Analyzing a Fleet Solution Using Scenarios

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Abstract. Transportation is one of the most important logistics activities, accounting for a significant part of the logistics costs and with high level of impact in terms of the service level provided to the customer. To counteract the upward trend in costs, it is fundamental to identify a transport strategy that can reduce costs and, at the same time, does not adversely affect the service levels agreed with customers. The main objective of this research is to propose a methodology for companies to identify, from a set of scenarios proposed and through a comparative analysis of scenarios, a new fleet solution, allowing the Company under study to reduce its transport costs without harming the current service level agreements with its customers. This research is grounded on a case study methodology. The case study used is of a small Portuguese company that produces, imports and distributes a wide range of products. The distribution is conducted based on both its own fleet and subcontracted transportation. The comparative analysis of scenarios allowed identifying the current transportation solution as the most advantageous one for the company. A roadmap to address fleet solution is provided.

Keywords: Transportation fleet · Costumer service · Case study

1 Introduction

The economic crisis that emerged in the beginning of the century is still producing effects. The price of fuel is at one of its highest values ever and transportation companies struggle to remain competitive.

Transportation is one of the logistical activities that absorb more costs and the transportation solution adopted influences the value proposal a company to the market [1]. Although intercontinental movements are mostly fulfilled with road transportation [2], the rising of its costs is leading companies to grasp for more effective solutions and there is no solution that best fits all companies. The transportation strategy can include different fleet options, outsourcing or a full reassessment of route solutions [2], but it should always reflect the goals of the company [3]. Although literature provides many topics for reflection in terms of the benefits and limitation of outsourcing versus insourcing, or even the use of a solution that considers a mix of both the approaches [2], each case and economical context needs to be analyzed individually. Approaching

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this issue goes beyond the traditional minimization of cost and distance and needs to also address service quality in a decision roadmap that is not yet stable in literature.

A Portuguese company that produces, imports and distributes household products for large retail players is facing the challenge of having to reduce its costs but at the same time must maintain or eventually increase the service level it provides to its customer. The Company can: (1) absorb the increase of the cost of fuel and therefore reduce its margins; (2) pass these increased costs to the costs of the products it sells, with the risk of becoming less competitive; or (3) search for more efficient transportation alternatives that do not impact negatively on its service level. The only option the company wants to consider is the third one. Under this scope, the purpose of this research is to develop a roadmap, based on scenarios, that can help the company overcome the challenge of adjusting its transportation solution into a more efficient one while not disregarding service quality.

Accordingly, the goal of this research is twofold: propose a methodology to help companies deciding between the most appropriate transportation scenarios for their specific situation, by unfolding the most suitable transportation modes and their limitations, and compare the solutions in terms of cost the service level.

Due to its nature, this research will follow a case study methodology and Yin's [4] recommendations will be followed. After a conceptual approach to the topic, the methodological framework will be detailed and the Company and its constraints will be explored, scenarios will be developed based not only on its current operation but also on alternative solutions, and scenario comparison will regard cost, truck occupancy, and service level.

2 Literature Review

2.1 Transportation and the Relevance of Customer Service

Although transportation was not considered a much relevant topic some decades ago, nowadays it is recognized as one of the most impacting logistical activities, being responsible for a large proportion of the logistical costs [5]. Being able to influence de competitive position of a company [3], it needs to be carefully managed.

Transportation influences the value of the product as it can only deliver value once available for the customer [1]. It generates value through its utility of place and time [1, 6]. Being able to reach the required locations in due time is paramount, and service level agreements are increasingly demanding and impact heavily on the competitive level of a company [7]. Customer service can be influenced by many aspects such as frequency of deliveries, deliveries according to the request, inventory level, processing time, on-time deliveries, dependability, communication, flexibility [2, 6].

2.2 Factors Influencing Transportation Costs

Transportation costs can generically be divided in fixed costs (those the company has to support regardless of the use of the equipment, such as financial duties, wages, insurance, taxes, depreciation) and variable costs (those that results from the level of

activity of the company and only occur if the equipment is being used, such as cost tires, fuel, maintenance, repair) [6]. Outsourcing, by its nature, dependent on the request of the organization, is considered a variable cost. Whatever factors that result in fluctuation in demand lead to variation in variable costs but not in fixed cost.

Economy in transportation can be influenced by several factors such as distance, volume, cargo density, stowability, handling, response, and market factors and empty return [6, 8].

Distance is the variable that influences the most transportation costs from a negative perspective as it impacts variable costs directly; as distance increases the fixed costs are diluted in the number of kilometers but the variable costs will increase proportionally [8].

