14th Annual International Conference on Industrial Engineering and Operations Management
Dubai, United Arab Emirates (UAE), February 12-14, 2024
Publisher: IEOM Society International, USA DOI: 10.46254/AN14.20240176
Published: February 12, 2024

Freight Broker Business Models in the Digital Age: A Comparative Analysis and Recommendations for Start-ups

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Abstract

The trucking industry plays a vital role in the supply chain, GHG emissions, and the national economy. In recent years, due to a significant deficiency in freight forwarding, Digital Freight Matching (DFM) models have emerged. These models utilize information technology tools and advanced data analytics techniques to address the problems of the traditional approach. Recently, various DFM business models have been proposed, each with different characteristics. A review of the existing literature reveals a gap in studies examining these business models. In this regard, the present study not only critically reviews the evolution of freight forwarding but also comprehensively analyzes various DFM business models in terms of operational process, revenue, customer relationship, and digitalization. Moreover, it addresses critical questions about the advantages and disadvantages of traditional Freight Brokers and DFM models and their impact on the industry. Finally, the study results offer insightful suggestions, serving as a guide for startup companies looking to choose an appropriate business model. In addition, the result indicates that there is not a universal business model that fits all companies aiming to venture into DFM.

Keywords

DFM, Freight brokerage, Trucking industry, Business model, Start-up.

1. Introduction

The trucking industry plays an important role in both macroeconomics and microeconomics. In 2020, trucks transported more than half of Canada's $384 billion exports to the U.S. and nearly three-quarters of its $264 billion imports from the U.S. (Fan & Heminthavonf, 2022). Historically, the industry has depended on traditional processes, heavily using intermediaries like Freight Brokers to link shippers with carriers (Van Duin et al., 2019; Huang et al., 2019). While freight forwarding has been pivotal in this sector, literature reviews highlight significant challenges in the trucking industry due to this manual approach, such as empty mileage, extended waiting times for shippers and carriers, and cost inefficiencies. In the past decade, the emergence of new information technology tools has empowered

scholars and industry professionals to develop new business paradigms addressing the aforementioned deficiencies of traditional freight forwarding (Bădică et al., 2020).

The most notable shift in this sector has been the emergence of Digital Freight Matching platforms. DFM leverages technology to link shippers with available carriers by employing real-time data, streamlining transportation requirements, and diminishing inefficiencies (Zhou & Wan, 2022). DFM stands out for its transparency, immediate matching, dynamic pricing, and robust rating system (Armstrong & Associates, 2016). Crucially, while traditional methods relied on paper-based systems, DFM predominantly benefits a data management system by saving and analyzing them using an advanced data analytics tool This matter empowers decision-makers and stakeholders with key performance indicators (e.g., matching rate and service quality), offering a deeper understanding of market conditions.

A market analysis and literature review indicate that various business models, such as platform-based and brokerage, have emerged for DFM over time (Zintel et al., 2021). A business model outlines how a freight company creates, delivers, and captures value. It includes its operations, strategies, and methods of revenue generation (Casadesus-Masanell & Heilbron, 2015). Essentially, it determines how a company operates and generates income, steering both strategic choices and daily practices.

Despite all the advancements in both academic and industrial sectors of the freight industry, there remains a gap in the literature that offers a reliable resource for startup companies looking to enter the trucking industry. These companies need to review the pros and cons of each business model before establishing their own. Aiming to bridge this gap, the primary goal of this study is to create a comprehensive resource that facilitates a comparison between different DFM business models for startups. To achieve this, a comparative analysis is performed on existing business models, and their key features are highlighted.

Additionally, this study seeks to address the following questions:
What are the respective advantages and disadvantages of traditional Freight Brokers and Digital Freight Matching models, and how do these shape the industry?
How do Digital Freight Matching business models differ in terms of their operational processes, revenue generation strategies, customer relationships, and digitalization level?
This study enriches the literature by proposing a practical framework for comparing various business models in the trucking industry. Furthermore, it offers a scientific resource that comprehensively contrasts the DFM business model with strategies that support startup companies.
The rest of the paper is organized as follows: initially, the evolution of freight forwarding and DFM models are explored. The methodology of the study is then detailed in section 3. Following this, section 5 presents a comparative case study where various business models are critically analyzed. In the concluding section, the contributions and primary findings of the study are discussed.

2. Literature Review

This section provides a review of the literature concerning research gaps. It is organized into three subsections. The first explores the evolution of freight brokerage. The second goes through studies focused on the business processes of freight forwarding. In the final subsection, studies relating to DFM models are discussed.

2.1 Evolution of Freight Brokerage

Securing sufficient truck capacity poses challenges for freight forwarders seeking to continually rebalance the supply and demand of trucks and drivers (Eriksson et al., 2022). This cycle alternates between relative capacity shortages, which drive up rates due to increased demand, and relative capacity surpluses, which drive rates down (Caplice, 2021). Therefore, it is key to predict future market trends, despite external factors that can bias the results such as economic changes, technological advances, and human psychology that can introduce unpredictability into the equation (Pickett, 2018; Negrutiu et al., 2020). Understanding the progression of freight forwarding is essential in investigating the impact of DFM platforms (Riedl et al., 2018; Wurst, 2021). In this study, we trace key steps in the evolution of freight brokerage (Mikl et al., 2021; Meyer et al., 2022).

The origins of freight brokerage can be traced back to the early days of trade when intermediaries facilitated the movement of goods across long distances (Brown, 1984). They acted to connect shippers with carriers, negotiating deals, and ensuring the smooth flow of commerce (Luncean & Badica, 2014).

The emergence of motorized transportation, particularly trucks and the interstate highway system in the United States, transformed the logistics landscape (Canna, 2022). This era witnessed the establishment of licensed and regulated freight brokers, introducing a degree of formality and accountability to the profession (Danyluk, 2021). The late 20th century saw the integration of computer systems and electronic data interchange (EDI) into freight brokerage operations (Agnihotri & Bhattacharya, 2023). These technological advancements streamlined communications and information sharing, enhancing the efficiency of matching cargo with carriers (Paik & Gharehgozli, 2022). However, it's worth noting that these innovations primarily focused on improving internal processes rather than disrupting the broker's role as an intermediary (Arooj et al., 2022).
The 21st century is a new era with the advent of DFM platforms (Elbert & Gleser, 2019; Huber, 2021). These platforms leverage advanced algorithms, real-time data, and digital connectivity to directly connect shippers and carriers, and potentially get around the traditional broker's role (Majeed et al., 2021; Choudhury et al., 2023). This marks a profound departure from historical norms, where brokers were central to the freight matching process.

