Ridesharing in Rail-Freight Transport and Use of Digital Aggregator: Prospects and Difficulties – A Developer's Perspective

Md Shakil Ahmed
School of Computing, Engineering and Physical Sciences
University of the West of Scotland
Glasgow, Scotland
md.shakil.ahmed@uws.ac.uk

Ravi Chandra Koirala
School of Computing, Engineering and Physical Sciences
University of the West of Scotland
Glasgow, Scotland
ravi.koirala@uws.ac.uk

Keshav Dahal
School of Computing, Engineering and Physical Sciences
University of the West of Scotland
Glasgow, Scotland
keshav.dahal@uws.ac.uk

Andrii Prokhorchenko
Operational Work Management
Ukrainian State University of Railway Transport
Kharkiv, Ukraine
prokhorchenko@kart.edu.ua

***Abstract*— The adoption of ridesharing principles, inspired by the Uber model, in road transport has presented a promising perspective for cost and time reduction. Particularly within the expanding urban transport networks, this concept has significantly enhanced passenger comfort. The implementation of an aggregator, a software program that gathers data from various sources and consolidates it based on user requirements or history, facilitates swift decision-making across different interfaces. This service model is employed in the context of rail-freight transport with ridesharing. The investigation aims to comprehend how an aggregator in rail-freight ridesharing can modernize freight operations, leading to cost and time savings and making the overall business model appealing to stakeholders.**

Keywords—rail-freight, ridesharing, aggregator, transportation, business model

I. Introduction

Rail-freight is an economical and eco-friendly means to transport diverse goods like furniture, foodstuffs, metals, and industrial raw materials [1]. This mode of transport is advantageous compared to road freight system in terms of sustainability [2], since this one generates about one fifth of the emissions per kilometer compared to trucks. Additionally, it offers greater loading capacity, lower accident rates, and reduced theft risks. With the world population on the rise, urban areas, especially in transportation sectors, are facing increased pressure. Newly developed road infrastructure struggles to keep up with the growing number of vehicles, leading to significant traffic jams during peak periods. Between 2001 and 2021, the registered motor vehicles in India surged from 55 to 292 million, representing a growth rate of 10.1% [3]. In contrast, road network development only progressed at a rate of 4.1% [4] during the same period. Consequently, significant traffic jams occur at various intersections during peak periods. Thus, ridesharing emerges as an effective method to alleviate the increasing pressure on vehicles. Passengers easily share vehicles when travelling to similar destinations, a concept well-established in road transportation services like BlaBlaCar and Liftshare [5]. But it is not yet prominent for the cases of rail-freight transport systems. An additional term to consider is the intermodal rail-freight system, where freight is shifted using multiple modes of transport, typically involving standard-sized (20 or 40 ft) containers transported by rail, sea, or road [6]. This paper focuses on investigating rail-cargo ridesharing supported by digital services (rail-freight aggregators), aiming to reduce the time and cost for enhanced performance.

In rail-freight ridesharing, stakeholders like customers, railway signaling, consigners/operators, secured networks, and IoT devices are involved. The development of a rail-freight aggregator is crucial to support these stakeholders and facilitate transportation services. However, creating such an aggregator, which aids decision-making by consolidating information, presents a challenging task. To systematically implement ridesharing in rail-freight, the following steps are crucial:

1) *Establishing the users' requirements.*
2) *Mapping rail routes using available geographic data.*
3) *Capturing the real-time data for cargo movements.*
4) *Developing the algorithms to find the best route with reduced cost and time.*
5) *Developing the digital service (aggregator) where customer demands are placed as input, processed through algorithms, and presented with the best route options.*
6) *Developing a cross-platform app for customers to place orders and then complete the cycle which include secured payment and feedback options.*

This paper discusses the concept of ridesharing in rail-freight operations, exploring the prospects and challenges in developing the crucial component, the 'digital aggregator'. Section II reviews existing literature on ridesharing and digital aggregators. Section III outlines the basic concept of rail-freight ridesharing, while Section IV demonstrates methodologies for the design and development of the 'digital aggregator' supporting rail-freight ridesharing. Section V delves into the prospects and challenges from design, development, and business perspectives. Section VI provides an analysis, leading to the conclusion in Section VII.

