

Freight Matching Strategies in Online Spot Market for Balancing Shipper and Platform Performance

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Abstract

Freight matching strategy is an essential aspect of balancing the trade-offs between platform performance and user performance, particularly in the online freight transportation spot market. The online freight transportation market where the sellers provide services for transporting bulk product using one-time purchase transaction has variability in carrier availability and the rate that increase the pairing process's complexity. This study analyzes the matching process of carriers and shippers in the online freight transportation spot market platform to balance the platform's profit as well as shipper's reliability. A simulation approach is used to capture the complexity and uncertainties in the system. We find that the matching strategies significantly affect the platform's profit and shipment reliability. The balance between the platform and the shipper's intentions is obtained by putting equal weight on the carriers' rates and distance to the pickup location. The finding will help the online spot market platforms deliver the balance strategy in pairing their demand and therefore improve the supply chain performances.

Keywords

Matching Strategy, Online Spot Market, On-Demand Sourcing, Transportation Service Sourcing, Simulation Study

1. Introduction

With advanced technology, online platforms for freight transportation services have emerged, especially the technology dealing with on-demand sourcing for road transportation. The freight transportation spot market, where the shippers purchase the transportation services is improving their traditional phone call method to more advanced functions such as task automation and online transaction (Armstrong and Associates, 2016). Some platforms such as Buddy Truck, Uber Freight, Uship, or Kargo.tech are examples of the online spot market companies that support on-demand transportation services. In Indonesia, e-commerce reached 24.82 Million transactions in 2018, and 10.19% accounts for freight and warehousing services (National Bureau of Statistics, 2019). The increasing number of transactions results in increased competition among players, especially when dealing with the short time windows (Alnaggar et al., 2019). Thus, the online platforms for freight transportation require a matching strategy to pair the supply and the demand.

As an innovation in the freight industry, the online platforms should solve the issue such as balancing the user performance. The on-demand transportation sourcing is characterized by uncertain condition while the supply and demand are unpredictable (Kantari et al., 2020). With all those conditions, shippers, as the demanders, intend to have their shipment arrived on-time while the platform should make a maximum profit for their services. The shipment reliability and profit are trade-offs parameters that need to be balanced. Thus, the platforms are required to make a good strategy in pairing the available sources to each shipment load.

The purpose of this research is to analyze several freight matching strategies to pair shippers and resources in the online platform aiming to balance the shipper and platform performance. The specific research questions are (1) 'How significant the matching strategies affect the shipment reliability and platform's profit?' and (2) 'What matching strategy is giving the balance between the shipment reliability and platform's profit?'. The finding will

help the online spot market platforms to deliver the balance strategy in pairing their demand and improving the supply chain performances.

This paper develops a simulation model to explore sourcing transportation services using on-demand sourcing obtained from online platforms. In particular, we consider evaluating several different matching strategies for pairing shipment load to available resources under supply and demand uncertainties. The supply uncertainties include the availability, rate, as well as location of the carrier. The shipment demand from shippers is fluctuating. These uncertainties affect the occurrence of the shipment process's events, such as a longer queuing time when the demand is high or a longer searching time when the providers are limited. It makes the system are more complex and complicated to solve using an analytical approach. Therefore, this study uses discrete-event simulation since it is the suitable method to solve complex problems, mainly when the system involves uncertainties (Law, 2015).

The rest of the paper is organized as follows. In Section 2, literature related to on-demand transportation sourcing is discussed. Section 3 presents the model development and experiments. In Section 4, results obtained from the proposed method are analyzed and discussed. Section 5 summarizes the concluding remarks and further research.

2. Literature Review

Studies on the online spot market for freight transportation services have been constructed for over a decade. Some of them interested in determining the optimal procurement strategies (Oliveira, 2017; Seifert et al., 2004; Xu and Huang, 2017), pricing model (Wu et al., 2020), mix sourcing strategy (Kantari et al., 2019; 2020), or identifying the development barrier (Chen et al., 2019). Most of the studies are interested in solving the problems in crowdsourced delivery where the supply of the services, especially for last-mile delivery, are provided by the crowd (Alnaggar et al., 2019). Only a few studies considered the problem in transporting the first-mile delivery (Kantari et al., 2020). This paper models the online freight transportation spot market focusing on sourcing services for transporting bulk items.

As the number of studies on last-mile delivery is dominant, matching supply and demand in transportation sourcing has been applied extensively for last-mile delivery. In the ride-hailing industry, a driver and a rider are matched if they have the same origin and destination (Masoud and Jayakrishnan, 2017). In addition, the threshold of picking time and time windows also becomes a consideration, especially dealing with optimizing delivery routes (Hou et al., 2018; Wang et al., 2020). Hou et al. (2018) proposed a concept of matching level to measure how close a rider's route is to the existing routes. Different from the ride-hailing services, carrier in freight matching platforms generates their fare. Other factors, such as volatility of rate and the carrier's performance, are often neglected. Alnaggar (2019) provides an extensive classification and typology decisions of the existing crowdsourced delivery systems. Unlike the above studies, our work mainly explores the freight matching strategy involving the supply uncertainties from transportation providers, such as volatile rate and location.