Understanding this historical evolution is crucial as we navigate the contemporary landscape, where DFM platforms represent a disruptive force challenging traditional freight brokerage models (Liao, et al., 2021). It underscores the enduring importance of intermediaries in the logistics and transportation industry and sets the stage for evaluating how DFM platforms are redefining this historical paradigm (Herold et al., 2023).

2.2 Overview of Business Processes of Traditional Freight Brokerage

As discussed, traditional freight brokerage has long been an integral component of the logistics and transportation industry and its fundamental role revolves around orchestrating the movement of goods efficiently and effectively.
Traditional freight brokerage operations are characterized by a set of manual and multifaceted processes that revolve around matching cargo with suitable carriers. This matching ensures the seamless and efficient movement of goods within the logistics and transportation industry (Alacam & Sencer, 2021). These operations can be categorized into three parts matching, routing, and pricing.

About matching, one of the basic functions of traditional brokers, to reduce uncertainties (e.g., trip failure), is to enhance the quality of matching by aligning the size of cargo with carrier capacity (Caplice, 2021). This entails evaluating factors such as the size and type of trucks, maximum weight limits, and available space for cargo (Choudhury et al., 2023). Moreover, effective matching requires scheduling coordination to ensure that carriers have availability during the required timeframe and that they can meet the shipment's delivery deadline (Jarašūnienė et al., 2022). Furthermore, the success of cargo and carrier matching depends on the broker's ability to identify carriers that not only meet the logistical requirements but also align with the shipper's specific needs (Li & Yu, 2017). This encompasses considerations like the nature of the cargo (e.g., perishable goods, hazardous materials), specialized equipment requirements (e.g., refrigerated trucks, flatbeds), and any other unique specifications. Efficient matching offers several benefits, including optimized efficiency, cost savings, timely deliveries, and reduced risk (Kim et al., 2021).

Regarding routing, brokers examine the route compatibility taken by carriers and the origin-destination pairs specified by shippers (Pellegrino et al., 2021). The routing aims to identify carriers whose existing routes align with the shipment's itinerary, minimizing detours and optimizing efficiency.

Lastly, the traditional approach plays a central role in negotiating terms and rates that satisfy both shippers and carriers (Karam et al., 2021). They act as intermediaries, leveraging their industry knowledge and negotiation skills to strike mutually beneficial agreements. This may involve rate negotiations, brokers negotiate the freight rates, aiming to secure competitive pricing while compensating carriers fairly for their services (Stölzle & Häberle, 2021). They facilitate the creation of contractual agreements that outline the terms and conditions of the transportation arrangement, covering aspects such as liability, insurance, and payment terms (Feng & Cheng, 2021).

2.3 Digital Freight Matching (DFM) models

The emergence of technologies like the DFM platforms has ignited a transformative shift that is reshaping the landscape of the logistics sector (Furr et al., 2022). Through an extensive literature review, we went through the role played by DFM platforms and their profound impact on the logistics industry (He et al., 2022). The adoption of digital technology, specifically DFM platforms, has begun in a new era for the logistics sector (Zhou & Wan, 2022). These platforms represent a paradigm shift in the way cargo is matched with available carriers (Heinbach et al., 2022). They

leverage various algorithms, data analytics capabilities, and real-time connectivity to revolutionize the freight matching process (Angelopoulos et al., 2023). Scholarly works by Tsvetkova et al. (2021); Chen and Yang (2022) and Sullivan (2020) have highlighted the role played by DFM platforms in the logistics industry's evolution. These platforms have rapidly ascended to prominence, promising to redefine the very essence of freight matching. Wang and Sarkis (2021) have shed light on the technological capabilities of DFM platforms, emphasizing their advanced algorithms and data analytics capabilities, which have become key drivers of efficiency and innovation (Ortwein & Kuchinke, 2021).

The value of DFM platforms is multifaceted, as highlighted by Gorman et al. (2023). Their ability to streamline the complex freight matching process has resulted in several advantages:

- Greater Transparency: DFM platforms bring unprecedented transparency to the logistics process, allowing stakeholders to access real-time information about shipments, routes, and pricing (Zhou & Wan, 2022).
- Efficiency Gains: By automating and optimizing the matching of cargo with carriers, DFM platforms have ushered in remarkable efficiency gains, reducing delays and optimizing resource utilization (Kern, 2021).
- Cost-Effectiveness: The cost-effectiveness of DFM platforms is a central feature. They enable shippers to find carriers at competitive rates, potentially reducing transportation costs significantly (Meyer et al., 2022).
- Direct connection: One of the most revolutionary aspects of DFM platforms, as noted by Min and Kang (2021), is their capacity to enable direct connections between shippers and carriers. This decreased dependence on traditional intermediaries, such as Freight Brokers, has the potential to reshape the logistics landscape significantly.

As conclusion, through the literature review, many articles were analyzed, starting with the evolution of freight brokerage, moving from traditional business models to the most modern ones called DFM, where the 3 most used sub-models could be identified. We note that there is no article that presents a detailed explanation of the world of DFM in its entirety. Some articles explored presented the explanation of some DFM models, but they only presented one model, and they are more general explanations to make the reader understand the idea of what is proposed, but no articles have been found that study and compare the different business models of DFMs, and even fewer from a perspective of helping start-ups in this world of digitalization of freight brokers and selecting one of these models that best suits these new companies.

3. Methodology

As displays the methodology employed in this study is structured into six steps. As the first step, a comprehensive literature review is conducted to gain a thorough understanding of the existing body of knowledge in the domain of business models within the logistics industry. This review aims to identify gaps in the field of study and sets the foundation for the subsequent research.

The second step is the applications and results of comparative studies, which are divided into three main parts. In the first part (step 3), we do an exploration of the evolution of freight brokerage in the trucking industry, to do this, a comparative analysis is undertaken to elucidate the distinctions between the traditional freight brokerage model and DFM model. Next, we examine pricing policies and strategies, and finally, logistics technologies and software solutions. As we navigate through the digital transformation era, the study narrows its focus to delve deep into DFM (step 4). This involves an exploration of the benefits offered by DFM, factors influencing clients' selection of DFM providers, the challenges and impediments faced by DFM models, and an examination of regulations governing DFM. For the third part of the applications and results, a comparative analysis of the different DFM business models is carried out (step 5). To do this analysis, we divide the process into six stages. First, we defined the scope of the comparative study as the freight broker industry in North America. Second, we selected a sample of eleven freight brokers that operate in this region, covering different sizes, markets, and technologies. Third, we identified four dimensions that characterize different freight broker business models: operational model, revenue strategy, customer relationship, and digitalization level. Fourth, we apply a classification to group the business models into types based on the elements. Fifth, we validate and refine our typology using secondary data from literature reviews, industry reports, and websites. Sixth, we analyzed our results and derived implications for start-ups who want to enter or innovate in this industry.

