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IMPROVING TRANSPORTATION CONTRACT MANAGEMENT USING SIMULATION

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Abstract: Transportation management is one of the areas that has strong impact on organization performance. If a company does not have expertise or resource, it would be better to outsource to logistics/transportation provider. The company can form contracts or hire trailers at spot rate. By forming a contract, specific number of trailers will be dedicated to the company and the cost per trip will be lower than the spot rate. However, there is a minimum number of trips requirement. If not properly managed, the company may end up paying more with the contract. The objective of this paper is to experiments with the simulation model to enable the manager to identify appropriate fleet size and negotiate for better contract condition, resulting in better on-time delivery and lower cost. The result shows that the company should increase the number of contracted trailers to match with the transportation needed and renegotiate the minimum number of trips per trailer per month. This will help the company significantly decrease late delivery and reduce costs. In addition, this study also use simulation model to plan for future contract negotiation when there are uncertainties in demand for transportation. Simulation model proves to be an important tool that enables one to gain better understanding of the contract situation and be able to manage the transportation contract that best suits the company's objective.

Key words: Outsourcing, Simulation Modelling, Transportation Contract, Transportation Management, Uncertainty

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Introduction

Transportation and logistics are one of the crucial activities that support organization to satisfy customers and create competitive advantage. Having the right product, but unable to distribute to customers on-time or at lower cost will undoubtedly affect organizational performance. Robinson (2014) found that typical transportation and logistics related costs range from 9% to 14% of sale; however, the costs can be reduced to 4% to 7% if adopting a logistics efficiency management approach. For a company that does not have expertise or capability in logistics, it would be better to outsource such activities to gain better performance at lower costs while focusing on core activities (Rice and Hoppe, 2001). For transportation outsourcing, the company may choose to negotiate with transportation providers to form a transportation contract or to hire at spot rate. In general, forming a contract usually incurs lower rate; however, the company may have to commit to a specific

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number of fleet size and minimum number of trips required. Therefore, the company has to be able to correctly estimate its demand for transportation before making a commitment. Otherwise, it may eventually pay more for a contract if the minimum requirement is not met. This introduces a challenge for the company especially when demand and transportation time are uncertain.

The objective of this research is to use the simulation model and the case study that were previously developed in Setamanit (2018) to further support a company in making decision regarding outsourcing transportation contract under uncertainty. Specifically, the previous research uses simulation to identify the appropriate number of fleet size in order to reduce late delivery. However, the costs incurred are still not the lowest. Thus, this research aims to further identify ways to reduce cost by investigating the impact of the minimum trip requirement per trailer. This will allow the company to have sufficient information to negotiate the contract condition with the transportation service provider in order to improve on-time delivery performance and also reduce costs. In addition, simulation model is also be used to support the company to plan for the contract in the future when demand increases. By experimenting with the simulation model, the company can evaluate the impacts of the increase in demand on on-time delivery performance and costs.

Literature Review

The decision making in transportation and distribution systems is quite complex since it involves many factors, especially when taking into account uncertainty of demand and lead time (Janssens et al., 2009; Laporte et al., 1992; Mungwattana et al., 2019; Pujawan et al., 2015). Thus, distribution and transportation planning in terms of resources, time, and costs is one of the most popular area that have used simulation (Terzi and Cavalieri, 2004). In outsourcing transportation activity, it is very important to accurately estimate demand for shipment and identify the fleet size required in order to have appropriate contract with the transportation provider, which allows company to meet the on-time delivery objective while reducing costs. Jagatheesan and Kilcullen (2011) found that uncertainty had impact on fleet size requirements and needed to be considered for more accurate projection of the optimal fleet size. As a result, simulation is widely used to identify fleet size under uncertainty or to evaluate different management policies on delivery performance (Dong and Song, 1999; Herrel, 2014; Ulewicz et al., 2014; Kavakeb et al., 2016; Lesyna, 1999; Park and Kim, 2015; Setamanit and Khanittha, 2018; Shen et al., 2017).