Most intentions in developing the matching strategies are focus on three main goals. First, the matching is developed to obtain as many supply and demand pairs. Stiglic et al. (2016, 2018) studied the deterministic matching approach to maximize the number of ride-sharing pairs. Second, the matching is designed to minimize the total mileage. Stiglic et al. (2016) studied the matching between a rider and a driver to obtain maximum the number of matches and distance savings. Third, the matching is created to obtain a monetary benefit for the service providers. Li et al. (2020) studied the implication of freight matching to maximize the expected revenue. Only few matching studies are considering the intention of balancing the platforms and user's performance, such as having a good profit and good shipment reliability. However, balancing the performance is the problem in the real world. Thus, studies on this topic are essential not only for literature but also for practice.

3. Methodology

The simulation study is developed to model the uncertainties and complexity of the matching strategy for freight transportation services sourcing. This method is chosen because the uncertainties which affect the events in the shipment process and the large number of parties involved in the model make it hard to solve using an analytical approach. The development of the simulation model follows several steps. The first step is determining and developing the matching model. Then, verification and validation of the model are performed to ensure the credibility of the simulation model. After that, the design of experiments is generated to answer the purpose of this study.

3.1 Matching Model

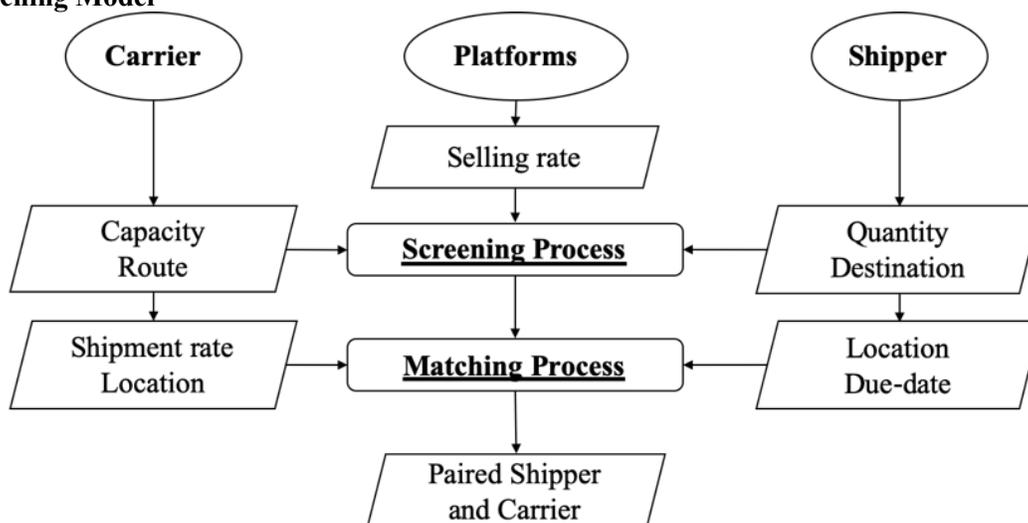


Figure 1 Matching shipment demand to carrier mechanism using resource sharing platforms

Matching the available providers to the shipment request is modeled in Figure 1. The model consists of three players, namely carriers, the platform, and the shipper. Carrier is the truck owners or the freight companies who provides the resources to deliver the load. The platform refers to digital companies that collect the carrier's information and pairs it to the shipper's request. The online spot market platform allows carriers to submit their schedule or actively update their availability using pure self-scheduling (Alnaggar et al., 2019). The information of the carriers, including the type of transportation, capacity, route, shipment rate, departing locations, is required when the providers update their availability. This information constantly changes following the current updates from the carriers.

Shipper, in this study, assigns shipment requests to the platform. The shipment demand is submitted, followed by information, including load capacity, destination, pick-up location, and due-date. The arrival of the demand is unpredictable follows the statistical distribution demand for each destination for one year, both platform and the providers are being updated in real-time. Then, the platform filters the providers who fulfill the shipper requirements using the screening process. After that, the matching process is performed to pair the remaining providers to the load. The result of the matching process is then updated to the chosen transportation provider and the shipper. In this study, we assume that the shipper and the providers have a very low probability of rejecting the result of the matching process. The shipment process is executed after both shipper and provider are agree to the matching results. In this study, we develop a simulation model consisting of one shipper with 68 shipment destinations and one freight transportation spot market platform with 27 carrier options.

