

An Application of Operations Research for Reducing Fuel Costs

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Abstract. The objective of this work is to identify gas stations out of the route predetermined by a transport company based both on refueling feasibility and on lower fuel costs. The work consists of a case study that collected data such as kilometers run, amount refueled, product transported, type of operation, and average diesel consumption during the trip. Through the Operations Research, we were able to evaluate the feasibility of deviating the vehicle from the current route (mainly highways) to stations in the surroundings. The aim was to check if the organization would obtain any significant fuel cost reduction from this deviation. Our findings suggested cost reduction for the route used in the model, as well as the need to apply the mathematical model whenever there was an intention to deviate from the route in order to refuel at stations with lower diesel prices.

Keywords: Fueling · Operations Research · Cost reduction · Gas stations

1 Introduction

Consistently searching for cost reduction in all stages of the logistic process is a goal to be reached. Freight movement absorbs between one-third and two-thirds of logistics costs, and that is exactly why improving efficiency using the most of the transport equipment and personnel is one of the greatest concerns of the segment [1].

In Brazil, the current scenario of inflation, economic stagnation, and poor economic growth has been causing increased fuel prices, and eventually impacting the transport companies' operating costs, as well as other services relying on fuel and oil derivatives.

Based on this scenario and on the high fuel costs observed, we attempted to strategically evaluate how to reduce these costs in order to achieve profitability without affecting the operation and customer service.

To avoid any significant impact on the increased operating costs, it is necessary to get adapted and prepare a plan while seeking lower costs at the same time. To cut down operating costs, an organization has to adapt itself to the country's economic situation and prepare its operations aiming at the lowest costs possible. The Vehicle Routing and Scheduling (VRS) method is an important tool that many organizations that have been implementing this method through software applications in order to reduce the operating costs. The organization object of this study is engaged in transportation services and uses the VRS method to support the route planning process.

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2 Methodology

Stage one consisted of detecting the problem by observing transport related operations. To this end, we used reports extracted from an automated fueling control website, as well as dynamic spreadsheets and tables that are typically used to measure KPIs (Key Performance Indicators) used to assess a driver's award (prepared by the organization).

We also used reports extracted from the ERP system. Stage two consisted of collecting data from the organization regarding the management of financial costs with fuel, organizing such data into tables, and evaluating them. We used an online fuel management system that keeps record of the amount refueled and fuel price on a realtime basis, as well as of the location of each station on the route. For stage three, we assessed prices and refueling feasibility at stations where drivers are not authorized to fuel their vehicles. To select these new stations, we used criteria such as local topography, infrastructure, and accessibility of the station. Stage four consisted of structuring the data into a mathematical model, taking into account the total kilometers of the route, tank capacity, average kilometers run per liter, and the location and prices of the selected stations.

3 Case Study

The organization object of this study has been present in the Brazilian market for 75 years providing road transportation services. Organizations must focus on providing its services with excellence, efficiency, and effectiveness and meeting their customers' requirements at low operating costs, for it sees both increased earnings and reduced costs as profit [2].

One of the operating costs comes from the fleet, that is the essence of a road transport organization, thus requiring full attention and dedication. The main fleet-related costs include tires, fuel, IPVA [Motor Vehicle Ownership Tax], driver's salary, lubricants, maintenance, tolling, and overheads. In this study, we focused on the fuel factor.

Transport sector is involved in a very competitive market and besides, it has been changing due the technological development e economic [3].

Among other factors, the amount of fuel to be consumed on a certain route depends on the distance, traffic, load weight, and km/l.

3.1 Defining the Problem

The problem consists of determining the best option to refuel the vehicle during the trip, taking into account the cost and distance variables and the feasibility of deviating from the route to refuel at a station where the price per liter is cheaper, due to the fact that, by failing to look at these factors, usually only the liter price alone is taken into account, while the kilometers run and respective consumption associated with the deviation are left aside.

Main aspects of a problem are the exact description of the study objectives, identification of possible decision alternatives, and confirmation of the system limitations, restrictions, and requirements [4].

Within these aspects, we have as exact description of the study objectives the cheaper fuel costs. The possible decision alternatives would be the methods to solve this problem, while the confirmation of the limitations would be the vehicle and its capacities.