Once the optimal fleet size is determined, the company can develop a transportation contract to obtain a better transportation rate in return of the capacity commitment (Kovács & Gubán, 2017). However, due to uncertainty in demand for transportation, logistics flexibility, the ability to accommodate various inbound and outbound activities, is crucial (Manders et al., 2016). To manage flexibility, several studies consider the combination of long-term contract with capacity commitment and spot carrier for excess demand (Gurler et al., 2014; Kuyzu et al., 2015;

Tempelmeier and Bantel, 2015; Zhang et al., 2015). It was found that increasing the number of contracted carrier results in higher fill rate. However, dedicated contracted capacity does not guarantee the accomplishment of demand due to uncertainty (Kantari et al., 2019). Spot carrier will be needed when there is excess transportation demand, thus increasing the costs. Therefore, it is important to find the right balance between contracted carrier and spot carrier in order to meet delivery objective with lower transportation costs.

This study will use simulation model to help the case study company make appropriate decision regarding transportation contract negotiation and management, specifically to answer the question: what is the optimal number of contracted trailers with dedicated capacity commitment that will result in higher delivery performance and lower transportation costs. In addition, another important advantage of simulation is that it allows users to evaluate different alternatives under uncertainty. The presence of uncertainty forces decision makers to work with buffers to ensure consistent performance (Van der Vorst and Beulens, 2002). For example, the appropriate fleet size should be able to handle variability in demand during the peak time but still be able to incur reasonable costs when demand is low. Furthermore, simulation also allows the company to evaluate the impact of expected increase in demand on delivery performance.

Research Methodology

This research uses the simulation model developed by using a simulation software package, ARENA version 14 (Rockwell Automation, Milwaukee, WI, USA) to evaluate the contract condition regarding the minimum number of trips requirement per contracted trailer. This allows the company to negotiate with the transportation provider to get the right number of fleet size and minimum trip requirement which can result in better delivery performance and lower cost. In addition, the simulation model is also used to evaluate the impact of increase in demand on delivery performance which can help the company to plan for the transportation contract in the future.

Case Study Background and Simulation Model

The case study company is an automobile manufacturer and distributor in Thailand. The focus of this work is the distribution part. The company aims to deliver the cars to its customers within two day after receiving the orders. Each car carrier trailer can carry seven cars. The trailer has to be fully loaded before traveling to the customer destination. Once the trailer finishes unloading the cars, it will travel back and be ready for another delivery. If there are cars waiting but the trailer is not available, the company will call for additional trailer at spot rate which usually costs higher than the contracted trailer. The company currently has a contract with the transportation provider for 10 car carrier trailers with the minimum trip requirement of 40 trips per trailer per month. The current delivery performance is rather poor; approximately 15% of the orders require longer than two days to deliver to the customers. Therefore, the company needs to re-evaluate its contract to identify the appropriate number of trailers that can meet delivery objective within reasonable costs. Thus, a simulation model is created to represent an outbound distribution system of this company. Detailed information about the company and the simulation model developed can be found in Setamanit (2018).

Performance Measures

There are two key performance measures which are 1) %LateDelivery that measures the percentage of the delivery that takes longer than two days and 2) CostPerUnit that measures the costs incurred to deliver one order (one car) to the customer. To calculate CostPerUnit, the total trip costs will be calculated first and then divided by the number of order delivered. The total trip costs include the cost of using contracted trailer, 80 Euro per trip multiplied by the number of contracted trailer trips, and the cost of using spot trailer, 93 Euro per trip multiplied by the number of spot trailer trips. Note that with the current contract, the company has to guarantee the minimum of 40 trips per trailer per month or 400 trips per month which will cost 32,000 Euro per month. For each simulation run, the model will collect the statistics needed such as total number of contracted trailer trips, total number of spot trailer trips, total number of orders delivered, etc., and then use these information to calculate %LateDelivery and CostPerUnit. Note that the total number of contracted trailer trips and spot trailer trips will also be useful in determining the minimum trips requirements in the contract.