Finally, the article presents the conclusion. Limitations, and avenues for future research endeavors in this domain, are outlined in the conclusion section, offering valuable insights to further advance our understanding of DFM and its evolving landscape (Figure 1).

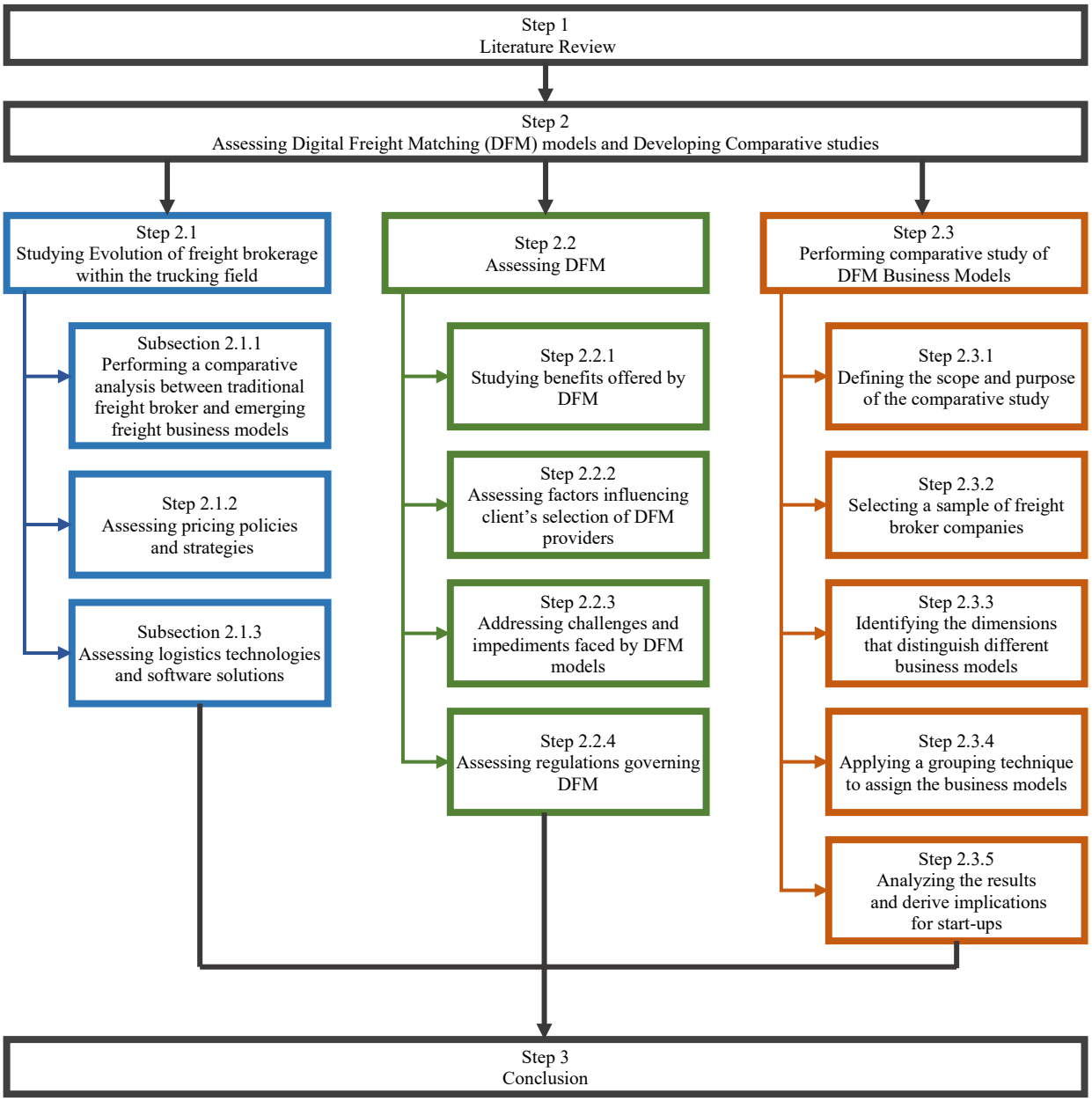

Figure 1. Research Methodology Section

In this section, first, we will detail the evolution of freight brokerage in the trucking industry, moving from traditional freight brokers to DFM. Next, we analyze the DFM model in more depth. Finally, a comparative study is carried out on the different DFM models based on different dimensions and criteria to guide a new company in the selection and choice of any of these models and their good practices.

4.1 Step 2.1. Studying evolution of freight brokerage within the trucking field

As the landscape of logistics continues to evolve and adapt to modern demands, it becomes increasingly imperative to gain a comprehensive understanding of these two approaches. This section seeks to compare various key factors, including the details of the matching process, the level of transparency, economic factors, reliability of services, flexibility for different shipping needs, market access, integration with advanced technology, and their important roles in the constantly evolving logistics ecosystem.

A freight broker serves as an intermediary, facilitating the intricate coordination of transportation services for shippers by engaging carriers. These individuals wield their comprehensive industry expertise and well-established carrier relationships to adeptly negotiate rates, orchestrate cargo dispatches, and synchronize freight movement. Additionally, freight brokers efficiently manage administrative responsibilities such as tracking shipments, troubleshooting issues, and streamlining payment processes.

On the other hand, the advent of DFM introduces a technology-driven paradigm, seamlessly matching shippers with carriers. DFM platforms leverage information technology techniques including algorithms and data analytics to match available transport capacity with shipments awaiting conveyance. This method speeds up the process of finding shipping capacity while also saving costs. For carriers, digital freight matching platforms offer new business opportunities and help make better use of their resources.

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4.1.1 Step 2.1.1. Performing a Comparative analysis between traditional freight broker and emerging freight business models

Although freight brokers and digital freight matching (DFM) platforms both connect shippers and carriers, they operate differently. Freight brokers provide personalized service with dedicated agents who guide and support throughout the shipping process. In contrast, DFM platforms use automation for a self-service approach, allowing shippers and carriers to manage their transactions independently.

The Table 1 presents a comparative study of some of the most important aspects, between the traditional freight broker and the new DFM models.

