ASSESSING THE RISKS OF A FREIGHT FORWARDER ENTERING THE TRANSPORT MARKET WITH STOCHASTIC DEMAND

Vitalii Naumov[1,*], Guldana Nugymanova[2], Ihor Taran[3], Yana Litvinova[4]

[1]Transportation Systems Department, Faculty of Civil Engineering, Cracow University of Technology, Cracow, Poland
[2]Mukhametzhan Tynyshbaev ALT University, Almaty, Kazakhstan
[3]Department of Roads and Bridges, Faculty of Civil and Environmental Engineering and Architecture, Rzeszow University of Technology, Rzeszow, Poland
[4]Transport Management Department, Faculty of Mechanical Engineering, Dnipro University of Technology, Dnipro, Ukraine

*E-mail of corresponding author: vitalii.naumov@pk.edu.pl

Vitalii Naumov 0000-0001-9981-4108, Guldana Nugymanova 0000-0001-6035-9590,
Ihor Taran 0000-0002-3679-2519, Yana Litvinova 0000-0003-2806-4076

Resume

This research investigates freight forwarders' operational risks when entering a new transport market characterized by stochastic demand. A simulation model was developed to represent the service request flow potentially experienced by a freight forwarder in a new market. The proposed model incorporates key operational parameters such as average request interval, service tariff, and request processing time. Based on the simulation results, a regression model was developed to predict the market entry risk. The obtained model demonstrates that the risk increases with longer average request intervals between service requests and decreases with higher service tariffs. The findings provide insights for freight forwarders seeking to enter new markets. The simulation-based approach offers a practical tool for assessing operational risks and informing strategic decisions related to market entry and service pricing.

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1 Introduction

The increasing interconnectedness of the global economy has elevated the significance of logistics and international cargo transportation. As the world becomes more integrated, efficient and reliable movement of goods across borders is critical for businesses to thrive. Logistics, encompassing the planning, management, and optimization of goods, information, and financial flows, plays a pivotal role in streamlining these processes. International cargo transportation, in turn, facilitates the long-distance delivery of goods, expanding market access and stimulating economic growth.

The symbiotic relationship between logistics and transportation significantly impacts a company's competitiveness and the development of international trade. To navigate the complexities of the global marketplace, effective management of logistics processes and efficient organization of cargo transportation are paramount. Globalization itself, characterized by the integration of national economies, has profound implications for the evolution of transportation and logistics operations. The surge in global trade volumes and heightened competition necessitates continuous improvement in processes and technologies to ensure the timely and reliable delivery of goods.

The dynamic nature of the transportation market is marked by uncertainty, conflict, and fluctuating goals. Numerous stochastic factors influence technological processes, and the competition for limited financial and material resources exacerbates risk. Consequently, freight forwarders, carriers, 3PL providers (Third-Party Logistics providers), and shippers face a myriad of risk situations when making decisions. By proactively considering and managing these risks, stakeholders can mitigate potential losses arising from market fluctuations and optimize their operations. Additionally, risk assessment can serve as a valuable tool for evaluating the feasibility of administrative decisions.

This research aims to propose a methodological framework for estimating the possible risks of freight forwarding companies when a company enters a new market of transport services or changes its resources and financial policy.

The research gap addressed in this paper lies in the limited focus of existing risk assessment methods for freight forwarders on external factors, especially - parameters of nondeterministic demand. Existing methods typically concentrate on external challenges such as political instability, natural disasters, or economic downturns. Instead, this research introduces a simulation-based approach to evaluate internal operational risks specifically. By focusing on the service request flow, the study provides a more nuanced understanding of the risks of a freight forwarding business. Essentially, this research bridges the gap by shifting the focus from primarily external risks to internal operational risks, providing a more comprehensive framework for freight forwarders' risk assessment.

The paper has the following structure: the second section contains a brief review of contemporary literature related to recent trends in the freight transportation market; the third section presents the developed simulation model that allows for the estimation of risks for a forwarding company; the fourth section describes the simulation experiment, its numeric results, and results of the regression analysis completed based in the obtained data; the last part contains conclusions and directions of future research.