Our findings suggested that there is a need to study the causes of the high prices left aside and to propose solutions to cut down these costs. We collected the following data: routes used, load weight, vehicle model and capacity, location of each station and diesel price per liter.

The organization currently uses an automated fueling control website to determine what stations their drivers are authorized to stop by and refuel. This authorization is granted on a real-time basis, and the diesel price can be negotiated through the system. As a consequence, only the agreed-upon prices can be carried out by the parties.

We identified that many stations that are close to the routes currently used offer diesel at a more affordable price, but drivers are not authorized to refuel at these stations.

We selected the route from Campinas/SP to Catalão/GO because it has the highest diesel consumption and worst consumption performance of liter per kilometer run. The route holds over 200 trips every month. With the help of Google Maps - Fig. 1 - we could see that the way to this route, through the BR-050 highway, is 601 Km long.

Based on Table 1, it is concluded that a truck with full tank can run at most 392.6 km. This means that it will need to refuel during the trip. To avoid any incidents, the organization requires drivers not to use a vehicle with less than 1/4 of the tank, thus making it necessary to scheduler fueling at intervals of approximately 300 km.

The load being carried consists of automotive parts, and we considered the vehicle operating at its maximum capacity. The customer from Catalão wanted the transportation to be carried out by a Mercedes-Benz truck Axor 2644 model.

Hence, it was possible to address the study as a function of the truck functional characteristics [5], as listed in Table 1.

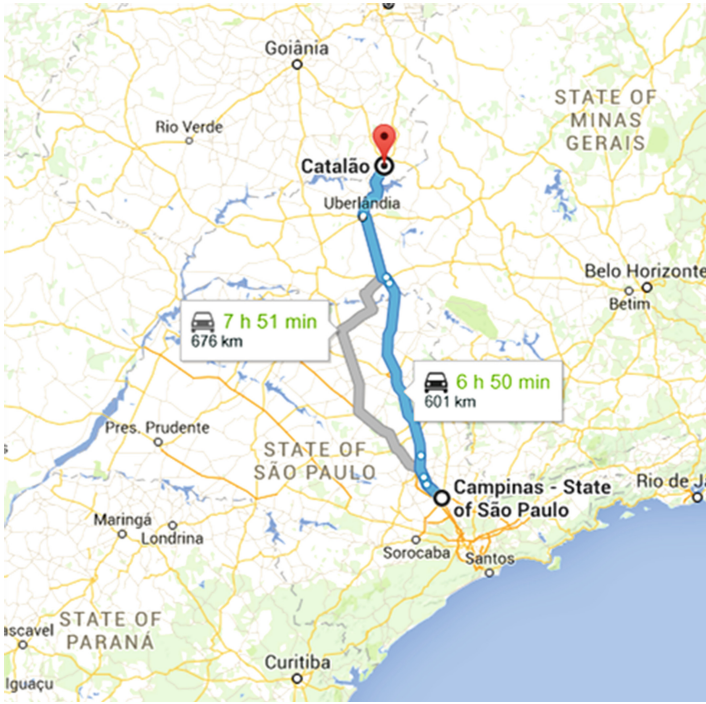


Fig. 1. Route from Campinas to Catalão

Table 1. Truck specification: Mercedes-Benz/Axor 2644

Load	Tank capacity (l)	Max. load (tons)	Tons × km/l
Empty	200	40	2.3
Full	200	40	1.963

The value of $(t \times km)/l$ was obtained by evaluating the fuel consumption history of this type of truck in February of 2015, where it showed a general average of $t \times km/liter = 1.963$, according to Table 2.

Based on intervals of 300 km, with the help of Google Maps, we can see that on this route, the vehicle will pass through region of Guar and Ituverava—So Paulo’s inland cities, and the organization has agreements with gas stations of both these cities located on the highway. The methods described in this work were applied to the city of Guar while trying to respect the most of the interval limits.