Volume or weight also influence the transportation costs as the cost the unit of weight transported is affected by the total weight, leading to lighter cargo to be more expensive to move, if weight is considered [8]. The capacity of the equipment will limit the volume that is carried and therefore the cost per weight unit. As such, cargo with different weights should be grouped so that volume and weight limits are reached as simultaneously as possible.

Density is a variable that considers volume and weight simultaneously; the lower the density of the cargo, the higher the price per kilo [8].

Stowability of a product, or ability to be stored, influences greatly transportation costs as products that are out of format or with odd shapes lead to loss of cubic capacity in the equipment, which could be used for other products, leading to higher transportation costs [8].

Handling is also relevant in terms of transportation costs. Products that can be moved using standard equipment lead to less expensive handling as there is no need to use special equipment [8].

The market itself greatly influence transportation costs as due to location issues, routing, cargo aggregation of other factors, a delivery may lead to an empty return, which also have to be considered [8].

It is the reasoning between these factors that dictates the transportation costs for each situation, which often cannot be influenced by the companies but dictated by the nature of the cargo itself and the requests of the customer.

2.3 On-Road Transportation

Road transportation is usually linked to intra continental movements and is the most used one [2]. The flexibility and high adaptability of the road transportation, along with the low investment when compared to other transportation modes and low fixed and high variable costs, makes it very popular mainly to small cargo and shorter distances; nonetheless it is very dependent from external conditions, such as weather and existing infrastructures, limited in terms of cargo volume and more expensive and time-consuming for longer distances [8]. Road transportation has clear advantages within a specific geographical area, and although more sophisticated transportation modes are emerging, it is still the number one transportation option for traditional distribution.

2.4 Route Planning

One way of reducing transportation costs is by reducing distance and transit time, i.e. by identifying the most efficient routes. The longer a truck is in transit, the fewer deliveries are possible to complete in a specific period and the higher the transportation cost will be [9]. Under this scope, companies should strive for reducing transit time by adopting metrics that lead to new, shorter, and faster routes.

The Vehicle Routing Problem (VRP) combines a mathematical and a computer science perspective to servicing customers using vehicles [10]. Usually, when using this methodology, products are located at a central warehouse or at a starting point, and requests emerge from various customers. Generally, the main goal is the minimization of the total distance vehicles must travel or its associated time or cost [11]. Due to many variables involved in these mathematical models, heuristics have been developed to address them.

The Clarke and Wright [12] heuristic is still one of the most popular heuristics for the VRP due to its simplicity. It is based on the concept of savings, i.e., the reduction of costs by merging customers into the same route instead of considering a single route for each one of them. The development of computer technology and mathematical knowledge allowed the design and implementations of more sophisticated heuristics, able to improve initial routs in a reasonable amount of time. The Vehicle Routing Problem Heuristic (VRPH), by [13], is one such example and its authors made it available [14] by means of an open-source software library of several local search heuristics for some routing problems that are variations of the classical VRP. This local search heuristics are characterized by the search of new solutions in the neighborhood of previous ones, using initial solutions derived from Clarke and Wright's heuristic, and by diversifying solutions, returning the best solution.

2.5 Insourcing Versus Outsourcing

Outsourcing is the act of contracting from others parts of the activity of the company. Using outsourcing is a way companies use to become more agile, reduce infrastructure, equipment, and personnel. There are many reasons why outsourcing is used and it is not always an option but a necessity instead. A company may have the ability to perform the activity and decide not to do it for some reason, may need to use it as it required additional capacity, or may simply not have the skills required to complete the activity [15].

One of the main advantages that lead companies to contract service providers is that they can focus on their own activity, relying on others, specialists, the activities that are not considered critical, leading to cost reduction, but the reduction of complexity of the operations is also worth mentioning, as well as the reduction of fixed costs, which are transformed into variable ones; at the same time, and among other disadvantages, it makes them lose control over part of the logistical pipeline and limits their contact with the customer [2]. Additionally, outsourcing services should not operate without control; therefore, additional costs will emerge from this activity, and they also need to be considered in the decision of making or buying [15].

When demand is volatile, many companies aiming for better use of the capacity installed use solutions that are a mix of insourcing and outsourcing. This solution allows them the benefits of both insourcing and outsourcing while minimizing the disadvantages of outsourcing. This is a flexible solution and the volume of outsourced service can change over time according to the best scenario for the company at any given moment. This justifies why outsourcing is a solution that so many companies adopt to fulfill their transportation needs.