2 Literature review

The intense competitive landscape of the logistics market serves as a powerful catalyst for innovation. In their quest to offer superior services, companies are compelled to prioritize factors such as rapid delivery times, reliability, and operational efficiency. This relentless drive for excellence fuels the development of innovative solutions and the continuous refinement of logistics processes [1].

On a global scale, innovation encompasses both technological advancements and organizational strategies. By embracing innovation, freight forwarding companies can optimize their operations and elevate their cargo transportation capabilities to contemporary standards. Key areas of innovation include technological investments, route optimization, flexibility and adaptability, infrastructure development, sustainability and environmental consciousness, and strategic collaborations and partnerships.

The integration of modern information and communication technologies has emerged as a critical factor in enhancing the efficiency of logistics processes [2-3], which significantly influenced the estimated risks for the business entities participating in the delivery chain. Logistics Management Systems [4] enhance efficiency by automating warehouse processes [5] and enabling real-time tracking of shipments. Big data analytics and the Internet of Things [6, 7] provide valuable insights into supply chain performance, allowing for data-driven decision-making. Additionally, advanced cargo tracking systems [8] mitigate the risk of theft and loss.

Route optimization algorithms and technologies [9-10] reduce transportation costs and time, particularly critical in the face of resource shortages and rising fuel prices [11]. Furthermore, flexible supply chains [12] and backup suppliers [13] enable logistics providers to respond effectively to demand fluctuations, seasonal variations, and unforeseen disruptions [14-15].

Investments in transportation infrastructure, including roads, ports, airports, and warehouses [16-17], are essential for efficient and reliable logistics operations. These investments facilitate the smooth flow of goods and reduce transit times. As environmental concerns grow, logistics companies are increasingly adopting sustainable practices. The use of eco-friendly vehicles [18-19], energy-efficient technologies [20-21], and carbon reduction initiatives [22] can enhance a company's reputation and reduce its environmental impact.

Strong partnerships between suppliers, carriers, and distributors [23-24] can optimize resource utilization and risk management [25]. Collaborative efforts can lead to improved efficiency, cost savings, and enhanced service quality.

The dynamic nature of the logistics industry is characterized by uncertainty, conflict, and fluctuating goals [26-27]. Numerous stochastic factors, such as economic fluctuations, geopolitical events, and operational disruptions, can impact logistics operations. As the result, transport service providers, including freight forwarders, carriers, and 3PL providers, face significant risks. These risks stem from factors like demand variability [28], economic downturns [29], geopolitical tensions [30], and vehicle breakdowns [31]. Additionally, intense competition [32-33] can lead to conflicts between companies and labor unions [34].

To mitigate these risks, logistics providers must adopt a proactive approach. By considering risk factors in decision-making processes, companies can reduce potential losses and ensure business continuity. Risk assessment can also help evaluate the feasibility of strategic initiatives and identify opportunities for improvement.

One of the most frequent situations characterized with the high enterpreneur risks are the situations of entering at new market. This relates to freight forwarding companies when they start their operations or change price politics [35].

Contemporary research in freight forwarders' risk assessment underscores the importance of proactive risk identification. The study [36] utilizing the failure mode and effects analysis method has effectively identified critical risks across the freight forwarding process, encompassing transportation, customs clearance, and documentation. The paper [37] employing a risk map within the context of service supply chains provides a valuable framework for quantitatively classifying and prioritizing risks, enabling freight forwarders to make informed decisions regarding risk mitigation strategies. The significance of implementing effective risk mitigation strategies is also highlighted in the specialized literature. The study [38] investigating the benefits of flexible pricing and hedging instruments demonstrates how proactive financial strategies can enhance the resilience and profitability of freight forwarding operations by mitigating the impact of fluctuating fuel costs. Additionally, research [39] utilizing the decision-making trial and evaluation laboratory method emphasizes the importance of understanding the interdependencies among various operational risk factors to develop targeted and effective risk response strategies.