II. Background

The effective handling of rail-freight relies on combining various loads and destinations into economically efficient flows, with transaction expenses incurred at each transition point [7]. Integration of data from advanced travelers' information systems and freight and fleet management tools has been observed to decrease vehicle operating costs, delivery times, service levels, and environmental impact [8]. In this perspective, the different types of rail-freight systems and the concept of a digital aggregator in implementing rail-freight ridesharing will be discussed.

A. Types of Rail-freight

The hub-and-spoke logistics network, initially proposed by O'Kelly, enables centralized goods transportation between hubs, capitalizing on scale benefits of trunk transportation to offset insufficient full load rates. Widely applied in shipping, transportation, express delivery, communication, and other fields, this network reduces construction costs and achieves economies of scale compared to traditional point-to-point networks. However, its success relies heavily on the stability of the hub [9]. These systems often lack the flexibility and adaptability required to meet the dynamic demands of contemporary logistics. In contrast, the proposed ridesharing model introduces a paradigm shift, drawing inspiration from successful ridesharing implementations in road transportation [10]. By applying the principles of sharing economy and digital aggregation, the rail-freight system aims to enhance efficiency, reduce costs, and offer a more responsive solution to the burgeoning challenges of freight transportation.

Contrarily, point-to-point networks connect locations directly without service interruptions and are used by railways in the UK, Italy, and France [11, 12]. High-volume rail systems, like those in Sweden, Germany, Austria, Canada, and the United States, are integrating hub-and-spoke and corridor topologies into the Grid Network, implementing a hierarchy of transport supplies based on frequency and volume.

A conceptual model known as the foliated transportation network (FTN) presents a hybrid approach enhancing transportation system efficiency by integrating two prevalent network structures: direct shipment (DS) and hub and spoke (H&S) [13]. Through the foliation of both structures (DS and H&S), there is an elevation in physical resource utilization without compromising other essential performance metrics like total traffic work, the number of resources in the system, lead time, flexibility, and more.

An intermodal inland railroad freight transport terminal loads /unloads goods stored in containers for long-haul journeys via rail and road (pre-and post-haulage) [14, 15]. The terminal, acting as an interface between transportation modes and shippers/carriers, significantly influences intermodal freight transport competitiveness [15]. However, these systems may not completely meet the evolving needs of a rapidly growing and dynamic global market.

One of the ways to improve the technology of transportation of wagon and group shipments is the creation of technology for organizing car flows in stepped routes on the principle of ridesharing [16]. Ridesharing involves sharing a vehicle through services that connect fellow travelers based on the concept of economy of common use [17], an approach proved effective in road transport and aviation [18]. However, its application in the railway industry remains unexplored, prompting further analysis, drawing insights from platforms like Uber.

B. Uber Infrastructure

Uber has expanded beyond its cab-hailing service, venturing into areas like Uber Eats (on-demand food delivery) and Uber Freight (on-demand trucking). Launched in 2017, Uber Freight functions as a marketplace for seamless matching of shippers with carriers. It operates as a facilitator on a mobile platform [19], as illustrated in Figure 1, showcasing the data flow within Uber's infrastructure [20]. Uber continually collects analytical data from its data centers, forming the basis for analytics. These data streams are incrementally archived and ingested into the data warehouse for various machine learning and data science use cases. Real-Time Data Infra processes the data for critical functions such as dynamic pricing (Surge), intelligent alerting, operational dashboards, etc. A similar concept for rail-freight ridesharing will be explored further.

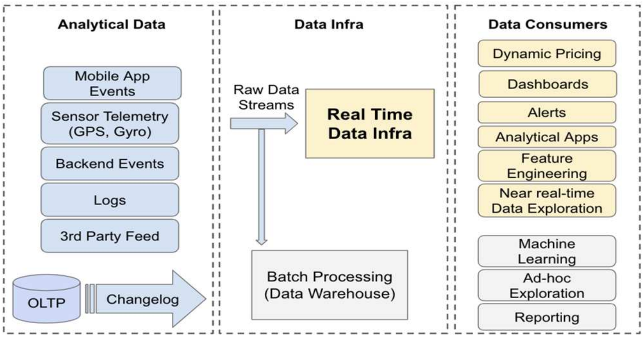

Fig. 1. A high level data flow in Uber infrastructure [20].