2.6 Final Remarks

Road transportation is a very flexible transportation mode and very popular among traditional distribution. To improve their customer service levels while maintaining competitive positions, companies continuously search for the best solutions in terms of fleet management and routing. Although having their own fleet presents advantages for the companies, it also involves challenges as transportation and delivery might not be the core of their business. Regardless these arguments, the choice of the best scenario of insourcing versus outsourcing or an eventual balance between the two requires the balance between efficiency in the use of the resources available but at the same time the need to fulfill service level agreements. A roadmap to properly address such challenge is not yet stable.

3 Methodological Framework

Building on [4] and [16], the research framework proposed and the collection techniques to be used in each research phase are shown in Fig. 1.

Although the phases of this roadmap are generic, for each particular case, adaptations may have to be introduced after exploring the nature of the company and its specificities. Interviews should be conducted throughout the process to assure the suitability of the scenarios and understand the company's perspective.

Phase 1 concerns the characterization of the company and its constraints: facilities, current owned fleet, employees, outsourcing delivery services, service level agreements with customers, customer delivery points, among other aspects. Such information is generally provided by company records, as well as interviews and direct observation.

Demand level and profile, in terms of number of pallets or other unit that expresses the volume do cargo of the company, correspond to Phase 2. Predictions and statistical analyses may have to be conducted, based on the data collected from the company records and interviews. In some cases there might be the need to conduct direct observations to collect additional data regarding weight or other relevant characteristics of pallets. For instance, incompatibility of certain items is relevant as it will influence cargo aggregation.

Identification of fixed and variable transportation costs, extracted from company records, are included in Phase 3. In some cases data regarding for instance fuel or toll costs might need confirmation from sources outside the company, but the remaining costs should be extracted from the company's system and records as to truly reflect its reality. The company perspective and the fleet challenges it wants to analyze is

represented by different scenarios identified in Phase 4, mainly based on interviews. Some scenarios emerge from literature but are only worth pursuing if the company considers them as alternatives.

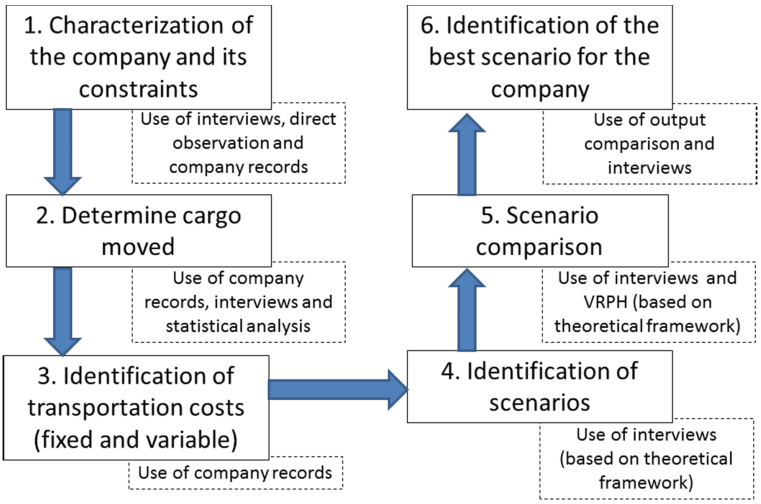

Fig. 1. Methodological framework of the research and data collection and analysis used in each research phase.

Scenarios' comparison and discussion are conducted on Phase 5. Comparison is both quantitative and qualitative, respectively for transportation costs and service levels. Optimization framework, as is the case of routing heuristics like VRPH, may have to be run for cost determination, while discussion reflects the company policies, with response time and logistics service quality having to be analyzed against cost reduction.

Finally, the best scenario for the company is identified in Phase 6, based on the output comparison and again supported by the company's perspective collected from interviews. As the fleet solution is a decision that involves some investment and impacts the company's competitive position, the choice of scenario should not be restricted to the near future of the company.

This roadmap of analysis will be tested based on a use case of a company in the need to assess its current fleet solution in comparison to alternatives that suit its reality. This is a case of a company who wants to optimize its costs but not at expense of it service levels and its competitive position in the market.

4 The Use Case

4.1 The Company

The Company is an average size one with an annual sales volume of about 5.5 million euros. It produces, imports and distributes a wide range of household products. Many

of these products are not of regular shape, requiring additional care in handling and transportation efforts, such as ironing boards. The Company produces and sells under its own brand but also for its customers, with its own brand.