Results and Discussions

This section can be divided into three subsections. The first subsection discussed the previous study that use simulation to identify the appropriate number of contracted trailers to provide background of the work. The rest of the sections are the finding conducted in this paper to further analyse the situation and experiment with the simulation model in order to find the ways to manage transportation contract to reduce costs (2^{nd} subsection) and also to evaluate the impact of the increase in demand on the delivery performance (3^{rd} subsection).

Previous Work Results (Identification of Appropriate Fleet Size)

As mentioned earlier, this work is an extended work from Setamanit (2018) which developed a simulation model to identify appropriate fleet size for a case study company. It was found that the case study company should have a contract for 16 trailers (instead of current number of 10 trailer) in order to meet the on-time delivery performance (%LateDelivery of less than one percent). Note that the %LateDelivery shown in Figure 1 is an average. The average %LateDelivery when having 15 trailers is 0.05%, having 16 trailers result in the average %LateDelivery of 0.02%. However, with further examination, it was found that the probability of having %LateDelivery of less than one is 97% for 15 trailers, and 100% for 16 trailers. Therefore, 16 trailers are the better options to meet the company’s delivery target. Nevertheless, when comparing cost per unit, it was found that a contract for 16 trailer costs more than a contract for 15 trailers (CostPerUnit of 12.03 Euro vs. 11.84 Euro). Figure 1 shows the results of the experiment to identify appropriate fleet size that was conducted in Setamanit (2018).

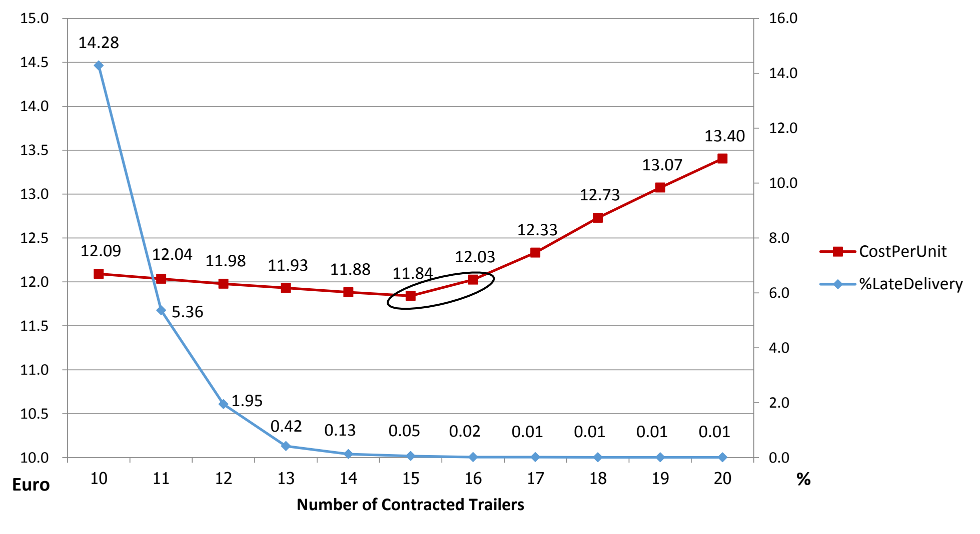

Figure 1. %Late Delivery and CostPerUnit under different number of contracted trailers
Source: Setamanit, 2018.