C. Ridesharing and Concept of Digital Aggregator

Uber Freight functions as a digital freight brokerage service. Other companies in this domain with smartphone apps include Transfix, Loadsmart, and Cargo [21]. This aspect of ridesharing involves real-time data flow and communication between shippers and carriers, facilitating the smooth coordination of cargoes with the available transport capacity. The benefits are real-time communication, GPS shipment tracking, secure payment, and efficient document collection - all conveniently managed through mobile applications. Brokerage platforms effectively optimize excess capacity across various transportation modes for a broader shipper audience [22, 23]. This aligns with the principles of sharing of economy and environmental considerations [24]. The key stages of the ridesharing service can be illustrated as [23]:

1) Mediation: Drivers input their travel details, including start point, destination, date, and price, on the online portal. The service aligns these details with passengers' search queries, connecting compatible users.

2) Organization: If the indirect partners agree on a meeting place (landing), further details of the tour will be discussed at the stage of organization. The driver acts as an organiser among all passengers, which s/he accepts.

3) Implementation: The participants of the trip gather in an agreed place and start the journey.

4) Payment: After boarding, passengers pay the fare to the driver and, and an online agency fee if required.

Analysing real-world instances of ride-sharing services in different sectors has unveiled key aspects of the technology applicable to railway logistics. Notably, utilising a service model for grain cargo transportation, inspired by ridesharing principles, can lead to substantial cost reductions and increased engagement from shippers [23]. This will be further clarified in the next section.

III. RAIL-FREIGHT RIDESHARING

The concept of rail-freight ridesharing is visually depicted in Figure 2. The Trunk Line Sta-$_{BF}$ represents long-distance rail transportation, featuring a powerful main engine capable of supporting numerous wagons in comparison to local lines. A singular Hub is designated for goods loading and unloading, equipped with facilities for handling wagons headed to different routes. Hub activities encompass compartment interchanges, scheduling via web/app, digital aggregator for ridesharing services, heavy-duty forklifts for cargo handling, and optimization of loading, unloading, and delivery processes to enhance operational efficiency.

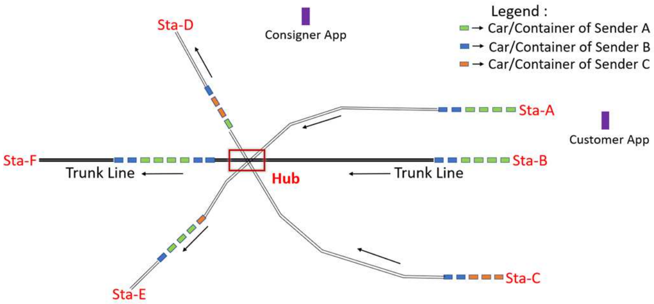

Fig. 2. Concept of rail-freight ridesharing (mixed).

For a conventional rail-freight system, customers purchase paper-based tickets for shipping goods from a specific station to their destination. The trains operating in this system are either point-to-point or hub-and-spoke types, incurring greater time and cost compared to the contemporary ridesharing concept. The rail-freight ridesharing system, as illustrated in Figure 2 also shows two short-distance routes Sta-$_{AE}$ and Sta-$_{CD}$. The trains for these routes pass through the Hub, as mentioned in Figure 2. The wagons destined for Sta-F will be re-sorted or detached /coupled at the Hub. When the main long-distance Trunk Line Sta-$_{BF}$ is available at the Hub, those wagons will be attached to the train engine for that route. Such an approach can allow shippers to pre-plan rearrangements at the Hub, reducing costs and synchronising dispatch movements for the potential consolidation and acceleration of transit to destination points. For further reduction of time and cost, in this system, we need some type of digital communication support (services) like Uber Aggregator, where both the customers and consigners (railway official /controller) will be connected. Further details of this rail-freight aggregator are in next section.