3.2 Verification and Validation

The logic check and experimentation validation are applied to justify the accuracy of the model. First, the logic of the simulation model is checked by performing extreme condition testing (Sargent, 2000). We check the animation of the model under very limited available resources in the online platforms. This condition results in a long pairing process and very low shipment reliability. Second, the run-length, replications, and warm-up period are calculated to support the experimentation validation (Robinson, 2014). We performed the initial simulation, analyze the result, and determine that the simulation model need to be replicated at least six times and applied 20 – 30 days of warm-up periods. This model is run daily for 365 days with initial 30 days warm-up period and replicated 30 times to improve the accuracy. All the verification and validation tests did not reveal any invalid results. Thus, the experiment can be performed to the model.

3.3 Experimental Design

To analyze the effectiveness of the strategy, we determined several scenarios of the matching, as mentioned in Table 1. In this study, the initial matching process does not consider the provider's attributes. Then, we added more strategies involving the volatility of the provider's cost as well as the distance from the shipper location. All four strategies performed using the same simulation conditions. The experiment also measured the effect of different market availability levels to measure the sensitivity of the proposed matching scenario.

Table 1 Proposed designed of matching strategy

Factors	Levels	Definitions
<u>Matching strategies</u> The logic in pairing the demand to the available supply. It involves provider's attribute namely cost and distance to shipper's location.	Matching 1: Random	This strategy does not consider provider's attributes.
	Matching 2: Highest platform's profit	This strategy aims to generate maximum profit by prioritizing the cheapest provider as the winner.
	Matching 3: Nearest distance carrier	This strategy aims to improve the shipment reliability by choosing the nearest provider.
	Matching 4: Equal weight for profit and distance	This strategy applied an equal weight for provider's attributes to determine the winner.
<u>Market availability</u> It represents the availability of the carrier in the spot market. The lower the value means that the supply is limited.	10%	Very low availability of spot market providers
	30%	Low availability of spot market providers
	50%	Moderate availability of spot market providers
	70%	High availability of spot market providers
	90%	Very high availability of spot market providers

This study aims to generate a balance of the users' intentions. Thus, two performance measures are developed to justify the simulation results. First, we analyze the shipment reliability, which compares the total of shipments that arrived before the due date to the total shipments using the online platform (Eq. 1). Second, we also measure the profit obtained by the platform by measuring the difference between the platform offering rate and the carrier's rate (Eq. 2).

$$\text{Shipment reliability} = \text{Shipment arrived before due date} / \text{Total shipments} \quad (\text{Eq. 1})$$

$$\text{Platform's profit} = \text{Platform's rate} - \text{Carrier's rate} \quad (\text{Eq. 2})$$

4. Results and Discussion

In this section, we present the results of the experiments. First, the results from statistical analysis are presented and, then, we show in graphical form the effect of factors on each performance indicator. The statistical analysis is mainly checking the significance of the effect each factor has on each of the performance indicators, while the graphical analysis will show the directions and visual presentation of the impacts.

4.1 Statistical Analysis

The statistical analysis is conducted using Anova to check the significance of the factors to the performance indicators. Using a 95% confidence level, Table 2 shows that all modeling factors are significant to all performance measures shown by Sig. value less than 0.05. The effect of matching strategies significantly affects both shipment reliability and the platform's profit. It is shown by the partial eta squared value which is close to 1. The market availability, however, highly affects the shipment reliability but poorly affects the platform's profit. The combination of both factors moderately affects the shipment reliability and very weakly influences the platform's profit.

Table 2 Analysis of Variance

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Matching strategy						
Shipment reliability	6.666	4	1.667	15741.958	0	0.989
Platform's Profit	4.6298E+22	4	1.1575E+22	68414.457	0	0.997
Market Availability						
Shipment reliability	3.333	4	0.833	7870.15	0	0.977
Platform's Profit	4.4102E+19	4	1.1025E+19	65.169	0	0.264
Matching strategy * Market Availability						
Shipment reliability	0.091	16	0.006	53.488	0	0.541
Platform's Profit	1.3673E+19	16	8.5459E+17	5.051	0	0.1

4.2 Graphical Analysis

Figure 2 represents the graphical results for all the factors and performance measures. The scatter plot shows the relationship between two performance measures, namely shipment reliability and platform's profit per year. All the replications results of each scenario are plotted in different shapes and colors. The different shapes depict different matching scenarios and the lighter colors represent the lower market availability.