The mentioned publications underscore the critical need for robust risk management frameworks within the international freight forwarding industry. Contemporary studies conclude that by effectively identifying, assessing, and prioritizing risks, and by implementing proactive mitigation strategies, freight forwarders can enhance their operational efficiency, mitigate potential losses, and ensure long-term success in a complex and dynamic market of transportation services.

3 Proposed simulation model

The forwarder's risk of market entry encompasses a spectrum of potential threats. This risk, essentially the likelihood of an adverse event, can manifest as a loss of resources, diminished income, or increased costs stemming from the company's chosen operational or financial strategies. In the specific context of a forwarding company venturing into the transport services market, this risk translates to the probability of encountering challenges that could hinder its success - receiving a positive profit:

$$r = 1 - prob(I_{FF} > E_{FF}) = prob(I_{FF} \leq E_{FF}), \quad (1)$$

where:

I_{FF} and E_{FF} are income and expenses of a forwarding company within a considered period [EUR];

$prob(I_{FF} > E_{FF})$ is the probability that the forwarder's income from fulfilling requests for freight forwarding operations will exceed the costs of servicing;

$prob(I_{FF} \geq E_{FF})$ is the probability that the forwarder's income from fulfilling the requests will not exceed the servicing expenses.

To numerically assess a freight forwarder's market entry risk, one must analyze statistical data on the company's income and expenses (or profit) per a set of requests serviced during the given period. This data allows for the calculation of the probability of an event occurring, specifically when income I_{FF} is less than or equal to expenses E_{FF}. Key factors influencing this probability include the frequency of service requests (a random variable of the time interval between requests), the number of dispatchers servicing the requests' flow, and the company's service tariffs, which directly impact its income.

To investigate the relationship between demand parameters (request intervals), available resources (dispatchers count), pricing policy (service tariffs), and the associated market entry risk for a freight forwarder, a simulation model was developed to mimic the company's request fulfillment process. This model, implemented in Python and publicly accessible on GitHub [40], provides a platform for conducting experimental studies to quantify these dependencies.

The proposed software implementation of the simulation model follows the paradigm of object-oriented programming and contains the following classes:

- *Stochastic*: the class wraps the methods used to simulate random variables. The main parameters of the class allow for describing the distribution law alongside with the corresponding numeric characteristics - location, scale, and shape parameters.
- *Request*: the class represents a request for freight forwarding services. Its basic characteristics include the appearance time and a Boolean parameter that shows if a request is serviced.
- *RequestsFlow*: the class simulates the demand for forwarding services as a flow of requests. This class contains a collection of the generated requests for forwarding services, its main parameters are a stochastic variable of the interval between requests and the duration of the considered period.
- *Dispatcher*: the class represents a dispatcher of a forwarding company as an entity involved in servicing the requests. Basic fields of this class include a collection of requests serviced by a dispatcher and a stochastic variable of time needed to service a single request.
- *FreightForwarder*: the class is used to simulate the operations of a freight forwarding company. The basic parameters of this class are a collection of dispatchers and numeric financial characteristics - hourly self-costs, the tariff for services, and tax rates.

To simulate demand for forwarding services, the *generate* method of the *RequestsFlow* class was developed: for the given duration of the considered