IV. AGGREGATOR MODEL

The conventional aggregator model, popularized by companies like Uber or OLA, has transformed the transportation system by digitally connecting passengers with independent drivers [23]. This influential model serves as a conceptual foundation for envisioning a similar digital aggregator tailored for rail-freight with ridesharing (Fig. 3). Here, the Customer App represents the mobile or web interface, where a customer intends to transship the commodity such as grain from a particular location (source) to a destination. S/he will place a demand mentioning the good's features (weight and dimensions), intended date of shipment, and route (source and destination) using that App. Before placing an order, s/he needs to register first with the system. S/he will only be able to place an order after signing into the system. The consigner is, in fact, the rail-freight

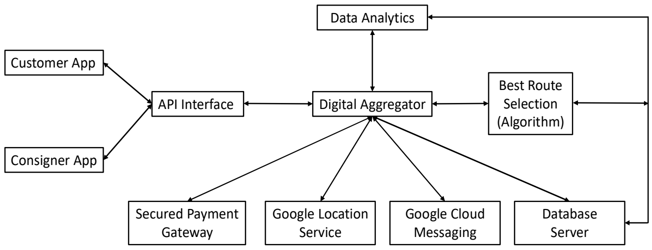

Fig. 3. Concept of digital aggregator for rail-freight transportation.

operator who can see the available rail routes, and taking the information from the existing rail traffic information, will confirm the assigned schedule to meet the customer's demand. The consigner might also be the rail-freight authority /driver /admin who runs the system and knows about the network of scheduled rail routes in a geographic area. Through the consigner app, other intermediary activities will be carried out, such as:

1) Notifying customers of schedule disruptions.

2) Assigning tasks to individuals involved in cargo transfers, like combining goods with another engine for a different route at a Hub/junction.

3) Updating the system as soon as the ridesharing process as above is complete.

4) Inform the customers as soon as the goods arrive at the assigned destination.

Digital Aggregator: According to dictionary.com, a digital aggregator is a digital technology which is a web-based or installed application that aggregates related, frequently updated content from various internet sources and consolidates it in one place for viewing. In other words, aggregators are intermediaries which fetch together various stakeholders like the customers, suppliers, and service providers to create a seamless but effective marketplace [26]. Other related interfaces with the aggregator are mentioned as follows:

A. API Interface

The digital aggregator is connected with the customer and consigner app via a secured API interface.

B. Route Algorithm

For example, a food grain supply chain extends from the farmer to the end consumer through different stages including miller, wholesaler, and retailer. A typical characteristic of a food grain supply chain is the bulky nature of the goods handled, which makes the distribution function more challenging [27]. It is interesting to note that even though a lot of research has been carried out around rail-freight transportation, there is a visible divide that exists between the solutions proposed in the existing literature and their practical implementation. The reasons are attributed to the high complexity of the overall task and other practical issues in implementing optimum solutions [27]. However, some mathematical models collected from existing literature related to rail-freight transportation are discussed as follows:

1) Linear Integer Programming Model (LIP): Asgari et al [28] present a case study of wheat production in Iran. A linear integer programming model is formulated to determine the optimal amounts of wheat to be transported from each producing province to the consuming province. A genetic algorithm-based solution methodology is also proposed. Hyland et al [29] propose conceptual and mathematical models for domestic grain supply chain that incorporates trucking, elevator storage and rail transportation.

2) Bi-Level Model: Maiyar et. al. [30] propose a bi-level model that represents the initial stage of the four-stage food grain transportation distribution process taken up by FCI. A linear model is formulated for the first level of the transportation distribution process, which considers only a single mode of transportation (by road). The second level of the transportation distribution process utilizes multimodal rail-road transportation and is represented by a mixed integer non-linear programming model. The same article also presents two variants of particle swarm optimisation algorithms as solution methodologies. The limitation of the work lies in the fact that it considers only the first stage of the transportation distribution process, which is relatively less complex than the remaining stages.

3) Mixed Integer Linear Programming Model (MILP): Tanksale and Jha [31] address the problem concerning storage and inter-state transportation of food grains taken up by FCI. The paper proposes a mixed integer linear programming model to minimise the transportation and inventory costs associated with the supply chain. A heuristic-based solution methodology is also presented. In [32], the researchers propose a mixed integer non-linear programming model to minimise the total cost, which includes transportation, inventory, and operational costs. A chemical reaction optimisation meta-heuristic is also presented for solving the model. Further, Mogale et al [33] extend this work by considering three stages in the transportation process. Constraints related to vehicle capacity are newly added to the problem.