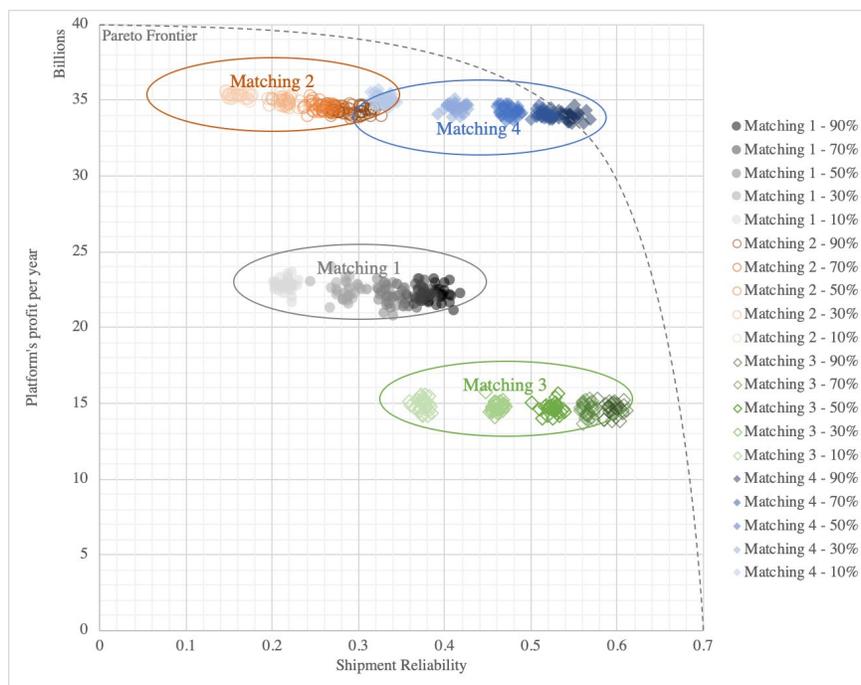


Figure 2 Scatter Plot of Shipment Reliability and Platform's Profit

The variation of matching scenarios is visibly shown in the plot. The highest profit can be obtained using Matching 2, yet the shipment reliability will be the lowest among other matching scenarios. On the contrary, the highest shipment reliability is obtained while using Matching 3, yet it results in the lowest profit for the platform. When the system prioritizes the cheapest carrier to match the shipment request, it neglects the distance factor. Therefore, the shipper has a higher chance of being matched with the distant carrier and increases the time for picking up the load. The cheaper carrier, moreover, has slightly lower punctuality compared to the pricier carrier. This issue also affects

the delay of the shipment and thereby results in lower shipment reliability. The contrast results between the parameters show that these two scenarios are not equalizing both participants' satisfaction in the system. The effect of market availability on shipment reliability is clearly seen in the graph. The lower availability showed by the lighter colors is always plotted in the left, showing lower reliability. The lower market availability increases the competition among the shippers, and finding the match is more difficult. The effect of availability on profit is significant, yet it is vaguely seen in the graph as the partial eta squared in Table 2 shows a relatively low value (0.264).

After putting all the results in the graph, we determine the competitive option of the scenarios by adding the pareto frontier line. The Pareto line shows the target performance of a company. In this case, shippers are more satisfied when achieving a higher value of reliability and the platform is more satisfied when obtaining a higher profit. The graph shows that all three proposed matching scenarios, Matching 2, Matching 3, and Matching 4, outperform the initial strategy, Matching 1. It is shown by the positions closer to the pareto frontier line. Put priority on providers with the lowest cost results in high profit but low shipment reliability. In contrast, give priority on the nearest provider's distance generates good shipment reliability but low profit for the platform. The closer the distance between carrier location and pick-up location make the response time faster.

Matching 4, which balances the matching criteria using equal weight for highest profit and nearest distance, results in more balance performances for the platform's profit and reliability. Even though the values have a slightly lower profit than Matching 2 and slightly lower reliability than Matching 3, the weighted matching performance is the closest to the Pareto frontier line. The weight is used to obtain the best candidate that generates high profit and maintains the reliability of shipment at the same time. This strategy provides a win-win solution for both platform and customers.

5. Conclusion

In this study, we have developed a simulation study that models the matching process of transportation provider sourcing in the online spot market platform. The experiment has been conducted to analyze the several matching strategies in pairing shipment load with the available transportation providers. The proposed matching strategies significantly affect the platform's profit and shipment reliability. The balance between the shipper and platform's intentions is obtained by equally weight the transport providers' rates and distance to the pickup location. The results of this study help the online spot market platforms generate the matching algorithm that balances the platform and user's intention. Therefore, the platforms can improve the supply chain performances.

The further direction of this study should be able to take into account the transportation providers' interests. We realize that the user of the platform is not only the shippers but also the transportation provider. Thus, generating the balance for all parties will be beneficial for the supply chain performance. Considering the various level of bargaining position among the players are important. The matching process is conducted within the platform's system, and therefore the weight in the attributes is not necessarily equal. Thus, various weights are also necessary to study.

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