The Company operates out of a large facility located about 40 km west of Lisbon. The warehouse has about 8000 m^2 and uses a straight-through layout. Inbound movements are usually received in containers. This cargo can be stored for future customer needs or integrate cross-docking flows.

According to the Company's data, from its 238 customers, 7 of them represent 70% of the volume of sales. These are the main retailers and wholesalers in Portugal. The Company aggregates its customers in three different classes, as shown in Table 1. These classes are the basis for the selection of transportation solutions.

Table 1. Classes of customers and their characterization.

Classes of customers	Description
Class I	Class composed by the two main Portuguese retail chains. They represent about 50% of the sales of the Company. Service Level agreements are extremely demanding. Orders are received twice a day (at 7:00 and at 18:00) and also delivered twice a day (at 14:00 and 8:30). Orders are delivered at the central warehouse of the customers but are already prepared by store. The Company has to support a penalty if the service agreed is not fulfilled
Class II	Customers with delivery points located less than 100 km from the Company's facility. Service levels depend on the volume ordered and the delivery dates are defined when the order is received: (i) orders of full truckloads: service levels are at least 95% and deliveries are usually completed on the same day but can also be completed the day after; (ii) less than full truckloads: service levels agreed for each order
Class III	All other customers (i.e. more than 100 km away). There is no predefined service level as it is agreed for each order. The Company has a lower investment in service for this class of customers. These customers usually order less than full truck load

The Company currently uses both its own fleet and a logistics service provider to transport its cargo. The Company only uses one service provider and does not wish to add more providers or switch to another as the service levels are fulfilled and prices are considered competitive. This service provider has the particularity of charging by the weight of the cargo instead of the volume as the remaining players in the market do. The Company's products have an overall low-density level, i.e., comparatively have more volume than weight.

Over the years, with service providers becoming more popular, the Company reduced its own fleet and currently only has two trucks and two truck drivers. The truck drivers also perform other activities: 65% of their time is dedicated to driving the trucks and 35% to handling activities at the Company's facility.

The use of outsourcing or its own fleet depends on the Class of the customer and the quantity ordered. Class I has priority over Class II in using the Company's fleet. Deliveries for Class III customers are exclusively completed using outsourcing.

Delivery points for Class I customers are both located 66 km from the Company's facility. Unloading arrangement for one of the customers requires about 50 min, while for the other one involves about 2 h. For other customers, unloading times are always lower than 2 h. At the Company's facility, loading a truck requires about 45 min. The Company estimates that trucks travel at an average velocity of 80 km per hour.

Each driver works 8 h per day, 40 h per week. It is possible to use extra time, up to 2 h per day. Each of the trucks of the company has capacity to 10 pallets per journey.

Deliveries to the islands (Madeira and Azores) are transported to the Lisbon seaport (less than 100 km). Thus these customers belong to Class II, and selection of fleet follows the previously described criteria.

4.2 Demand and Costs

The information system of the Company does not allow identifying the number of pallets delivered, only the level of demand in euros. One full reference year was considered. For this year, 3346 deliveries were completed.

The number of units in each order was transformed into pallets based on information from the Company and from the suppliers regarding the number of units in a full mono-product pallet. From here, and for each order, the number of pallets was computed and rounded up. To assure that stowability issues did not affect the estimative for the number of pallets, samples were collected, and statistical analysis was conducted.

A sample of 46 real orders was considered. A very experienced employee was asked to estimate the real number of pallets each of those orders would generate. Then, using statistical analysis, this number was compared with the computed number of pallets for each of the orders. The distribution of the two samples did not show a normal distribution leading to the use of non-parametric tests. The Wilcoxon test for paired samples showed p-value = 0.366, allowing to conclude that the difference between the two distributions is not statistically relevant. This way, our method to estimate the number of pallets was considered reliable.

As the quantity ordered has an impact on the transportation option (own fleet or outsourcing), it was needed to classify orders into Groups (A, B and C). Group A orders include all orders from Class I customers, exclusively, even if they are not full truckload orders. Orders from Class III customers were all considered in Group C orders, even if full truckloads are involved. Regarding Class II customers, their orders were classified into Group B or Group C depending on the size of the order. Within this Class, orders were divided in multiples of 10 pallets (maximum capacity of the Company's trucks): (i) all orders with less than 10 pallets were included in Group C as the company does not consider delivering them with their own trucks; (ii) the parts of these orders that are lower than 10 pallets were also included in Group C as the policy of the Company is to not even consider them for their own trucks; and (iii) the parts of the orders with exactly a multiple of 10 pallets were included in Group B orders. Table 2 summarizes these Groups.