C. Location Service

The system uses Google Location Service. When a customer initiates an order to transport goods from source to destination, the location data is captured from the app-based order form; and when the customer places an order, this data goes to the aggregator via the API interface. This information is stored in the database table. Upon storing this data, the aggregator employs a route algorithm to determine the optimal route, sharing the processed data with both the customer and consigner apps. The consigner app operator cross-references this route with the existing railway traffic system, and upon confirmation, the customer receives details about the order, including time, date, and shipping point. This process can be automated if traffic system data (from a different system) is integrated with the aggregator system, as mentioned in Figure 3.

D. Google Cloud Messaging

For seamless operation including tracking and feedback to the customers about their goods' movement, the Google Cloud Messaging service can be incorporated. Some related services, such as push notifications, are useful facilities in this regard.

E. Payment Gateway

When the customer places an order, s/he needs to complete it with payment at the end. However, for any reason, the goods could not be shifted as scheduled, the customer has the option to reschedule the order, or s/he can also cancel the order as a whole and s/he will be refunded. To ensure the secured transaction, a payment gateway (e.g., stripe) needs to be installed with the system at the backend.

F. Database Server

A database server is required to save the data in the tables. For route selection (algorithm), sending the required data to the customers, and also for real-time data analytics, a robust database system is a must.

G. Analytics Framework

For data analytics and faster queries, Apache Hive is used, which is a data warehouse software project built on top of Apache Hadoop [34].

V. Business Prospects and Difficulties

The use of digital aggregators provides the following advantages reshaping the business model in rail-freight transportation as mentioned below [26]:

A. Enhanced Efficiency:

One of the primary benefits of aggregators is their ability to streamline operations and enhance overall efficiency. By centralizing various components of a supply chain or marketplace, aggregators reduce redundancy and optimize resource allocation. For example, ride-hailing services like Uber and Ola have revolutionized the taxi industry by efficiently connecting drivers with passengers through a digital platform. This aggregation of services has led to shorter waiting times, lower costs, and improved resource utilization, benefiting both drivers and riders. This might also be true for rail-freight transportation with the use of the proposed digital aggregator. For example, the Trunk Line Sta_{BF} as mentioned in Figure 2 carries the bulk load with more cargoes (for longer distances) for goods shipments. With the effective use of this proposed digital aggregator, a shipper and other stakeholders can get an accurate schedule to bring their goods to a particular HUB to be transported with that route. Other auxiliary rail routes can also get this advantage with enhanced efficiency in terms of allotted loads, time, and costs.

B. Access to a Wider Customer Base:

Aggregators provide businesses with access to a broader customer base than they might have on their own. This expanded reach can be particularly valuable for smaller enterprises looking to compete with larger, established players. Airbnb, for instance, aggregates listings from hosts worldwide, allowing travelers to choose from a vast array of accommodations. This not only benefits hosts by increasing their visibility but also benefits travelers by offering more choices and price points. This is also true for the proposed rail-freight digital aggregators. Other customers who used to prefer road transportation for long-distance goods supplies, will be interested in using this service in multi-mode freight operations.

C. Data-Driven Insights:

Aggregators collect vast amounts of data on their platforms, offering valuable insights into customer behaviors, preferences, and market trends. This data-driven approach can help businesses make informed decisions and tailor their offerings to meet customer demands more effectively. Amazon, one of the world's largest e-commerce aggregators, uses customer data to personalize product recommendations and optimize its supply chain, resulting in higher customer satisfaction and increased sales. This is also true for the proposed rail-freight digital aggregators. Analyzing the customers' choices, the system might offer other related facilities such as getting the option for loading /unloading the goods by scheduled road trucks as soon as the goods reach the destination. If the shipper's agent or client can't collect the goods at the stipulated time at the HUB, s/he can communicate to other services for overnight or long-duration storage /holding facilities. Other similar services could be incorporated in the same data-driven rail freight aggregator.

D. *Lower Entry Barriers:*

Aggregators often reduce the barriers to entry for new players in the market. By providing a ready-made platform and access to a customer base, startups can focus on their core competencies rather than building everything from scratch. For example, food delivery aggregators like Zomato and Swiggy have enabled small local restaurants to enter the digital delivery space without the need for extensive infrastructure development. This has led to increased competition and more diverse dining options for consumers. Like international air ticket booking systems through different online brokers, this rail-freight aggregator can also be used for start-ups to facilitate a wide range of customers.