Table 2. (t × km)/liter

Manuf. year	Model	Branch	t × km/l	Fuel
2014	AXOR 2644	CATALÃO	1.99	Diesel
2014	AXOR 2644	CATALÃO	2.15	Diesel
2014	AXOR 2644	CATALÃO	1.75	Diesel
2014	AXOR 2644	CATALÃO	1.60	Diesel
2014	AXOR 2644	CATALÃO	1.97	Diesel
2014	AXOR 2644	CATALÃO	2.09	Diesel
2014	AXOR 2644	CATALÃO	1.86	Diesel
2014	AXOR 2644	CATALÃO	1.89	Diesel
2014	AXOR 2644	CATALÃO	1.95	Diesel
2014	AXOR 2644	CATALÃO	2.38	Diesel

3.2 Building the Model

To build the model, we needed details on the data used, an oriented graph, and mathematical modeling using linear programming principles.

We took infrastructure and accessibility into account to select the stations in a maximum distance of 4 Km from the road. Table 3 shows the data defining the actual price (AP) for each leg of the trip, i.e., the address of each station, its distance from the route (each way), and the fuel price per liter at each station. The Santo Expedito gas station is the one currently used, so there are no route deviations to get to it.

Table 3. Addresses, distances and prices

Trading name gas station	Address	Way In (km)	Way Out (km)	Diesel BRL/l
Santo Expedito	Anhanguera, km 395	0	0	2.869
Maranatha	Voluntários de Guará, 597	2.2	2	2.699
Guara	Duque de Caxias, 746	2.9	1.3	2.728
Avenida	Quinze de Setembro, 31	3.1	1	2.800

The branch of Campinas starts the trip after filling up at the Frango Assado gas station, at BRL 2.999 per liter. By applying these data to the formulas, the AP can be obtained, as listed in Table 4.

The linear programming model considered as the objective function the minimization of fuel cost, and constraints were related to origin and possible destinations. Constraints ensured that vehicle had only one origin for each destination

Table 4. AP structuring

	Trading name	Tank (l)	BRL per liter	Deviation to the station (km)	Liter price in the last refueling	AP1	Return to the highway (km)	AP2	total
P1	Santo Expedito	200	2.86	0	2.999	573.8	0	0.0	573.80
P2	Maranatha	200	2.69	2.2	2.999	543.1	2	2.75	545.91
P3	Guara	200	2.72	3.1	2.999	550.3	1.3	1.81	552.14
P4	Avenida	200	2.80	3.4	2.999	565.1	1	1.43	566.62
							(t × km)/l		1963

and ensured that vehicle had not more than one destination for each origin on the route.

3.3 Results and Discussion

To solve the problem, it was used the software LINDO 6.1, due its nature, which consists of a minimum path problem. This group involves combinatory analysis problems, and the number of possible solutions is 5040 combinations and only one is optimal.

Station P2 showed a total cost of BRL 545.91 with fueling to the route/type of distribution being studied, road topography restrictions, bridges with height restrictions, narrow streets where big vehicles cannot running time, i.e., 4.86% less than the cost of the current station. This method had a positive impact on the decision of the best option to refuel.

In another application, the percentage reduction will subsequently vary according get past. As previously stated, this method serves to evaluate and support the decision, thus, occasionally a station with which the organization already has an agreement may lead to greater cost-effectiveness. However, we concluded that the proposed scenario, with routes from Campinas/SP to Catalão/GO, suggested a significant reduction, considering that this trip is repeated 200 times/month in average, i.e.:

$200 \times 573.80 = 114,760 - 4.86\% = 109,182.67$; a reduction of over BRL 5.5 thousand.

4 Conclusions

This study presents a study to identify new partner ships between the organization and its potential suppliers. Therefore, this study should be extended to other routes. The model will be subsequently adapted for Road Distribution operations, where the route goes from the city of Duque de Caxias, in Rio de Janeiro State, to the city of Campina Grande, in Paraíba State, in addition to several other routes that need to be evaluated.

The study shows that, with correct evaluation, a small deviation from the route to refuel at a lower price may have a big impact on the reduction of fuel costs. The proposed method is based in a traditional Operations Research' tools in the sense that it can be adapted to different situations, to longer or shorter distances, to any demographic region, and to any type of fuel and vehicle.

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