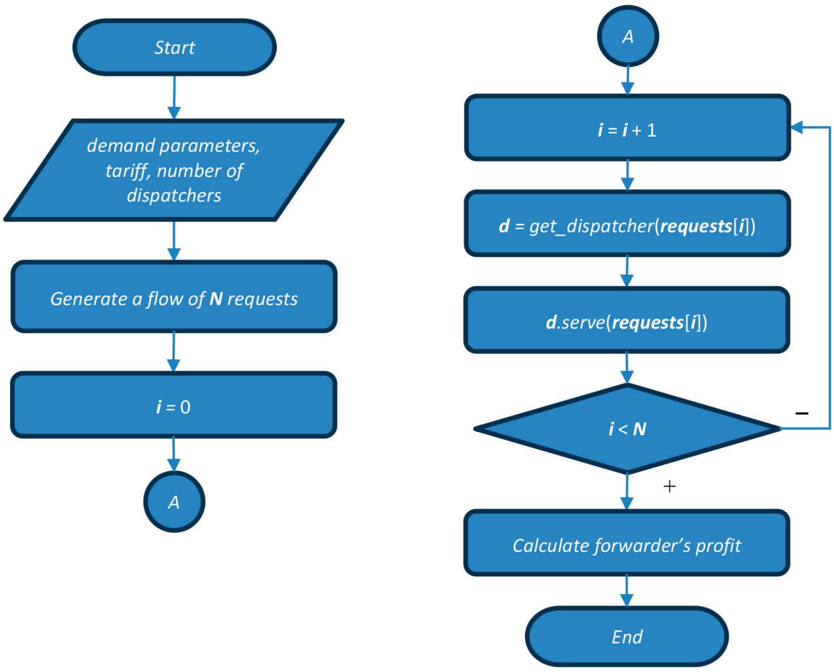

***Figure 1** Simplified algorithm of the simulation procedure*

period, the method generates a set of requests as entities of the *Request* class with the appearance time calculated based on the values of the provided variable of the requests' interval.

The simulation of the process of servicing the generated demand is run by the *serve* method of the *FreightForwarder* class with the corresponding *RequestsFlow* instance given as an argument: for each request in a flow, an available dispatcher is assigned by calling the *get_dispatcher* method, if such a dispatcher found, the *serve* method of the *Dispatcher* class is called with the request provided as an argument of this method. The *get_dispatcher* method returns a dispatcher that is not involved in servicing a request at the moment when the considered request appears. Additionally, this method finds the less busy dispatcher (a dispatcher who served the least number of requests) among the set of available dispatchers and returns it as a result. The *serve* method of the *Dispatcher* class sets the status of a request as a serviced one, adds it to the list of requests serviced by the dispatcher, and calculates the time when the dispatcher will become available after servicing the request.

The algorithm of the described above simulation procedure is presented in Figure 1.

The profit of a freight forwarding company is determined by subtracting its total expenses from its total revenue, considering taxes. This can be expressed as:

$$P_{FF} = I_{FF} - E_{FF} - VAT - PT, \quad (2)$$

where:
VAT and PT are value-added tax and profit tax, [EUR].

A freight forwarder's primary revenue comes from fees charged for services rendered. These fees can be calculated based on a fixed tariff per request:

$$I_{FF} = T_{FF} \cdot \sum_{i=1}^{N_d} S_i, \quad (3)$$

where:
T_{FF} is the tariff for services of a forwarding company, [EUR/request];
N_d is the number of dispatchers;
S_i is the number of requests serviced by the i-th dispatcher during the considered period, [requests/dispatcher].

$$E_{FF} = T_m \cdot s_h \cdot N_d, \quad (4)$$

where:
T_m is the duration of the servicing period (simulation time), [hours];
s_h are hourly self-costs of servicing requests by a dispatcher, [EUR/hour].

In this case, the value-added tax is determined based on the corresponding tax rate:

$$VAT = \delta_{VAT} \cdot \frac{I_{FF} - T_m \cdot s_{paid}}{1 + \delta_{VAT}}, \quad (5)$$

where:
δ_{VAT} is the rate for value-added tax;
s_{paid} is the hourly cost of services purchased by a freight forwarder from other companies, [EUR/hour].

Profit tax is calculated based on the net profit value as follows:

$$PT = \begin{cases} 0, & NP \leq 0, \\ \delta_{PT} \cdot NP, & NP > 0, \end{cases} \quad (6)$$

where:
NP is a net profit of a forwarding company during the considered period, [EUR].