E. *Improved Customer Experience:*

Aggregators place a strong emphasis on customer experience, which can significantly benefit both consumers and businesses. By offering user-friendly interfaces, transparent pricing, and convenient payment options, aggregators create a more seamless and satisfying experience for customers. Moreover, customer feedback and reviews play a vital role in maintaining quality and trust within these platforms. This commitment to customer satisfaction can result in higher retention rates and long-term brand loyalty. This is also promising for the proposed rail-freight digital aggregators because all other related stakeholders, such as loaders, operators, signaling persons, lifters, security personnel and more, will be gradually incorporated with this system.

Development Difficulties: Some difficulties towards the development of a digital aggregator for rail-freight ridesharing system are as follows:

1) The traditional railway traffic system is different from that of the modern aggregator system. The railway transport system authority might not agree to add this additional facility to the existing /traditional one. To overcome this, the consigner can update the requirements obtained from a customer's online demand via his app, which are both connected to the new aggregator system.

2) To obtain the real-time location data from the rail-freight, many IoT devices placed with the rail wagons and the platforms need to be connected to the network. Security implementation with these devices needs assurance for long-term sustainability.

3) Knowledge of machine learning model development to predict the ETA for trains at destination addresses using historical data in combination with real-time signals [35] is not an easy task to assimilate for a developer and this might be time-consuming.

VI. Analysis

The digital aggregator plays an important part in the analysis of user's requirements and providing the best route options for rail-freight operations. Here, the most important activity will be to facilitate the customers with all the required information starting from placing an order for cargo shipment from source to destination as per the available schedules, then online payment, and finally sending the feedback to the system. All this data will be retained with the system for similar types of orders /trips in future. To enhance overall security, blockchain technologies can be implemented with the system as mentioned for ridesharing services in [36].

To implement this digital system, the traditional rail traffic information might be necessary to be linked with the aggregator, which at times could be difficult to materialize. The alternative option will be to install the required number of IoT devices with all the cargoes and platforms. The scheduled operations might be captured from internet sources. Then the system will be independent in nature, fulfilling the customer requirements as a service. Here also, blockchain can be beneficial for these connected IoT devices with improved fault tolerance, trusted authentication, and secured data storage [37].

In the development process, the use of existing third-party tools will make the overall process cheaper, as mentioned in [20]. For example, Uber heavily relies on open-source technologies for the key areas of the infrastructure. On top of those open-source software, they add significant improvements and customizations to make the open-source solutions fit in Uber's environment and bridge the gaps to meet Uber's unique scale and requirements [20]. This will also be true for the development of rail-freight aggregators in future.

VII. Conclusion

In this paper, we have investigated the concept of aggregators in rail-freight ridesharing. Initially, we discussed the different modes of transportation in rail-freight operations. Then, how ridesharing could be utilized in an effective way with the intelligent development of a digital aggregator at the center (decision making), taking support from all the available third-party tools, was demonstrated. The third-party tools, such as Google location and cloud messaging services, database servers, analytics tools, python-based route algorithms, payment gateway etc., were highlighted. The business prospects and difficulties of developing this type of digital service were also discussed. To ensure the security of the overall connectivity of different elements, the probable use of blockchain technology was highlighted in the analysis section at the end. Developing a digital aggregator for rail-freight transportation demands further study since the usability (UX design) will differ from the Uber aggregator.

Acknowledgement

The authors acknowledge funding from Project number: 11150 "Integrated rail-freight optimisation in Ukraine: Railway sleepers, rolling stock and logistics", which is funded by Universities UK International (UUKi), UK-Ukraine R&I

twinning grants scheme. This publication reflects the views only of the authors, and the funding body cannot be held responsible or any use which may be made of the information contained therein.

REFERENCES

[1] Medium, "The Benefits of Rail-freight Services." [Online]. Available: https://medium.com/@aggregatorgroup/the-benefits-of-rail-freight-services-2c0d8ae59267. [Accessed: 15-Oct-2023].

[2] FREIGHTCONNECTIONS, "Road Transport vs Rail Transport-Head-to-head Comparison." [Online]. Available: https://dhl-freight-connections.com/en/solutions/road-transport-vs-rail-transport-head-to-head-comparison/#:~:text=The%20major%20advantage%20of%20rail,risk%20of%20accidents%20and%20theft. [Accessed: 15-Oct-2023].