Table 1. Comparative analysis between Freight Broker Business Model and DFM Business Model

Aspect	Traditional Freight Broker Business Model	Digital Freight Matching (DFM) Business Model
Definition	Acts as an intermediary between shippers and carriers.	Utilizes technology to directly connect shippers with carriers.
Characteristics	Intermediary role	Technology-driven
	Personalized service	Real-time updates
	Industry expertise	Automated processes
Advantages	Flexibility	Cost-effectiveness
	Risk mitigation	Transparency
	Time and cost savings	Efficiency
	Established relationships with carriers	Broader pool of carriers
Limitations	Cost	Technology dependency
	Limited control	Market saturation
	Communication challenges	Lack of personalization
		Potential less industry experience and knowledge
Payment and Rates	Negotiates rates on behalf of shippers	Transparent and competitive rates
	May charge brokerage fees	Potential lower costs for shippers and carriers
Risk Management	Conducts due diligence on carriers	Carrier verification and insurance verification
	Manages cargo insurance and claims	Real-time tracking and monitoring of shipments
Operational Efficiency	Time-consuming process due to manual interactions	Streamlined operations and real-time updates
		Reduced administrative overhead for shippers and carriers
Service Experience	Human interaction and personalized solutions	Automated systems and standardized processes
	In-depth knowledge of the transportation industry	Ratings and reviews for carrier selection
Technology Integration	May or may not utilize digital solutions	Utilizes advanced technology and algorithms
	Paperwork and communication via phone, email, etc.	Mobile apps and web platforms for load matching
Scalability and Reach	Depending on the broker's network and resources	Wide geographical reach and access to diverse carriers
Customer Support	Dedicated customer service and support teams	Technical support for platform users
	Communication and issue resolution via broker	Digital communication channels
Decision-Making Process	Human decision-making with industry knowledge	Automated decision-making based on algorithms and data
Market Presence	Established presence and reputation in the industry	Growing presence in the logistics and transportation technology market

4.1.2 Step 2.1.2. Assessing Pricing policies and strategies.

In the trucking system, pricing policies are characterized by a multitude of both direct and indirect variables. In other words, no singular particularity or deterministic element governs the formation or evolution of these pricing structures. Instead, there exist more localized mechanisms with regional impact pricing policies, as well as other pricing determinants that apply influence at national or international levels, where pricing policy trends may exhibit a greater degree of cross-cutting ubiquity.

Pricing policies consider various factors, such as inconsistent fuel prices, distance, weight and volume of cargo, toll charges, delivery deadlines, parking fees, government subsidies, different levels of uncertainty, risks due to geopolitical issues, and the use of intelligent art platforms, among others. Presently, the prevailing trend in pricing strategies involves the utilization of tools provided by the industry 4.0 paradigm and platforms enabling more intelligent trucking operations. However, it is important to note that comprehensive studies on pricing policy trends are rare in existing literature. This is likely due to the challenges arising from the diverse variables that influence these policies.

Freight brokerage companies employ various pricing strategies aimed at optimizing their competitive positioning and client acquisition. The following are several common pricing strategies observed within the domain of freight brokerage:

- Flat-rate Pricing: Freight brokerage firms may implement a flat-rate pricing scheme, wherein customers are levied a fixed fee for shipping services, irrespective of the shipment's distance or weight. This approach offers pricing transparency and simplicity.
- Volume-based Pricing: Volume-based pricing models are also prevalent. Here, clients are incentivized with discounts when shipping larger quantities of cargo. This strategy mutually benefits both the brokerage and its clientele by encouraging greater shipment volume and simultaneously lowering shipping expenses.
- Dynamic Pricing: Freight brokers may employ dynamic pricing structures that adjust the cost of shipping based on real-time market dynamics. Variables such as supply and demand, fuel costs, and shipping distances are considered, allowing the brokerage to remain competitive within a fluctuating market.
- Bid Pricing: A competitive approach can be seen in bid pricing, where multiple carriers vie for a specific shipment. The carrier submitting the most economical bid secures the shipment. This strategy facilitates the acquisition of optimal shipping rates while offering carriers the opportunity to compete for cargo.
- Accessorial Fees: Freight brokerage firms may impose supplementary charges, often referred to as accessorial fees, for extra services such as lift-gate service, inside delivery, and waiting time. These fees serve a dual purpose by allowing brokers to extend their service offerings while concurrently generating additional revenue streams.

4.1.3 Step 2.1.3. Assessing logistics technologies and software solutions.

A significant change is happening in the field of logistical transportation, marked by a promising future that combines intelligent solutions with sustainable alternatives. Enterprises find themselves compelled to preserve their competitive edge, necessitating the incorporation of cutting-edge technologies aimed at enhancing their distribution centers, warehousing infrastructure, shipping processes, and transport management. It is not feasible for these enterprises to fall behind the technological barrier, as consumer demands can only be met through the seamless integration of logistical technology. It is evident that only those enterprises that harmoniously evolve with technological advancements are poised to endure over the long-term period.

The proliferation of the Internet of Things (IoT) leads to the creation of multifarious connections between commodities, packaging, transport centers, and vehicles. This expansion of IoT technology furnishes an abundance of data, thereby facilitating remote asset management, risk forecasting, optimization of cargo handling, and traffic congestion prediction. When the IoT is synergistically coupled with blockchain technology, it has the capacity to give comprehensive end-to-end package visibility.

Table 2 provides a comprehensive overview of various IoT applications, offering detailed descriptions and insights into their functionality, making it easier to understand their specific roles and contributions.

Table 2. Internet of Things Technologies

IoT Application	Description
Cold Chain Traceability	Monitoring temperature-sensitive goods through the use of certified temperature recorders.
Cargo Theft Prevention	Implementing discreet, robust, connected solutions, such as magnetic contact-based truck door sensors to prevent theft.
Truck Fleet Tracking	Utilizing multiple wireless communication technologies (e.g., Bluetooth, RFID, LoRaWAN) to track trailers and monitor routes.
Driver Identification	Mandatory use of electronic logbooks for drivers to ensure compliance with driving hours and rest regulations.
Anti-Collision Technology	Incorporating 360-degree cameras and sensors for collision anticipation and prevention.
Cloud-Based Connectivity	Facilitating real-time data sharing among trucks via cloud-based connectivity systems.