Negotiation for Minimum Trip Requirement
Based on the results shown in the previous section, to meet the delivery target, the company needs to hire 16 trailers. However, the cost per unit is not the lowest. Therefore, further analysis is needed in order to evaluate the cost structure to identify ways to reduce the cost. It is found that the minimum trip requirement for contracted trailers plays an important role. Currently, the minimum trip requirement is 40 trip per trailer per month. When the number of contracted trailers is 10, the number of contracted trips is 127% of the minimum or 506 trips, but the percentage of spot trailers used is also high at 35% of the total trips (spot rate cost is higher) since there is not enough contracted trailers available. The cost per unit is 12.09 Euro. On the other hand, when having 20 contracted trailers, the spot trailers used are only 12% of the total trips, and the contracted trailers used are only 85% of the minimum trip requirement (682 trips compared with the minimum charge of 800 trips). Thus, the cost per unit is as high as 13.40 Euro. This indicates that if the number of contracted trailer trips is close to the minimum requirements and the number of spot rate trips is low, it is likely that the cost per unit will be lower. For example, with 15 contracted trailers, the contracted trailer trip is about 101% of the minimum requirements, and the spot trailer used is only about 22%, thus the cost per unit is the lowest at 11.84 Euro. The number of trips and cost comparison for different number of contracted trailers are shown in Table 1.

Table 1. Number of trips and costs comparison

No. of Contracted Trailers	10	11	12	13	14	15	16	17	18	19	20
Minimum Trip Required (40 per trailer per month)	400	440	480	520	560	600	640	680	720	760	800
No. of Contracted Trailer Trips	506	528	549	570	589	607	625	641	652	667	682
% Contracted Trailer Trip to Minimum Requirements	127%	120%	114%	110%	105%	101%	**98%**	**94%**	**91%**	**88%**	**85%**
Total No. of Spot Trailer Trips	270	247	223	204	184	167	151	136	119	106	95
% of Spot Trailer Trips to Total Trips	**35%**	**32%**	**29%**	**26%**	**24%**	22%	19%	18%	15%	14%	12%
Cost per Unit (Euro)	12.09	12.04	11.98	11.93	11.88	**11.84**	12.03	12.33	12.73	13.07	13.40

This finding shows that it is crucial for the company to try to identify the right number of contracted trailers and the minimum trip requirement that will closely match with its transportation need. Having higher number of contracted trailers will result in lower spot rate trailers needed, and increase the number of minimum trips required. Therefore, if the company has a high number of contracted trailers but not enough demand (total number of trips is less than minimum trip requirement), cost will be higher as shown in the situation when the number of the contracted trailers is 16 or more. Figure 2 shows the relationship among the number of contracted trailers, the number of contracted trailer trips, the number of spot trailer trips, and the cost per unit.

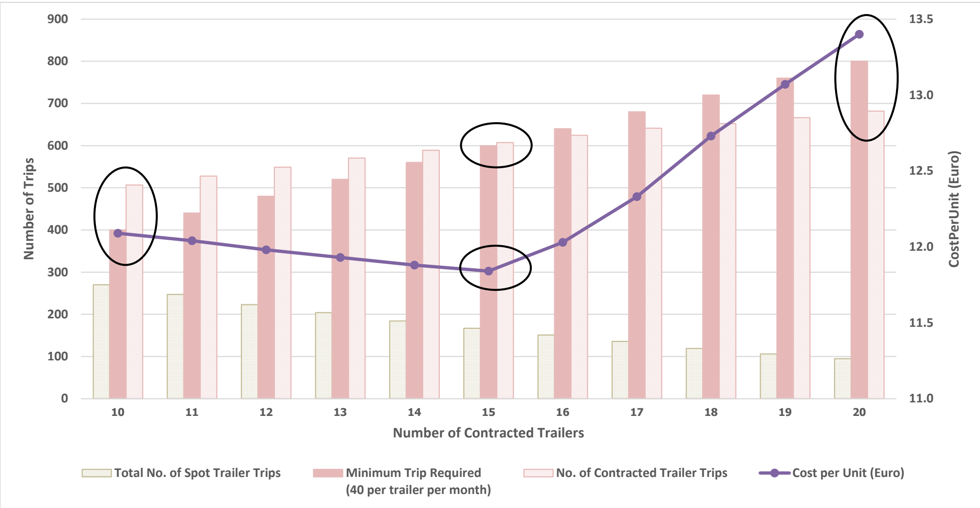

Figure 2. The relationship among the number of contracted trailers, the number of contracted trailer trips, the number of spot trailer trips, and the cost per unit