[3] "Road Transport Year Book 2018-19," Transportation Research Wing, Ministry of Road Transport and Highways, Government of India, September 2019.

[4] "Basic road statistics of India 2016-17," Transportation Research Wing, Ministry of Road Transport and Highways, Government of India, March 2019.

[5] Elmo (2023), "The Rise in Car Sharing and Ride Hailing Services." [Online]. Available: https://elmodrive.com/blog/rise-sharing-hailing/#:~:text=Car%20sharing%2C%20also%20known%20as,taxi%20or%20renting%20a%20car. [Accessed: 15-Oct-2023].

[6] RFG, "Rail-freight." [Online]. Available: https://rfg.org.uk/rail-freight/. [Accessed: 15-Oct-2023].

[7] J. Faulin, S. Grasman, A. Juan, and P. Hirsch (Eds.), "Sustainable transportation and smart logistics: decision-making models and solutions," Elsevier, 2018.

[8] M. Dotoli et al., "A decision support system for optimizing operations at intermodal railroad terminals," IEEE Transactions on Systems, Man, and Cybernetics: Systems, vol. 47, no. 3, pp. 487-501, 2016.

[9] W. Xu, J. Huang, and Q. YanZhao, "Study on the Optimization of Hub-and-Spoke Logistics Network regarding Traffic Congestion," Journal of Advanced Transportation, vol. 2021, Article ID 8711964, pp. 16, 2021. https://doi.org/10.1155/2021/8711964

[10] S. J. Jeong, C. G. Lee, and J. H. Bookbinder, "The European freight railway system as a hub-and-spoke network," Transportation Research Part A: Policy and Practice, vol. 41, no. 6, pp. 523-536, 2007, https://doi.org/10.1016/j.tra.2006.11.005.

[11] The Geography of Transport Systems. https://transportgeography.org/contents/chapter2/geography-of-transportation-networks/point-to-point-versus-hub-and-spoke-network/.

[12] European Commission, "Study on Single Wagonload Traffic in Europe – challenges, prospects and policy options. Final report." 2015. URL: https://transport.ec.europa.eu/system/files/2017-02/2015-07-swl-final-report.pdf (Application date: 05/06/2023).

[13] J. Kalantari and H. Sternberg, "Research outlook on a mixed model transportation network," 2009.

[14] T. Bektas and T. G. Crainic, "A brief overview of intermodal transportation," Interuniv. Res. Centre Enterp. Netw., Logistics Transport. (CIRRELT), Université de Montréal, Montreal, QC, Canada, Tech. Rep. CIRRELT-2007-03, 2007. [Online]. Available: https://www.cirrelt.ca/DocumentsTravail/CIRRELT-2007-03.pdf

[15] M. Dotoli, N. Epicoco, M. Falagario, C. Seatzu, and B. Turchiano, "A decision support system for optimizing operations at intermodal railroad terminals," IEEE Transactions on Systems, Man, and Cybernetics: Systems, vol. 47, no. 3, pp. 487-501, 2016.

[16] A. Prokhorchenko, M. Kravchenko, and A. Prokopov, "Improvement of railway logistics of grain cargo on the basis principles of ridesharing," Thesis of XIII international scientific and practical conference «Globalization of scientific and educational space. Innovations of transport. Problems, experience, prospects.», Vlora, May 21-26, 2021. Thesis. – Vlora. 2021. P. 63.

[17] DHL Trend Research, "Sharing economy logistics. Rethinking logistics with access over ownership." 2017. [Online]. Available: https://www.dhl.com/discover/content/dam/dhl/downloads/interim/preview/updates/dhl-trend-report-sharing-economy-preview.pdf. [Accessed: 10-May-2023].

[18] N. D. Chan and S. A. Shaheen, "Ridesharing in North America, Past, Present, and Future," in Transport Reviews, vol. 32, no. 1, pp. 93–112, 2012.

[19] MOBISOFT (2019), "Uber Business Model Explained: From Start to Finish." [Online]. Available: https://mobisoftinfotech.com/resources/blog/uber-business-model-explained/. [Accessed: 15-Oct-2023].

[20] Y. Fu and C. Soman, "Real-time data infrastructure at Uber," In Proceedings of the 2021 International Conference on Management of Data, pp. 2503-2516, 2021.