Finally, net profit can be calculated using the following formula:

$$NP = I_{FF} - E_{FF} - VAT - \frac{\delta_{VAT} \cdot T_m \cdot s_{paid}}{1 + \delta_{VAT}}. \tag{7}$$

The method *serve* of the *FreightForwarder* class returns a dictionary, containing the results of calculations for the indicators presented in Equation (2)-(7).

4 Simulation experiment results

The simulation experiment was designed to investigate the impact of key parameters on the financial performance of a freight forwarding company. Specifically, the experiment varied the following input variables:

- The average request arrival interval, modeled using an exponential distribution, ranged from 0.2 to 0.9 hours, with increments of 0.1 hours. As mentioned, it represents the average time between incoming requests for freight forwarding services.
- The freight forwarder's tariff charged per request varied from 4 to 8 EUR, with increments of 0.5 EUR. This range reflects typical market rates for freight forwarding services in Poland in the case when the requests from the specialized logistics portals are serviced.

The number of dispatchers employed by the company varied from 1 to 7. This parameter directly influences the company's capacity to handle demand. The productivity of dispatchers (reflected by the stochastic variable of servicing time) was assumed equal.

For each combination of these input variables, the simulation model was launched 1000 times to generate a statistically significant sample of outcomes. The primary outcome of interest was the probability of the company