One can see that the minimum trip requirement is a key factor that impacts cost. Since 16 contracted trailers are required to meet the delivery target, the next step is to find the ways to reduce cost when having 16 trailers. The author, thus, experiments with the number of minimum trips per trailer per month to evaluate the impact. It is found that if the minimum number of trips per contracted trailer can be reduced to 39 trips per month, having 16 contracted trailers will yield the lowest cost per unit at 11.80 Euro (compared to 12.03 Euro when the minimum trip requirement is 40 per trailer per month). In addition, if the minimum trip per trailer can be decreased further, the option to have higher number of contracted trailers will be more attractive as shown in Figure 3. Therefore, the company should consider hiring 16 contracted trailers and negotiate to reduce the minimum trip requirement to 39 trips per month. This will allow the company to meet on-time delivery objective while keeping the cost low. Note that, on the average, the company delivers approximately 5,000 cars per month, so 0.29 Euro saving per car can amount to a saving of 1,450 Euro per month or 17,400 Euro per year.

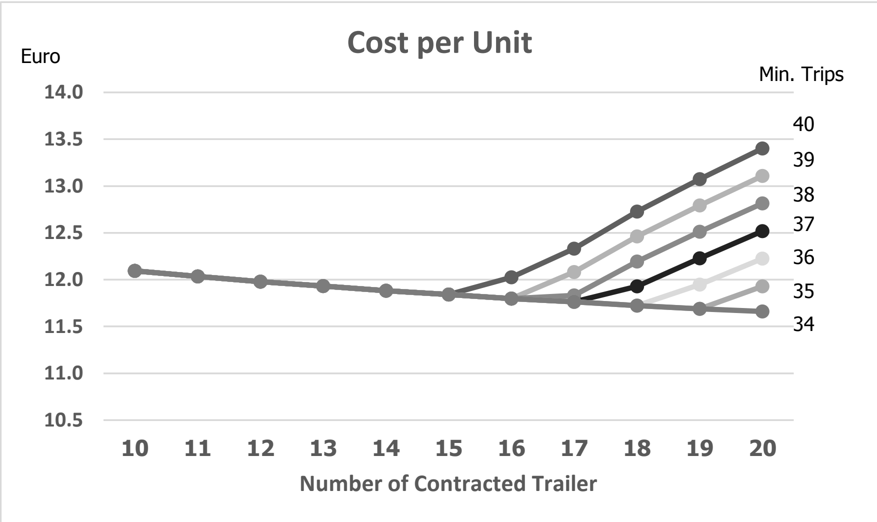

Figure 3. Cost per unit with minimum trip requirement

In conclusion, based on the result from this and the previous sections, the case study company should increase the number of contracted trailers from 10 to 16 trailers and negotiate for a minimum number of 39 trips per trailer per month. This will help the company decrease late delivery from 14% to 0.02% and reduce costs by 17,620 Euro per year.

Impact of the Increase in Demand

Another concern that the company has is that the demand may increase in the future and would like to explore the impact of the increase in demand on delivery performance when using 16 contracted trailers. Therefore, the simulation model is run with 5%, 10%, 15%, 20%, and 25% increase in demand. The Interval Plot of %LateDelivery is shown in Figure 4. One can see that the result can be roughly categorized into three groups. The first one is when there is a 5% increase in the demand, the difference in %LateDelivery from the current situation is not statistically significant. The second group is when the demand increases by 10%, 15%, and 20%, the %LateDelivery is higher than that in the 5% demand increase situation, but still within the policy of no more than 1% late. Note that for %LateDelivery among the three conditions, the differences are not statistically significant. The third group is when demand increases by 25%, the %LateDelivery increases to 2.5% which is significantly different from the latter group and is also unacceptable for the company. In conclusion, if the increase in the demand is less than 20%, the %LateDelivery may increase but will still be within one percent. However, if the demand increase by 25%, the %LateDelivery will be unacceptable.