Table 2. Groups of orders and their characterization.

Groups of orders	Description
Group A	Orders from Class I customers
Group B	Orders or parts or orders from Class II customers that are of 10 full pallets
Group C	All orders from Class III customers plus the orders or parts of the orders from Class II customers that are less than 10 full pallets

Based on [1], transportation fixed costs for the Company were considered as all the costs with the two employees (wages, taxes, insurance, other costs), but only at 65% as they perform other tasks at the Company, added by the insurance and national taxes of the trucks, in a total of €14,487.23 for the considered year. Amortization was not considered as both trucks already have 12 years.

Variable transportation costs came from both the owned fleet and outsourcing. As for the owned fleet variable costs, it was considered fuel, maintenance, tolls and additional costs for meals of the truck drivers that occur when the deliveries take longer. It was estimated a variable cost of fuel of €0.1651 per km and a total volume of other insource variable costs per year of €9,471.31 (maintenance, tolls, and meals), already with national taxes included.

All outsourcing costs are considered variable costs as they only occur if and when the Company requests the service. The Company uses these services for deliveries of orders in Group C, and for orders from Groups A and B when there is not enough capacity available at the Company. This way, the priority is for the use of the Company's fleet.

The transportation service supplier charges based on the weight of the cargo moved. In order to assure that the amount charged by the service supplier is correct, all cargo is weighted before leaving the Company.

As the information system of the Company does not register the weight of the cargo per pallet, only its total, the average weight of a pallet was estimated. To be able to identify a reliable result, a random sample of 99 orders expedited using the outsourcer was used. This sample considered a total of 156 pallets, and the average weight computed was of 71.8 kilos.

4.3 Scenario Development

Based on the current situation of the Company, using a mix of insourcing (with two trucks, each of 10 pallets, used with priority for Group 1 orders but also used for Group B orders when there is capacity available) and outsourcing (for order from Group C and some of Group B when the owned fleet is not available), several scenarios can be considered. Whatever scenario is considered, the policy of the Company has to be respected: aim for the lowest cost possible as long as the service level agreements are fulfilled.

A natural scenario (Scenario 1) is to keep the current situation of the Company, with two trucks and the use of outsourcing. This is a conservative solution but one that

needs to be addressed at least as a comparison point for the remaining ones. This scenario allows the company to keep control of one of its critical activities (transportation) but using outsourcing when there is not enough capacity available.

With the growth of the tendency to outsource, one inevitable scenario is the single use of outsourcing (Scenario 2). This involves selling the two trucks the Company currently owns and depend fully on a transportation service provider. As the Company does not consider the use of other transportation provider but the one it currently used, only this one and its costs will be considered.

The Company has two customers, representing together about 50% of its sales, with which service level agreements are very demanding. Simultaneously, the level of demand from these customers is quite variable and lead times are of less than half a day. As the outsourcing companies have difficulties fulfilling such demanding lead times, the Company could consider keeping one of its trucks, to assure the service level agreements, but increase the use of outsourcing as the tendency of these services are to be least expensive than insourcing. This option will be considered as a third scenario (Scenario 3).

The considered scenarios are shortly described in Table 3.

Table 3. Short description of each of the scenarios considered in the research

Scenario	Description
1	Current situation: two 10 pallet trucks plus outsourcing
2	Full outsourcing
3	Keeping one 10 pallet truck plus outsourcing

4.4 Scenario Comparison and Discussion

The number of pallets is a key element to compare the three scenarios. For each order, the corresponding number of pallets was thus computed using the procedure described in Sect. 4.2.

Orders allocation to the Company's fleet follows a similar procedure for Scenarios 1 and 3. The difference is the insource daily capacity: two trucks are available in Scenario 1, while a single one is available in Scenario 3.

For a given day, the route of a truck may consist of several trips: each trip is the way from the Company's facility to the discharge location and its return to the facility. The capacity of a truck for each trip is 10 pallets, while the total duration of the route is limited to 10 h (8 plus 2 h a day per driver). The traveled distance of a trip is twice the known distance between the Company's facility and the delivery location. Concerning the trip duration, it includes the obvious traveling time (based on 80 km/hour estimated average velocity), plus the loading time at the Company's facility and the unloading time at the customer. The resting and meal times required by legislation are also added up whenever they cannot occur simultaneously with unloading operations.

To simultaneously deal with the capacity and duration limitations, the VRPH was used for each day of the considered year, as described next.