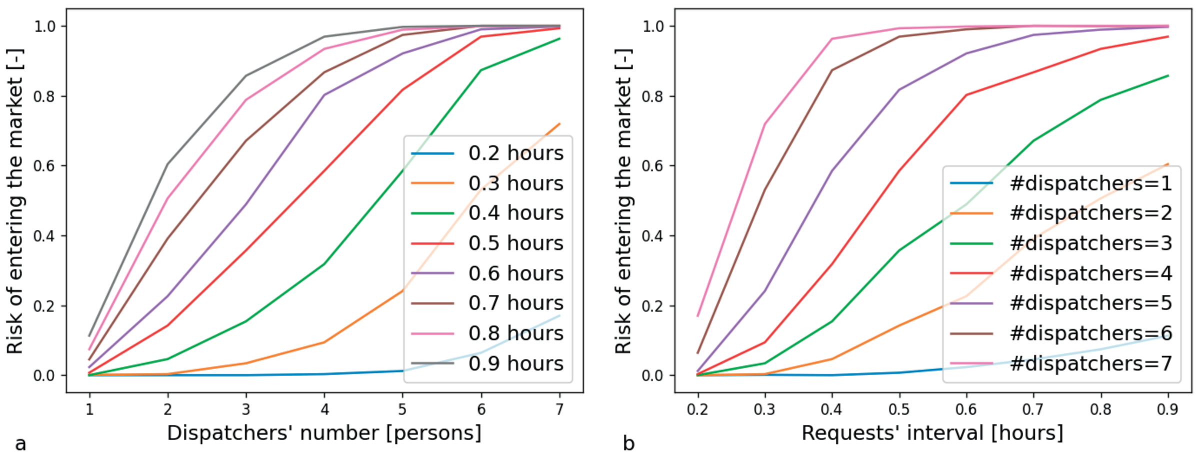

***Figure 2** Dependance of the forwarder's risk on:*
(a) the number of dispatchers (b) requests' mean interval

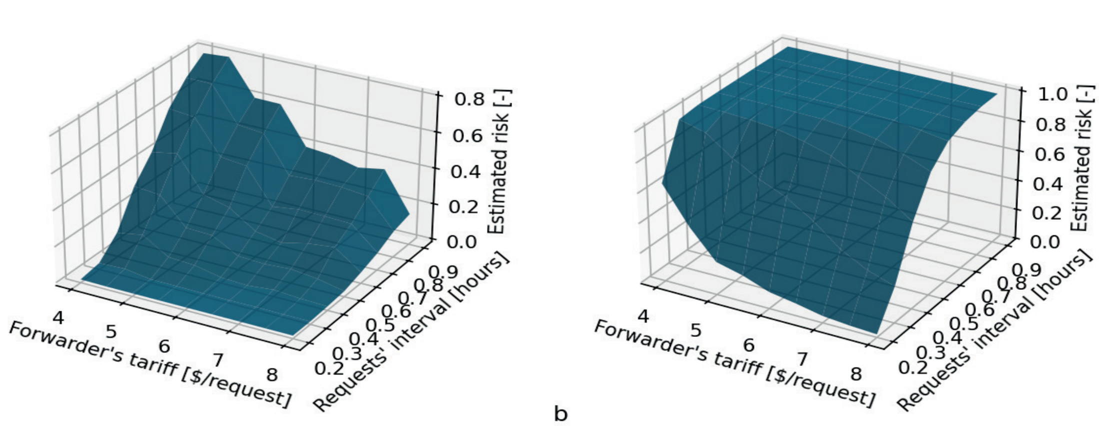

***Figure 3** Dependance of the risk on the tariff and mean interval for:*
(a) 2 dispatchers (b) 7 dispatchers

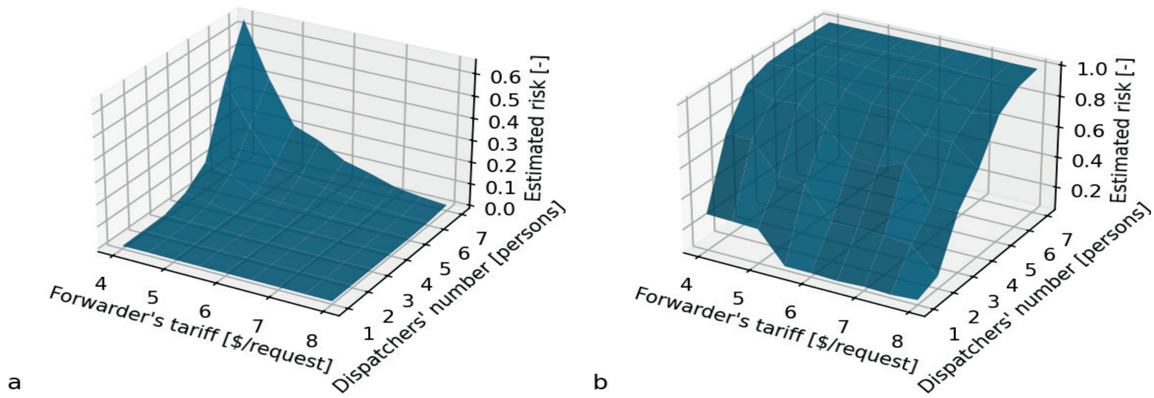

Figure 4 *Dependance of the risk on the tariff and the dispatchers' number for: (a) mean interval of 0.1 hours (b) mean interval of 0.7 hours*