[21] Shipware (2019), "The Rise of Digital Freight Brokerage: How Uber Freight Works." [Online]. Available: https://shipware.com/blog/digital-freight-brokerage-uber-freight/. [Accessed: 15-Oct-2023].

[22] Enables real-time management of less-than-load shipments and excess capacity brokerage. [Online]. Available: https://www.saloodo.com/en/. [Accessed: 01-May-2021].

[23] A. K. M. Prokhorchenko and A. Prokopov, "Improvement of railway logistics of grain cargo on the basis principles of ridesharing," GLOBALIZATION OF SCIENTIFIC AND EDUCATIONAL SPACE. INNOVATIONS OF TRANSPORT. PROBLEMS, EXPERIENCE, PROSPECTS, 2021.

[24] W. Kathan, K. Matzler, V. Veider, "The sharing economy: Your business model's friend or foe?," in Business Horizons/ Kelley School of Business, Indiana University, vol. 59, no. 6, pp. 663–672, 2016.

[25] Linkedin, "The Retransition of the Ride-Hailing Industry: From Aggregator to Fleet-Owned Model." [Online]. Available: https://www.linkedin.com/pulse/retransition-ride-hailing-industry-from-aggregator-model-inamdar/. [Accessed: 15-Oct-2023].

[26] Linkedin, "How Aggregators Can Transform Industries: 5 Amazing Benefits." [Online]. Available: https://www.linkedin.com/pulse/how-aggregators-can-transform-industries-5-amazing-benefits-nadar/. [Accessed: 15-Oct-2023].

[27] K. P. Anoop, V. V. Panicker, M. Narayanan, and C. T. Sunil Kumar, "A mathematical model and solution methods for rail-freight transportation planning in an Indian food grain supply chain," Sādhanā, vol. 43, pp. 1-20, 2018.

[28] N. Asgari, R. Z. Farahani, H. Rashidi-Bajgan, and M. S. Sajadieh, "Developing model-based software to optimise wheat storage and transportation: A real-world application," Appl. Soft Comput., vol. 13, pp. 1074–1084, 2013.

[29] M. F. Hyland, H. S. Mahmassani, and L. Bou Mjahed, "Analytical models of rail transportation service in the grain supply chain: Deconstructing the operational and economic advantages of shuttle train service," Transport. Res. E-Log, vol. 93, pp. 294–315, 2016.

[30] L. M. Maiyar, J. J. Thakkar, A. Awasthi, and M. K. Tiwari, "Development of an effective cost minimization model for food grain shipments," IFAC-PapersOnLine, vol. 48, pp. 881–886, 2015.

[31] A. Tanksale and J. K. Jha, "An effective heuristic for multi-period multi-foodgrain inventory transportation problem in India," Infor, vol. 54, pp. 355–379, 2016.

[32] D. G. Mogale, S. K. Kumar, and M. K. Tiwari, "Two stage Indian food grain supply chain network transportation-allocation model," IFAC-PapersOnLine, vol. 49, pp. 1767–1772, 2016.

[33] D. G. Mogale, S. K. Kumar, and M. K.Tiwari, "An MINLP model to support the movement and storage decisions of the Indian food grain supply chain," Control Engineering Practice, vol. 70, pp. 98-113, 2018.

[34] Wikipedia, "Apache Hive." [Online]. Available: https://en.wikipedia.org/wiki/Apache_Hive. [Accessed: 15-Oct-2023].

[35] Uber Blog – Engineering, "DeepETA: How Uber Predicts Arrival Times Using Deep Learning." [Online]. Available: https://www.uber.com/en-GB/blog/deepeta-how-uber-predicts-arrival-times/?uclick_id=fd6e852f-0eae-409a-a707-0d14f92cc4d5. [Accessed: 15-Oct-2023].

[36] R. Gupta and S. Shanbhag, "A Survey of Peer-to-Peer Ride Sharing Services using Blockchain," Int. J. Eng. Res. Technol, vol. 10(08), pp. 349-353, 2021.

[37] D. Pavithran, K. Shaalan, J.N. Al-Karaki, A. Gawanmeh, "Towards building a blockchain framework for IoT. Cluster Comput". pp. 1–15, 2020.