Calculations for Scenario 1 started by running VRPH for Group A orders. Two 10 pallets trucks are available, each limited to 10 h per day. Two situations may occur in a given day: (i) the owned fleet was not enough to accommodate all Group A orders: the remaining Group A orders were outsourced, as well as all Group B and Group C ones; (ii) the owned fleet was enough to accommodate all Group A orders: if there is still capacity left from the owned fleet, VRPH was run for Group B orders, and the remaining Group B orders were outsourced, if any, as well as Group C ones. Distances and durations were recorded, as well as the number of outsourced pallets. Table 4 summarizes the information for Scenario 1.

Table 4. Relevant information for Scenario 1

Fixed costs (insourcing)		Employees	€12,730.21			
		Trucks	€1,757.02			
		Total fixed costs			€14,487.23	
Variable costs	Insourcing (variable)	Fuel	€12,663.50			(5245 pallets)
		Maintenance	€1,627.90			(76,702 km)
		Tolls	€6,302.31			(645 routes)
		Extra meals	€1,551.16			
		Insourcing (variable)		**€22,144.87**		
	Outsourcing	Outsourcing	€24,388.77			
		Outsourcing		**€24,388.77**		(2443 pallets)
	Total variable costs				**€46,533.64**	(7688 pallets)
Total cost scenario 1					**€61,020.87**	

Scenario 1 shows dominance from variable costs, nonetheless fixed costs count for about ¼ of the total costs. Considering that amortization was not taken into consideration as vehicles are quite old, the possible future adoption of new(er) vehicles may heavily increase fixed costs and lead to a total cost for the scenario that is much higher than the one identified here.

Regarding Scenario 2 (full outsourcing), pallets of the orders were gathered by day, their weights were added up (based on an average weight of 71.8 kilos per pallet) and the outsourcing cost calculated (supplier charges by weight). Information is presented in Table 5. This scenario is clearly more expensive for the Company than scenario 1, but if the Company decides to use new(er) vehicles the increase in cost from amortization could lead to invert the relative position of the Scenarios if only cost is considered.

Table 5. Relevant information for Scenario 2

Variable costs	**Outsourcing**	**€77,753.17**		(7688 pallets)
	Total variable costs		**€77,753.17**	(7688 pallets)
	Total cost scenario 2		**€77,753.17**	

For Scenario 3 the procedure is similar to the one described for Scenario 1, but only one 10 pallets truck limited to 10 h a day is available. As trucks reduce from two to one, fixed costs with employees and trucks reduce by half when compared to Scenario 1. Maintenance costs will reduce as well. However, that value will not be half as it is expected that the occupancy rate increases and thus the traveled distances. Hence, Maintenance costs were calculated proportionally based on the maintenance cost per kilometer of Scenario 1 (€0.0212/km), as well as fuel costs (€0.1651/km). Toll and meal costs were calculated proportionally from Scenario 1 (respectively €9.7710 and €2.4049, per route). This data is shown in Table 6. A summary of the total cost per scenario is provided in Table 7.

Table 6. Relevant information for Scenario 3

Fixed costs (insourcing)		Employees	€6,365.11			
		Trucks	€878.51			
		Total fixed costs			**€7,243.62**	
Variable costs	**Insourcing (variable)**	fuel	€8,041.69			(3419 pallets)
		maintenance	€1,032.61			(48,708 km)
		tolls	€3,605.51			(369 routes)
		extra meals	€887.41			
		Insourcing (variable)		**€13,567.22**		
	Outsourcing	outsourcing	€24,388.77			
		Outsourcing		**€43,024.32**		(4269 pallets)
	Total variable costs				**€56,591.54**	(7688 pallets)
Total cost scenario 3					**€63,835.15**	

Table 7. Summary of the cost per Scenario

	Scenario 1	Scenario 2	Scenario 3
Insourcing	36,632.10 €	–	20,810.83 €
Outsourcing	24,388.77 €	77,753.17 €	43,024.32 €
Total	61,020.87 €	77,753.17 €	63,835.15 €

Scenario 1 shows that it is not possible to use exclusively the fleet of the Company to serve customers, therefore outsourcing will always be required to fulfill the agreed service levels. It should be noted that, according to the current situation of the Company, i.e. the use of vehicles that no longer involve amortization, a pallet transported using the fleet of the Company costs about 30% less than a pallet transported using the outsourcing company, which corroborates the decision of the Company to prioritize insourcing. It is also interesting to observe in this scenario that the occupancy rates of the vehicles are not very high (see Table 8). It shows that there is capacity slack to be

used if the customers increase their level of demand, which can be relevant in a market with such demand volatility as the one of the analyzed Company. Simultaneously, the occupancy rate might be considered lower than desired. Considering that (1) priority is given to Class A customers; (2) the service level agreed for Class A customers is very demanding; (3) orders for these customers often involve less than full pallets, are very variable in volume, and often result in less than full truckloads; the flexibility that this low occupancy rate provides can be advantageous to the Company in its competitive position in the market. The fact that insourcing is quite less expensive than outsourcing, adds to the strength of this Scenario.