Other logistics technologies used in the transport industry include:

- Blockchain technology, a decentralized and distributed innovation explicitly designed to revolutionize commercial operations, record transactions, monitor assets, and establish a transparent and efficient system for managing all documents involved in the logistic process, offers substantial gains in time and cost efficiency. Its integration contributes to the enhancement of supply chain security, particularly through the reduction of fraud, bottlenecks, errors, third-party certification, and the enhancement of overall operational efficiency.
- Transport Management System (TMS) is employed to oversee carrier management and enhance route automation. Its utility extends to real-time driver tracking, cost reduction within the transportation framework, augmentation of transparency, and the elevation of overall customer satisfaction metrics.
- The large amount of data coming from the supply chain is now routinely analyzed to identify trends. This helps logistical companies make necessary organizational changes. The application of Artificial Intelligence (AI) for decision-making within the supply chain domain stands as an effective measure in the reduction of human error. Particularly in the sphere of warehouse management, AI significantly streamlines the planning process by expediting the time required for analysis. Furthermore, the analysis and optimization of last-mile logistics, supplier selection, and workforce planning constitute processes fueled by the incorporation of AI and Machine Learning (ML) methodologies.
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In the domain of logistics, recent technological advancements have given rise to software solutions dedicated to optimizing operations within the trucking industry. These software applications are integral to modern logistics systems, where they play a fundamental part in enhancing efficiency and accuracy in the execution of transportation activities. In Table 3 we can distinguish the different solutions that each of them offers.

Table 3. Software solutions in the trucking industry

Trimble Transportation	Fleetilla Fleet Management	Degama's Dynamic Transportation Management System (DTMS)
- FleetFACTZ, a cloud-based, fleet management application. - Maps, satellite imagery, street view, weather, traffic, and other details seamlessly integrated. - Mobility Fleet Telematics.	- Supply Chain Visibility. - Transportation Management Solutions. - Mobility Fleet Telematics. - Video Intelligence. - TMT Fleet Maintenance.	- Electronic Data Interchange (EDI). - Adapt and integrate into existing business processes and software with integration partners. - Request for proposal (RFP). - Electronic logging device (ELD).

In the contemporary world characterized by the rise of technological platforms, it is noteworthy that manual procedures continue to be a central focus. In response to inquiries pertaining to the tools employed for the monitoring and management of Key Performance Indicators (KPIs), it is evident that a substantial proportion of shippers and carriers still prefer the utilization of traditional approaches, including Microsoft Excel, email correspondence, and shared document repositories.

4.2 Step 2.2. Assessing DFM

DFM uses an electronic platform or software equipped with advanced technology like AI, machine learning, and big data analytics. This technology improves how shippers and carriers are matched in freight logistics. These DFM platforms exhibit a proclivity to harness diverse repositories of data to facilitate the optimization of the matching process between shippers and carriers. These sources of data encompass but are not restricted to, historical records pertaining to shipping activities, meteorological and traffic conditions, and an array of salient data points pertinent to the process at hand.

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4.2.1 Step 2.2.1. Studying benefits offered by DFM.

Some of the benefits that bring this new approach are as mentioned before.

- Increased efficiency: DFM automates the matching process and reduces the need for intermediaries, which saves time and money.
- Better visibility: DFM real-time tracking provides, improves communication, and enhances supply chain visibility.
- Environmental sustainability: DFM reduces empty miles, improves capacity utilization, and lowers carbon emissions.

4.2.2 Step 2.2.2. Assessing factors influencing client's selection of DFM providers.

In the process of electing a DFM platform, clients deliberate upon a set of key determinants, encompassing.

- Pricing Model: the selection of an appropriate pricing model assumes paramount importance, with the imperative objective being to establish alignment with the exigencies of the business and fiscal constraints.
- Feature Set: a judicious evaluation of the available feature set is warranted, with specific attention directed towards attributes such as real-time tracking, automated payment mechanisms, and insurance coverage, all of which constitute salient determinants in optimizing operational efficacy.
- Marketplace Size: the choice of a DFM platform necessitates a discerning scrutiny of the marketplace dimensions. It is imperative to opt for a platform that boasts an expansive network of carriers and shippers, as this facilitates the augmentation of freight accessibility and simultaneously mitigates the incidence of unproductive transit miles.
- Customer Support: the selection process is further informed by the quality and timeliness of customer support provision. Optimal operational outcomes are fostered by electing a DFM platform that endorses the delivery of dependable and expeditious support services, aimed at the resolution of issues and the maximization of operational efficiency.

4.2.3 Step 2.2.3. Addressing challenges and impediments faced by DFM models.

After exploring the advantages and potential of Digital Freight Matching (DFM), let's now examine the challenges and difficulties this technology faces. While the benefits in efficiency and cost savings are clear, it's important to tackle the real challenges that must be overcome for digital freight matching to realize its full potential.
Table 4 summarized challenges of current DFM.

Table 4. Challenges and Obstacles for DFM

Challenge	Description
Fragmentation within the Industry	Pronounced fragmentation with small, independent carriers and shippers creates difficulties in achieving user mass and service consistency.
Complex Regulations	Intricate, jurisdiction-dependent regulations challenge compliance oversight for all participants.
Deficiency in Standardization	The absence of standardization leads to language and data format discrepancies, causing inefficiencies and errors.
Competition from Well-Established Brokers	Competition from established brokers with lasting relationships hampers market share acquisition.
Integration Complexities	Integration with diverse third-party systems (TMS, ELD, Telematics) presents compatibility and data integration challenges.
Cybersecurity Vulnerabilities	Safeguarding against hacking and data breaches requires ongoing investments in cybersecurity technology and expertise.
Dependence on Technological Infrastructure	Heavy reliance on technology demands continuous investments in infrastructure and redundancy to ensure operational stability.

4.2.4 Step 2.2.4. Assessing regulations governing DFM.

Within the domain of DFM the need for a freight broker license is determined by the services provided and operational practices. Regulatory oversight in the freight brokerage industry mandates broker licensure and bonding. It is worth noting that certain DFM entities may be exempted from this licensure requirement under specific criteria.

For example, a Digital Freight Matching (DFM) entity that mainly acts as a platform to help shippers and carriers interact and negotiate, without directly handling physical freight, can be considered a 'load board.' This classification may exempt it from needing a license. Conversely, if a DFM entity actively engages in coordinating freight movements, taking on responsibilities like transportation arrangement, rate negotiation, and financial transactions, it is likely to be designated as a freight broker, necessitating the acquisition of a license and bonding. The handling of payment is a key factor in determining whether a digital freight matching company must be licensed as a freight broker. The definition of a freight broker includes those who receive payment for arranging the transportation of goods on behalf of shippers and carriers. However, digital freight matching companies sometimes act as payment facilitators without receiving payment.