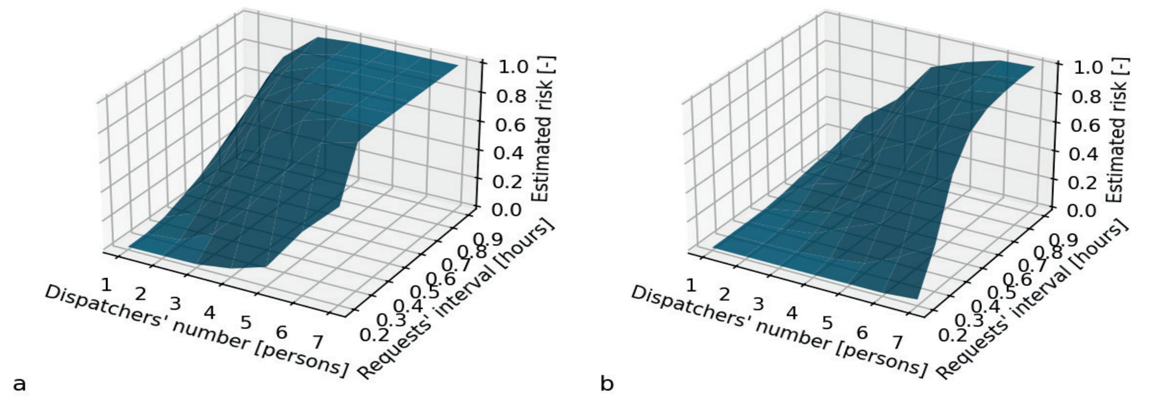

Figure 5 *Dependance of the risk on the requests' interval and the dispatchers' number for: (a) tariff of 4 EUR/request (b) tariff of 7 EUR/request*

incurring a loss, i.e., the probability that its revenue would be less than or equal to its expenses ($P_{FF} \leq 0$).

The results of the simulation experiment, focusing on a modeling period of 4 hours and a tariff of 5 EUR per request, are visually presented in Figure 2. In more detail, the obtained results are visualized in Figures 3-5.

The presented figures illustrate the complex non-linear interplay between the number of dispatchers and the average request arrival interval in determining the risk of financial loss.

5 Discussion

A key finding from the analysis is that the risk of financial loss increases as the number of dispatchers and the average request arrival interval both increase. This nonlinear relationship suggests that while adding more dispatchers can initially improve efficiency, it may also lead to overstaffing and increased costs if the volume of requests does not justify the additional labor. Furthermore, the simulation results highlight the importance of carefully balancing the company's capacity with the expected demand for its services.

To quantitatively assess the relationship $r = f(T_{ff}, N_d, \xi)$, where ξ is the average request arrival interval, a regression analysis was conducted on the simulation results. This analysis involved testing various functional forms to identify the most suitable model. The results of the regression analysis, summarized in Table 1, provide insights into the nature of the dependence between these variables.

Based on the data in Table 1, it can be argued that the most adequate dependence of the forwarder's risk from the tariff, dispatchers' number, and the mean interval is described by a model of the type $r = \beta_0 + \beta_T \cdot \ln T_{FF} + \beta_N \cdot N_d + \beta_\xi \cdot \ln \xi$. Considering the numerical values of the coefficients of the regression model, we obtain the following expression for the functional dependence of the risk of the forwarder entering the market:

$$r = 1.114 - 0.452 \cdot \ln T_{FF} + \\ + 0.131 \cdot N_d + 0.497 \cdot \ln \xi \quad (8)$$

The derived equation provides a valuable quantitative tool for assessing the impact of key operational parameters on the risk of financial loss for a freight forwarding company. By understanding the relationship between the tariff, number of dispatchers, and average request arrival interval, decision-makers can make informed choices about resource allocation and pricing strategies.

***Table 1** Impact of request intervals, dispatchers count, and tariffs on the forwarder's risk to entry the market*

Hypothesis about the type of dependence	Regression coefficients				R^2
	β_0	β_T	β_N	β_ξ	
$r=\beta_0+\beta_T\cdot T_{FF}+\beta_N\cdot N_d+\beta_\xi\cdot\xi$	-0.127	-0.078	0.131	1.016	0.8383
$r=\beta_T\cdot T_{FF}+\beta_N\cdot N_d+\beta_\xi\cdot\xi$	-	-0.092	0.127	0.975	0.8351
$r=\beta_0+\beta_T\cdot\ln T_{FF}+\beta_N\cdot\ln N_d+\beta_\xi\cdot\ln\xi$	1.139	-0.452	0.409	0.497	0.8506
$r=\beta_T\cdot\ln T_{FF}+\beta_N\cdot\ln N_d+\beta_\xi\cdot\ln\xi$	-	0.130	0.459	0.447	0.7335
$r=T_{FF}^{\beta T}\cdot N_d^{\beta N}\cdot\xi^{\beta\xi}$	38.191	-3.387	2.788	4.729	0.6919
$r=\beta_0\cdot T_{FF}^{\beta T}\cdot N_d^{\beta N}\cdot\xi^{\beta\xi}$	-	-1.527	2.946	4.572	0.6772
$r=\beta_0+\beta_T\cdot T_{FF}+\beta_N\cdot\ln N_d+\beta_\xi\cdot\ln\xi$	0.806	-0.078	0.409	0.497	0.8501
$r=\beta_0+\beta_T\cdot T_{FF}+N_d+\beta_\xi\cdot\ln\xi$	0.780	-0.078	0.131	0.497	0.8584
$r=\beta_0+\beta_T\cdot\ln T_{FF}+\beta_N\cdot N_d+\beta_\xi\cdot\ln\xi$	1.114	-0.452	0.131	0.497	0.8589†
$r=\beta_0+\beta_T\cdot\ln T_{FF}+\beta_N\cdot N_d+\beta_\xi\cdot\xi$	0.206	-0.452	0.131	1.016	0.8387