Table 8. Occupancy rate of the trucks, per Scenario

	Scenario 1	Scenario 2	Scenario 3
Truck 1	73.61%	–	79.14%
Truck 2	47.8%	–	–

Scenario 2 shows the most expensive cost per pallet. This is due to the fact that the outsourcing company defines its price based on the weight, with an additional cost per kilometer if the total weight is above 1 ton. Scenario 3 leads to a cost point per pallet between Scenario 1 and Scenario 2, although the occupancy rate of the truck is higher. As the truck is 12 years and breakdowns are more likely to occur, the Company does not have the flexibility of the second truck to overcome these constraints, having to rely on the outsourcing company for very urgent deliveries. If on the one hand there is lack of internal flexibility, on the other hand, the use of the outsourcer provides additional capacity slack. A problem that can emerge in this scenario is that the outsourcer might not have enough flexibility to respond to very short delivery times (a few hours), leading the Company to be exposed to penalties from the customers for not being able to fulfill the service level agreements. As so, a second truck in the fleet of the Company emerges as a positive solution. Additionally, this scenario shows an occupancy rate that is higher than the one from truck 1 in Scenario 1, but not much higher (under 80%), which is an unexpected result. It is possible that this result emerges from the fact that the uncertainty of demand leads to pallets that are not full pallets or truckloads that need to be sent even without full truckload for a specific client. The fluctuation of demand, regardless of the Class of the customer, also leads to days in which there are no deliveries, contributing to decrease the overall occupancy rate of the trucks. These results are interesting as most literature [1–3, 5–9] argues towards the use of outsourcing instead of own fleet as a way to reduce cost (among other advantages). For this particular case, this is not true. The fact that the Company is using trucks with 12 years, and therefore amortizations are no longer considered, substantially reduces the cost for Scenarios 1 and 3. Once the trucks have to be replaced, even if the Company buys used ones, the cost for these two scenarios (1 and 3) will increase. Nonetheless, due to the flexibility introduced by the self-owned fleet, aligned with the fact that Class A customers have a very short lead time and a very demanding service level agreement, full outsourcing (Scenario 2) would still present serious limitation.

The cost level per Scenario may also be the consequence of the very short lead times the Company has to fulfill, not allowing the outsourcing company enough time to aggregate demand and be able to reduce its price per pallet. This is under the scope of the argument of keeping internal capacity available for very critical situations and outsource for other situations, which is argued in [15].

As the Company's trucks have 12 years each, they are likely to require maintenance quite often. Although this maintenance can be performed outside the labor hours of the truck drivers, it is possible that an occasional malfunction occurs leading to immediate lack of ability to fulfill the short lead times, and to the inevitable penalties imposed by the customers. Nonetheless, if these penalties are lower than the saving exposed in Scenario 1 from the fact that the Company used its own fleet, it would still be worth maintaining the fleet with 2 trucks.

Other companies using the proposed roadmap should be careful about the amortization issue. For the specific company analysed, there were not considered as the current fleet is 12 years old. But it should be taken into consideration that the cost for Scenario 1 and Scenario 3 would increase if new(er) vehicles were included. In this case, as Scenario 1 involves 2 vehicles and Scenario 3 only one, it is possible that the cost per pallet would end up being higher for Scenario 1 than for Scenario 3. Nonetheless, the qualitative approach has to be taken into consideration: in Scenario 1 there is more flexibility and more slack in capacity for urgent and more demanding orders from the main customers than in Scenario 3. This balance between the qualitative and the quantitative approach should be considered by every company using the proposed roadmap otherwise the all approach would be not more than an optimization problem.

As a last remark regarding the use case, it is worth mentioning that the Company has a privileged location, 66 kms from the delivery points of Class A customers, which represent about 50% of its volume of sales. If the distance was longer, not only the lead time of only a few hours would not be possible to fulfill, but the empty return of the trucks could increase the price per pallet. In this case, outsourcing could emerge as a more interesting solution.