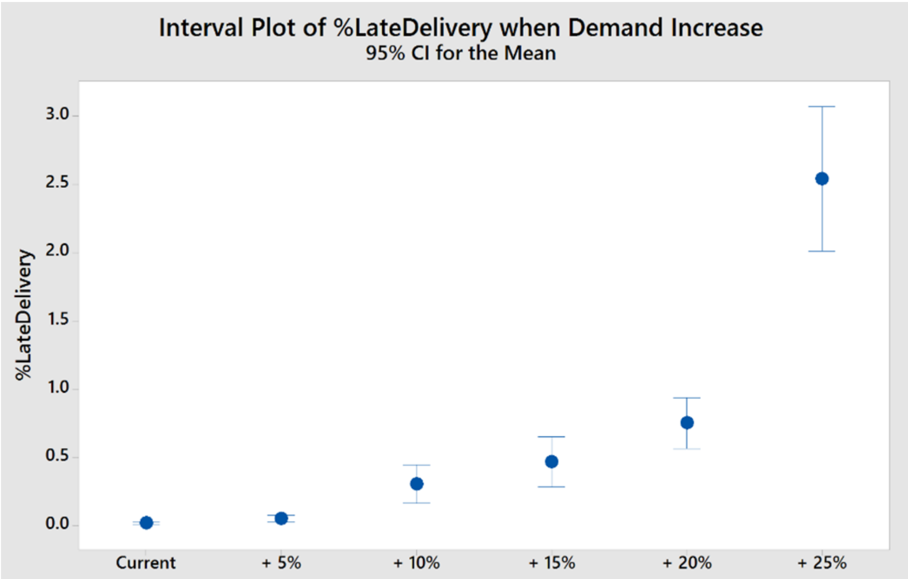

Figure 4. Interval plot of LateDelivery percentage when demand increase

Another aspect worth mentioning here is to evaluate the risk or probability that %LateDelivery is more than one percent. This represents another advantage of simulation which can examine the risk or the probability that the result will meet/not meet the target (Balakrishnan et al., 2006). To evaluate the probability of %LateDelivery less than one, a simulation model is run for 200 replications and data are collected for each replication. The results show that the probability of %LateDelivery more than one increases when demand increases as shown in Table 2. This allows the company to gain better insight of the risk of having late delivery.

Table 2. Probability of %LateDelivery when demand increase

	Demand					
	Current	+5%	+10%	+15%	+20%	+25%
Average %LateDelivery	0.02	0.05	0.30	0.47	0.75	2.54
No. of %LateDelivery more than 1%	0	1	14	24	42	102
No. of %LateDelivery less than 1%	200	199	186	176	158	98
Total number of replications	200	200	200	200	200	200
Probability that %LateDelivery is not acceptable (more than 1%)	**0%**	**1%**	**7%**	**12%**	**21%**	**51%**

These findings extend the previous result founded in Setamanit (2018) that would help the case study company make better and more comprehensive decision regarding its transportation contract. One can see that the company benefits not only in term of identifying the appropriate fleet size and contract condition, but also being able to evaluate the impact of changes in demand and the probability of late delivery. This allows the company to decide on appropriate time to renegotiate the transportation contract as change in demand occurs.