- Payment Handling: If a digital freight matching company handles the payment process, they must be licensed as a freight broker.
- Third-Party Payment Facilitation: If a third-party payment facilitator handles payments, the digital freight matching company may not need a freight broker license.
- Partial Payment Handling: If the digital freight matching company only handles a portion of the payment between shipper and carrier, they may not be required to have a freight broker license.

It is important to acknowledge that regulations governing DFM entities and freight brokers may vary from one country or jurisdiction to another, with certain having distinct licensing requirements for freight brokers.
In summary, the requirement for a freight broker license in the context of a DFM entity depends on the specific services offered and operational methods. Therefore, entities should seek guidance from legal and regulatory experts to ensure full compliance with applicable laws and regulations.

4.3 Step 2.3. Performing a comparative study: Business Models DFM

In this section, we will delve into a comprehensive, step-by-step process for conducting a comparative study of DFM business models. The aim is to provide a clear roadmap for entrepreneurs and start-ups looking to venture into this dynamic and rapidly evolving industry.

4.3.1 Step 2.3.1. Stage 1: Defining the scope and purpose of the comparative study.

The scope of this study encompasses a comprehensive analysis of the freight broker industry in North America. The primary objective is to gain a thorough understanding of the operational dynamics within these companies, including their business models and best practices.

4.3.2 Step 2.3.2. Stage 2: Selecting a sample of freight broker companies.

Eleven companies have been chosen, ensuring within the DFM sector, ensuring diversity in terms of company size, target markets, and technological approaches. These companies are situated within the geographical area of our study, and our objective is to conduct an in-depth examination and analysis of each one.
The eleven companies studied are:

- Aljex
- Ascend TMS
- CH Robinson
- Convoy
- Coyote Logistics
- J.B. Hunt
- Loadsmart
- Project44
- Schneider
- Transfix
- Uber Freight

4.3.3 Step 2.3.3. Stage 3: Identifying the dimensions that distinguish different business models

We have pinpointed and categorized four distinct dimensions that serve to characterize various DFM business models. These dimensions are fundamental in understanding the diversity within the industry:

- Operational Model: Describes how brokers manage their daily operations, including carrier sourcing and logistics management.
- Revenue Strategy: Focuses on how brokers generate income, encompassing pricing models and fee structures.
- Customer Relationship: Explores how brokers interact with clients, including customer service, communication, and value-added services.
- Digitalization Level: Evaluate the integration of digital technologies, software platforms, and data analytics into the broker's operations.

4.3.4 Step 2.3.4. Stage 4: Applying a grouping technique to assign the business models

DFM constitutes a technologically facilitated process designed to establish connections between shippers and carriers, with the primary objective of optimizing the discovery and alignment of transportation requirements. In the realm of DFM, an array of distinct business models has emerged, each endowed with specific operational nuances and characteristics:

- Platform-Based Model: Within the paradigm of this model, entities function as operators of digital platforms that handle the seamless matching of shippers and carriers. Such platforms effectively streamline the process of load identification and reservation, while concurrently affording stakeholders' insights into the prevailing capacity, pricing structures, and estimated delivery timelines. This enhanced visibility in platform-based DFM promotes expeditious interactions between shippers and carriers, thus engendering a symbiotic ecosystem for load conveyance.
- Brokerage Model: This model assumes the intermediary role in facilitating interactions between shippers and carriers, a function achieved through the strategic incorporation of cutting-edge technology. These

entities typically possess well-established affiliations with carriers, capitalizing on these relationships to wield prowess in rate negotiations and logistical oversight.

- Carrier-Based Model: Organizations adopting the carrier-based model distinguish themselves by the ownership and operation of dedicated fleets of transportation vehicles, providing shippers with a direct conduit for securing transportation services. In pursuit of operational optimization and efficiency, these companies often employ DFM technologies to streamline internal logistics processes.
- SaaS-Based Model: This model is predicated on the provision of transportation management software as a service (SaaS) to both shippers and carriers. The software suite offers functionalities encompassing load matching, route optimization, and real-time visibility, thereby empowering clients to execute logistics operations with heightened effectiveness.
- Asset-Light Model: Within the asset-light model, business entities function as intermediaries, employing technology to connect loads with an array of available carriers. Significantly, these organizations abstain from direct ownership of transportation assets, instead relying on a network of carrier partnerships to fulfill the diverse spectrum of transportation requisites.

4.3.4.1 Revenue strategies

The dynamics of modern logistics have witnessed the emergence of various methods by which DFM models generate income. These methods govern the financial aspects of digital freight services and play a pivotal role in shaping the interactions between shippers, carriers, and DFM. In this context, we identified five distinct income-generation mechanisms adopted by DFM models, delving into their revenue structures and operational implications.

- Subscription-based Model: Within this financial framework, the DFM platform implements a recurring subscription fee structure, requiring shippers and carriers to remit regular payments in return for unrestricted utilization of its digital platform.
- Commission-based Model: In the context of this commercial model, the DFM platform adopts a commission-based compensation system. Under this arrangement, carriers are subject to fees calculated as a percentage of the value of each transaction successfully conducted through the platform.
- Transaction-based Model: This economic structure involves the DFM platform imposing transaction fees upon both shippers and carriers for each completed transaction executed via their digital infrastructure.
- Hybrid Model: In this multifaceted business paradigm, the DFM platform integrates various revenue streams to foster financial sustainability. For example, logistics enterprises employ a hybrid business model that harmonizes brokerage services, contractual logistics, and digital freight matching to create diverse income channels.
- Partnership Model: In this business model, the Digital Freight Matching (DFM) platform partners with other logistics companies to provide a complete solution for shippers and carriers. For instance, a DFM platform works with logistics firms to offer a range of services that include full visibility, optimization, and automation in supply chain operations.
- These diverse income-generation mechanisms within the DFM sector underscore the flexibility and adaptability of modern logistics platforms. While subscription-based and commission-based models focus on direct monetization, transaction-based, hybrid, and partnership models showcase innovative revenue-generation strategies that cater to the evolving needs of shippers and carriers. The selection of a specific income-generation mechanism by a DFM platform plays a critical role in determining its competitiveness and sustainability within the digital logistics landscape. As this sector continues to evolve, these various approaches provide stakeholders with the means to navigate an ever-changing terrain of digital freight solutions.

4.3.4.2 Industry players

Companies at the forefront of this digital revolution have harnessed the power of technology to transform freight brokerage. In Table 5 the eleven companies are presented, showing what DFM business model they use and how they generate revenues.

Table 5. DFM business model and revenue strategies used by each company.