This research, although focusing on a single case, was able to propose a methodology that can be used by other companies addressing the same challenge, thus contributing to the knowledge in this area. The proposal has to be adjusted to the specific situation of each company, but the overall approach, the roadmap that is proposed considering both a quantitative and a qualitative approach, can be followed by other companies.

5 Conclusions

This research is based on a real case and aimed at analyzing a proposed roadmap for analysis of fleet solution in companies wanting not only to reduce cost but also to address service quality in their fleet decision. A specific Company is used and the current situation is compared with alternative scenarios based on cost, truck occupancy rate and ability to fulfill service level agreements.

Arguments in literature recommend outsourcing transportation as a solution for lowering costs and even achieve improved service quality as experts will be conducting the route planning and will be able to aggregate cargo and therefore increase truck occupancy rate [1–3]. Nonetheless, findings showed that for this Company keeping its own fleet (and even not reducing it) is the best solution (Scenario 1). A context of very short lead times, demand uncertainty, and high service levels encourage the Company to pursue maintaining its own fleet, which is in line with recommendations from [15] for the outsourcing decision.

As a case study, this research contributes directly to the analyzed Company. Nonetheless, it provides reflection material for other companies with similar constraints regarding lead times and service level agreements. In terms of the overall knowledge in the area, this research proposed a roadmap to address the challenge of comparing alternative transportation scenarios when both quantitative and qualitative issues need to be addressed.

This research is limited for the fact that the number of pallets per order in the case study had to be estimated. Nonetheless, the statistical analysis allowed concluding that the estimates are reliable. Additionally, the costs for the Company were based on the fact that amortization no longer exists, which reduces the costs used for the simulation. It would be interesting to assess if newer trucks and correspondent amortization were considered, the recommendation for the Company would remain the same. In fact, once the current fleet has to be replaced, and the Company faces the challenge of having to buy new trucks or outsource its total operations, the problem that was analyzed using the proposed roadmap will have to be reassessed, and the same roadmap can be followed. A second limitation of this research is that the proposed roadmap was tested using a single case. Although further testing should be developed, this roadmap was based on [4] and [16], so consistency is already imbedded in the proposal. The issue of amortization should be considered by other companies using the proposed roadmap as it might apply to their specific situation.

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References

1. Carvalho, J.C.: Logística e Gestão da Cadeia de Abastecimento. Edições Sílabo, Lisboa (2017)
2. Rushon, A., Croucher, P., Baker, P.: The Handbook of Logistics and Supply Chain Management: Understanding the Supply Chain, 6th edn. Kogan Page Limited, London (2017)
3. Stock, J., Lambert, D.: Strategic Logistics Management, 4th edn. McGraw-Hill, Irwin (2001)
4. Yin, R.: Case Study Research and Applications: Design and Methods, 6th edn. Sage, London (2017)
5. Mangan, J., Lalwani, C.L.: Global Logistics and Supply Chain Management, 3rd edn. Wiley, Chichester (2016)
6. Christopher, M.: Logistics & Supply Chain Management, 5th edn. Financial-Times/ Pearson, Edinburgh (2016)

7. Chopra, S.: Supply Chain Management, 7th edn. Pearson, London (2018)
8. Bowersox, D., Closs, D., Cooper, M.B., Bowersox, J.: Supply Chain Logistics Management: Strategy, Planning and Operation, 5th edn. McGraw Hill, New York (2019)
9. Ballou, R.: Business Logistics Management, 4th edn. Pearson/Prentice Hall, New Jersey (2004)
10. Dantzig, G., Ramser, J.: The truck dispatching problem. Manag. Sci. **6**, 80–91 (1959)
11. Prins, C.: Efficient heuristics for the heterogeneous fleet multitrip VRP with application to a large-scale real case. J. Math. Model. Algorithms **1**, 135–150 (2002)
12. Clarke, G., Wright, J.R.: Scheduling of vehicle routing problem from a central depot to a number of delivery points. Oper. Res. **12**, 568–581 (1964)
13. Groër, C., Golden, B., Wasil, E.: A library of local search heuristics for the vehicle routing problem. Math. Program. Comput. **2**(2), 79–101 (2010)
14. Groër, C.: The VRPH software (2010). https://sites.google.com/site/vrphlibrary/. Accessed 27 July 2019
15. Simchi-Levi, D., Kaminsky, P., Simchi-Levi, E.: Designing and Managing the Supply Chain: Concepts, Strategies, and Case Studies. McGraw-Hill (2009)
16. Voss, C., Trikriktsis, N., Frohlich, M.: Case research in operations management. Int. J. Oper. Prod. Manag. **22**(2), 195–219 (2002)