Conclusion

This study aims at using simulation modelling to make decision regarding transportation contract in order to meet delivery objective and also to reduce costs. The results show that the case study company should hire 16 car carrier trailers in order to meet on-time delivery objective. However, the cost per unit delivered is still not the lowest. Thus, the author experiments with the model and find that the minimum trip requirement (per trailer) plays an important role in costs. Therefore, the company should negotiate with the transportation provider for a minimum of 39 trips per trailer per month. With this condition, the percentage of late delivery will be reduced to only 0.02% and the company can save about 17,620 Euro per year. The contribution of this study is to illustrate that it is crucial to determine the optimal fleet size and the appropriate number of minimum trip requirements that match with the demand for transportation before signing the contract with the transportation provider to ensure on-time delivery at the lowest cost. In addition, the simulation model is also used to explore the impact of the increase in demand. It is found that, on the average, the percentage of late delivery is still lower than 1% even when demand increases by 20%. However, the probability that the %LateDelivery will be higher than one will increase. This allows the manager to decide whether the risk is acceptable before increasing the fleet size when demand increases. This study emphasizes another advantage of the simulation model to evaluate the probability of meeting the delivery target. Without simulation, it will be rather difficult for the company to negotiate with the transportation provider. Nevertheless, the simulation model developed in this study is applicable for the case study situation. To use simulation modelling in other different situations, modification of the model will be needed to ensure that it can accurately represent such situations. Further study should be conducted under several varying conditions to identify common factors that will have impacts on on-time delivery and transportation costs.

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POPRAWA ZARZĄDZANIA UMOWAMI TRANSPORTOWYMI Z WYKORZYSTANIEM SYMULACJI

Streszczenie: Zarządzanie transportem jest jednym z obszarów, który ma silny wpływ na wydajność organizacji. Jeśli firma nie ma specjalistycznej wiedzy ani zasobów, lepiej zlecić usługi logistyczne / transportowe. Firma może zawierać umowy lub wynajmować przyczepy według stawki spot. Poprzez zawarcie umowy konkretna liczba naczep zostanie poświęcona firmie, a koszt przejazdu będzie niższy niż stawka kasowa. Istnieje jednak minimalna liczba podróży. W przypadku niewłaściwego zarządzania firma może ostatecznie zapłacić więcej z tytułu umowy. Celem tego artykułu jest eksperymentowanie z modelem symulacyjnym, aby umożliwić menedżerowi zidentyfikowanie odpowiedniej wielkości floty i negocjowanie lepszych warunków umowy, co skutkuje lepszą terminowością dostawy i niższymi kosztami. Wynik pokazuje, że firma powinna zwiększyć liczbę zakontraktowanych przyczep, aby dopasować je do potrzebnego transportu i renegocjować minimalną liczbę przejazdów na przyczepę miesięcznie. Pomoże to firmie znacznie ograniczyć opóźnione dostawy i obniżyć koszty. Ponadto w tym badaniu wykorzystano również model symulacyjny do planowania przyszłych negocjacji umów, gdy istnieje niepewność co do popytu na transport. Model symulacyjny okazuje się ważnym narzędziem, które pozwala lepiej zrozumieć sytuację kontraktową i być w stanie zarządzać umową transportową, która najlepiej odpowiada celowi firmy.

Słowa kluczowe: outsourcing, modelowanie symulacji, umowa transportowa, zarządzanie transportem, niepewność

使用模拟改进运输合同管理

摘要:运输管理是对组织绩效产生重大影响的领域之一。如果公司没有专门知识或资源,则最好外包给物流/运输提供商。公司可以按即期价格订立合同或租用拖车。通过签订合同,特定数量的拖车将专用于该公司,并且每次旅行的费用将低于即期费用。但是,有最少旅行次数要求。如果管理不当,公司最终可能会支付更多合同费用。本文的目的是通过仿真模型进行实验,以使管理人员能够确定合适的机队规模并商定更好的合同条件,从而实现更好的按时交货和更低的成本。结果表明,公司应增加订约拖车的数量以适应所需的运输,并重新协商每个拖车每月的最小出行次数。这将帮助公司大大减少延迟交货并降低成本。此外,在运输需求不确定的情况下,本研究还使用模拟模型来计划未来的合同谈判。仿真模型被证明是一种重要工具,它使人们可以更好地了解合同情况并能够管理最适合公司目标的运输合同
关键词:外包,仿真建模,运输合同,运输管理,不确定性