Companies	Business Models DFM	Revenue strategies

	Platform-based	Brokerage	Carrier-based	SaaS-based	Asset-light	Subscription-based	Commission-based	Transaction-based	Hybrid	Partnership
Loadsmart	X					X				
Uber Freight	X						X			
Convoy	X							X		
C.H.Robinson		X							X	
Coyote Logistics		X						X		
J.B.Hunt			X					X*		
Schneider			X					X*		
Ascend TMS				X		X				
Aljex				X		X				
Project44				X						X
Transfix					X				X	

*These companies, as they are Carrier-based model, receives the transaction fee from the shipper side.

In the domain of platform-based logistics and transportation enterprises, three prominent entities, namely Uber Freight, Convoy, and Loadsmart, have garnered attention for their distinct approaches to income generation. Each of these firms operates within the platform-based business model, albeit employing different revenue models that align with their strategic orientations and cater to the specific demands of their clientele.

Uber Freight, a recognized industry leader, adheres to a Commission-based income model. This method involves the charging of a percentage-based fee on the total value of shipments brokered via its platform. Noteworthy is the scalability of this model, which ensures that, as the volume of transactions rises, so does Uber Freight's income.
Conversely, Loadsmart adopts a Subscription-based model, wherein customers are required to pay periodic subscription fees for access to the platform. This model is structured to cultivate enduring customer relationships by providing consistent access to an efficient and cost-effective logistics solution. Steady subscription revenues offer Loadsmart a reliable income stream, decoupled from transaction volume fluctuations.

In contrast, Convoy deploys a Transaction-based income model, whereby charges are applied for specific services rendered within the transportation process. This affords shippers the flexibility to tailor their logistics solutions according to their precise requirements. Convoy's income, accordingly, scales in line with the utilization of services and features by its customers.

Notably, these enterprises, while employing diverse income generation models, share a common trait in their success within the platform-based business paradigm. This analysis underscores the absence of a universally applicable revenue generation model within this context. It accentuates the significance of an aptly devised strategy, complemented by a profound comprehension of customer exigencies, as determinants of economic success.

In summation, Uber Freight, Convoy, and Loadsmart serve as exemplars within the platform-based logistics sector, illustrating the viability of tailored income generation strategies. In an industry where adaptability and innovation reign supreme, the diversification of income sources emerges as a pivotal factor impacting long-term viability and prosperity.

In the case of the partnership model, companies like Project44 usually partner with logistics companies such as J.B. Hunt or Schneider (carrier-based model) Since these companies have their own fleets of trucks, it is easier to partner with companies that provide them with services and vice versa.

4.3.4.3 Customer relationship

Effective customer relationship management is a critical component of the DFM industry, ensuring that the needs of both shippers and carriers are met efficiently. How DFM models approach customer relationships significantly impacts the success and user experience within each model. In the following paragraphs, we will delve into the specific approaches and customer relationship management in each of these DFM business models.

- Platform-based Model: Platform-based models prioritize automated and self-service interactions, enabling shippers and carriers to use the platform directly, and fostering efficient and transparent communication with real-time updates and easy service access. However, the challenge lies in reduced personal touch as interactions are primarily digital and automated, potentially impacting the depth of customer relationships.
- Brokerage Model: The brokerage model excels in fostering personalized customer relationships by offering hands-on assistance, expertise, and guidance throughout the shipping process. Brokers act as intermediaries, providing personalized service and the ability to navigate complex logistics challenges. Nevertheless, the challenges emerge in its comparative lack of efficiency as fully automated models and customer relationships heavily rely on the broker's performance, which can vary.
- Carrier-based Model: In the carrier-based model, the primary customer relationship centers on carriers maintaining relationships with shippers through dedicated account management teams or customer service departments, ensuring direct communication that can lead to strong and consistent relationships. The challenge is the limited control over the entire logistics process, as carriers tend to focus on their specific services, potentially limiting their ability to address the full spectrum of shipper needs.
- Software as a Service (SaaS): SaaS providers offer customer support and assistance while primarily focusing on maintaining and enhancing the software platform. This approach allows for scalable, cost-effective, and streamlined customer interactions through the software, although challenges arise from limited involvement in the actual logistics processes, which may necessitate additional communication channels to ensure comprehensive customer support.
  Asset-light Model: Asset-light models strike a balance between technology-driven interactions and direct support, offering flexibility and scalability to adapt to evolving customer preferences. They often leverage platform-based models and SaaS solutions to facilitate communication and provide personalized assistance as needed. However, these models face the challenge of managing relationships across various channels while ensuring that technology does not compromise the personalized service that customers may require.

4.3.4.4 Digitalization level

Advanced technologies and digitalization have revolutionized the logistics and transportation industry, particularly in the domain of Digital Freight Matching (DFM). These technologies play a fundamental role in streamlining operations, enhancing efficiency, and improving customer experiences. Across various DFM models, digitalization is a common thread, although the extent and focus of technological integration differ. In the following sections, we will explore how each DFM model leverages digitalization and technologies, their respective advantages, and the challenges that come with these innovative approaches. This analysis sheds light on the impact of technology in influencing the situation of logistics and freight matching.

- Platform-based Model: Platform-based DFM models depend on digitalization and advanced technologies, such as algorithms, machine learning, and data analytics, to effectively connect shippers and carriers. These models provide real-time tracking, automated document management, and communication tools, ensuring high efficiency, transparent operations, and immediate responsiveness. They offer the benefits of seamless, real-time communication, transparent pricing, and wide accessibility for shippers and carriers. The challenges arise from the substantial development and maintenance costs of the platform and the intense competition within this field.
- Brokerage Model: The brokerage model embraces technology for load matching, communication, and document management, although it may not be as technology-centric as platform-based models. Traditional brokers offer a vital human touch in customer interactions, delivering personalized service and expertise in handling complex logistics challenges. The main advantage lies in the personalized, expert service, yet these models face challenges regarding efficiency in comparison to fully automated models and reliance on brokers whose performance can fluctuate, especially as the industry evolves.
- Carrier-based Model: In the carrier-based model, carriers adopt varying degrees of technology, often integrating telematics, GPS tracking, and mobile apps to streamline operations, optimize routes, and

enhance customer communication. The advantages include close integration with carriers, potential cost savings, and flexibility in managing shipments. Challenges stem from the limited control over the entire logistics process, reliance on carriers' technological capabilities, and the potential for inconsistencies in service quality among different carriers.

