidence from China. Transportation Research Part A: Policy and Practice, 155, 128-141.

Waqas, M., and A. Najmi (2023). Enhancing consumption of sustainable transportation: Determinants and outcome of consumer engagement with bike-sharing service. Environmental Science and Pollution Research 30 (18): 53411-53423.

Xu, W., Lin, G., & Zhu, X. (2022). Nash-stackelberg game perspective on pricing strategies for ride-hailing and aggregation platforms under bundle mode. International Journal of Industrial Engineering Computations, 13(3), 309-318.

Yang, J., Zhao, D., Wang, Z., & Xu, C. (2022). Impact of regulation on on-demand ride-sharing service: Profit-based target vs demand-based target. Research in Transportation Economics, 92, 101138.

Yang, Y., Tian, Q., & Wang, Y. (2020). Who is more likely to get a ride and where is easier to be picked up in ride-sharing mode?. Journal of Management Science and Engineering, 5(4), 264-286.

Zhang, C., et al. (2020). Pricing and allocation algorithm designs in dynamic ridesharing system. Theoretical Computer Science 803: 94-104.

Zhao, Y. (2022, December). Research on the Monitoring of Drivers' Hygiene Behavior by Online Car-Hailing Platforms During the Epidemic. In 2022 3rd International Conference on Management Science and Engineering Management (ICMSEM 2022) (pp. 424-433). Atlantis Press.

Zhong, Y., Yang, T., Cao, B., & Cheng, T. C. E. (2022). On-demand ride-hailing platforms in competition with the taxi industry: Pricing strategies and government supervision. International Journal of Production Economics, 243, 108301.