† The biggest value of the determination coefficient

Within the specified ranges of the average request arrival interval (0.2 to 0.9 hours) and the freight forwarder's tariff (4 to 8 EUR/request), the model reveals a monotonic relationship between these variables and the risk of financial loss. Specifically, increasing the average request arrival interval leads to a higher risk, while increasing the tariff reduces the risk. This implies that to minimize the risk of entering the market, the company should strive to set a higher tariff for its services.

It is important to note that the applicability of this model is limited to the specified parameter ranges. For values outside these ranges, it may be necessary to employ more complex modeling techniques or conduct additional simulations to accurately assess the risk profile.

6 Conclusions

The dynamic and complex nature of the transportation market, characterized by uncertainty, volatility, and competition, poses significant risks to various stakeholders, including freight forwarders, carriers, third-party logistics providers, and shippers. The ability to effectively assess and mitigate these risks is crucial for ensuring the sustainability and profitability of businesses operating within this sector.

The research presented in this paper offers insights into the factors influencing the risk profile of freight forwarders. By employing simulation modeling techniques, we have demonstrated that the probability of financial loss for a freight forwarder is significantly impacted by the average request arrival interval and the tariff charged for services. Specifically, the risk increases with a longer average request interval and decreases with a higher tariff.

These findings provide a foundation for freight forwarders to make informed and justified decisions regarding pricing strategies, resource allocation, and risk management. By setting appropriate tariffs and optimizing operational efficiency, freight forwarders can mitigate the risk of financial loss and enhance their competitive position in the market.

Longer intervals between service requests increase the risk of financial loss. This suggests that freight forwarders should actively seek to optimize their customer base and service offerings to ensure a consistent and predictable flow of requests for their services. This could involve strategies such as: engaging with a wider range of clients across different industries to reduce reliance on a few major customers; offering complementary services such as warehousing, customs clearance, and supply chain consulting to enhance customer relationships and attract new business; expanding into new geographical markets or specialized service areas to capture new opportunities.

Higher tariffs generally lead to lower financial risk; however, it is crucial to achieve a balance between profitability and competitiveness. Freight forwarders should carefully analyze market trends, competitor pricing, and customer value perceptions to determine optimal pricing strategies. This could involve conducting market research, implementing dynamic pricing models, or negotiating favorable terms with carriers.

While this research has made contributions to the understanding of freight forwarder risk, further investigation is necessary to explore additional factors and refine the modeling approach. Future research could delve into the impact of factors such as:

- the possibilities of definition of the demand patterns using the dedicated machine learning algorithms,
- the influence of economic fluctuations and supply chain disruptions on freight forwarder risk,
- the role of competition intensity, market

concentration, and competitor behavior in shaping risk profiles,
- the potential benefits and challenges associated with emerging technologies, such as digital freight platforms and autonomous vehicles.

By considering these additional factors and refining the simulation models, it is possible to develop more comprehensive and accurate assessments of freight forwarder risk. This knowledge can be used in practice to develop robust risk management strategies and improve decision-making processes within the industry of freight transportation.

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Conflicts of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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