- Software as a Service (SaaS): SaaS providers in DFM offer cloud-based software solutions characterized by a high level of digitalization, relying on cloud infrastructure and data analysis to provide features like load matching, tracking, and analytics. These solutions are cost-effective, scalable, and accessible for small and mid-sized businesses, with straightforward integration into existing systems. Nevertheless, challenges arise from the potential inability to offer the same comprehensive service as platform-based models and limitations in customization that may not fully align with specific customer needs.
- Asset-light Model: Asset-light models leverage technology to optimize their operations and network. They often rely on SaaS solutions and platform-based models to efficiently manage loads, track shipments, and communicate with carriers, offering flexibility, scalability, and reduced operational overhead. They provide advantages such as adaptability and scalability, along with access to a wide network of carriers without the need for extensive resources. However, challenges encompass competition from fully digital platforms and the necessity for continuous adaptation to evolving market conditions.

4.3.5 Step 2.3.5. Stage 6: Analyzing the results and derive implications for start-ups.

Each business model in DFM has its advantages and challenges, and the choice of which model to adopt should align with a company's specific goals, available resources, and market conditions.

Therefore, if a new company aims to enter the world of DFM, the first thing we must understand is that there is no single, universally reliable, and correct recipe. As we have observed, many successful companies employ various business models, all of which yield positive results. This underscores the importance of assessing the specific strengths and resources a company possesses before choosing a business model. For example, if it has developed a highly effective algorithm and boasts a well-functioning technological platform, it might consider the platform-based model. On the other hand, if a company possess extensive expertise in transportation and logistics, backed by a substantial workforce in this field, the brokerage model could be a suitable choice. Conversely, if a startup owns a fleet of trucks, maintains strong relationships with carriers, and has equipped its trucks with advanced technology, the Carrier-based model may be the most advantageous option.

However, it is important to remember that adopting a specific business model, as shown in this study and the analyzed companies, doesn't mean following it completely. Some companies may employ a particular business model while implementing a different revenue strategy compared to another company using the same model.

Another potentially good idea is to employ a hybrid model that aligns with the company's strengths. Select a business model that suits the company's needs, complemented by a revenue strategy that best suits its goals, a customer relationship approach, and technology that aligns with the company's objectives.

To facilitate the explanation and understanding Table 6 shows some benefits and complications when using each of these different models, along with recommendations for start-ups.

Table 6. Benefits and Complications using DFM models.

Business Model	Benefits	Complications	Recommendations
Platform-based Model	Centralized access to a wide network of shippers and carriers.	Dependency on third parties, potentially affecting control.	The company should assess their specific needs and the needs of their target customers.
	Streamlining the logistics process.	Data security concerns when dealing with sensitive information.	Evaluate the trade-offs between centralization and control.
	Providing valuable data and services.	Fees associated with using the platform.	Establish clear partnerships and data security measures to mitigate risks.
Brokerage Model	Expertise and personalized service.	Additional costs, potentially reducing cost-effectiveness.	The company should carefully analyze its capacity to provide expertise and personalized service. Consider the trade-off between costs and added value.
	Risk mitigation through intermediaries.	Potential dependency on intermediaries for service.	Ensure transparent communication with customers regarding intermediary involvement.
Carrier-based Model	Efficient capacity utilization.	Challenges related to data integration and ensuring data quality.	The company should align their model with its expertise and capacity.
	Direct communication with shippers and carriers.	Managing the size and dynamics of the network.	Focus on providing efficient and reliable solutions. Invest in robust data integration and quality assurance processes to build trust.
Software as a Service	Scalability for growing businesses.	Reliance on internet connectivity for operation.	The company should assess its scalability and integration needs.
	Cost-efficiency, often lower initial investment.	Data security concerns when using a cloud-based service.	Weigh the benefits of cost-efficiency and accessibility against potential complications
	Accessibility from anywhere with an internet connection.	Integration challenges when connecting to existing systems.	Ensure data security and offer transparent pricing models.
Asset-light Model	Flexibility and ability to adapt quickly.	Dependence on carrier relationships, potentially impacting service quality.	The company should consider their ability to build carrier relationships and maintain quality standards.
	Cost savings by not maintaining physical assets.	Quality control challenges, especially with limited physical control.	Evaluate competition and identify unique niches where they can excel.
	Focus on specialized expertise and service.	Strong competition in the market, requiring differentiation strategies.	

5. Conclusion

This study has provided insights into the diverse features of Digital Freight Matching (DFM) business models in the trucking industry. The research has demonstrated that there is no one-size-fits-all solution when it comes to choosing the most appropriate business model for a company looking to enter the world of DFM. Instead, the choice should be guided by a thorough assessment of a company's unique strengths, available resources, and market conditions.

One of the primary contributions of this study is the creation of a comprehensive resource that facilitates a comparison between different DFM business models. This is particularly valuable for startup companies looking to enter the trucking industry as it enables them to make informed decisions about the pros and cons of each model.

The research also addressed critical questions regarding the advantages and disadvantages of traditional Freight Brokers versus DFM models and how these shape the industry. It further explored the variations in DFM business

models concerning their operational processes, revenue generation strategies, customer relationships, and digitalization levels.

The comparative case study conducted in this research shed light on the distinctions within various DFM business models, offering valuable insights for both existing industry players and newcomers. The framework developed in this study provides a practical tool for assessing and understanding the different approaches within the trucking industry.

As demonstrated in the analysis, successful companies in the industry employ different models, each customized to their unique needs. The choice of a business model should be informed by factors such as a company's technological capabilities, transportation expertise, carrier relationships, and technological infrastructure. It's worth noting that companies can also opt for hybrid models that combine elements from various business models to better align with their goals.

Limitations in this study include the analysis of established industry players, possibly overlooking smaller startups or regional companies, which can offer unique insights. Furthermore, the study primarily focuses on internal factors influencing DFM model selection, and there is limited exploration of external factors such as, economic conditions, and competitive landscapes that can significantly impact the industry. Future research should aim to encompass a more comprehensive sample of participants and consider a broader spectrum of companies, while also examining the influence of external factors on the digital freight matching landscape. Additionally, further research into the impact of DFM models on environmental sustainability, including carbon footprint reduction strategies, will be crucial as the industry faces growing concerns regarding its ecological impact. Evaluating eco-friendly initiatives and their impact on operational efficiency could be a focus area.

In conclusion, this study serves as a valuable resource for startups and industry professionals in the rapidly evolving DFM sector, it is essential to have a robust understanding of the practical insight of the various business models and their implications to select the most suitable business model, emphasizing adaptability, and tailoring to a company's strengths and goals. Our research aims to foster continued growth and innovation in the trucking industry, ultimately enhancing efficiency, reducing costs, and improving service quality for all stakeholders.

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