Transportation of Diesel and Gasoline to Different Regions of the Philippines

Ruthishenel O. Liu[1], Cathryne Denise B. Tecson[1] and Yvette Fajardo-Lim[1,*]
[1] *Mathematics and Statistics Department*
De La Salle University
Taft Ave., Manila
**Corresponding Author: yvette.lim@dlsu.edu.ph*

Abstract: In this paper, we will illustrate how to apply transportation model to find an efficient way of distributing diesel and gasoline all over the country minimizing distance which is assumed to be proportional to cost. We used the data on the Philippines' refined products import, refinery production, and total product demand per region last 2017. This study aims to determine which refinery must supply the demand of a particular depot.

Key Words: transportation model; objective function; demand constraint; supply constraint

1. INTRODUCTION

The transportation model deals with the distribution of goods from several points of supply to a number of points of demands such that the total transportation cost is minimized. Typical examples include petroleum products distribution system, railways, roadways, telephone system and citywide water system.

This study will focus on the application of the transportation model in the distribution of the oil products over the country. Transporting massive amounts of oil products, it is essential to optimize the total efforts from leaving origins (refineries) until reaching destinations (depots). The paper entitled "Transportation Optimization Model of Oil Products" (Abduljabbar, et. al., 2011) used the transportation model to find the minimum possible transportation cost from particular refineries to depots in Iraq.

Another paper by Pudasaini and Shrestha, "A Multi-Product Transportation Model with Case Study of a Petroleum Distribution Network" (Pudasaini & Shrestha, 2019) used the same model. The objective of the study is to minimize the total logistics cost for shipping all oil products in Nepal. The constraints ensure that every available supply of each product at the sources are shipped to meet the minimum demands at the destinations.

Conducting a similar study here in the Philippines, limitations were encountered. The first limitation was data gathering. Some relevant data for the study were not collected from the Department of Energy because of the Data Privacy Law of 2012. Another was the division of the depots and the refineries. The study only relied on the data provided in relevant websites. Hence, this paper will only consider the distribution of gasoline and diesel from the refineries of Petron and Shell to their different depots.

2. TRANSPORTATION MODEL AND DATA COLLECTION

2.1 The Transportation Model

For the purpose of our study, we aim to determine the amount of oil products to be transported from each refinery to each depot in a year such that the transportation distance is minimized. We use distance since it is commonly the most basic condition affecting transport cost (https://transport-geography.org). We will use the general formulation of the transportation problem as described by Winston (Winston, 2004). Our transportation problem is given by a set of m supply points (refineries) and a set of n demand points (depots). The transportation model is as follows:

$$\text{minimize} \sum_{j=1}^{n}\sum_{i=1}^{m} c_{ij}\, x_{ij} \qquad (objective\ function)$$

subject to

$$\sum_{j=1}^{n} x_{ij} \leq s_i \qquad (i = 1,2,\dots,m) \qquad (supply\ constraint)$$

$$\sum_{i=1}^{m} x_{ij} \leq d_j \qquad (j = 1,2,\dots,n) \qquad (demand\ constraint)$$

$$x_{ij} \geq 0. \qquad (i = 1,2,\dots,m; j = 1,2,\dots,n)$$

where:

i = number of refineries

j = number of depots

x_{ij} = amount of oil products transported from refinery i to depot j

c_{ij} = distance between refinery i and depot j

s_i = supply of oil products at refinery i

d_j = demand of oil products at depot j

In this model, the objective function minimizes the transportation distances of transporting oil products from refineries to depots. The supply constraint indicate that for each refinery, the amount of oil product that is transported to all depots should not exceed the amount of oil product that is available. Meanwhile, the demand constraint suggests that the total amount of oil products transported from all refineries must be at least as large as the amount demanded by that depot. The last constraint represent the non-negativity condition for the decision variables x_{ij}.

2.2 Data

We utilized the data on the Philippines' refined products import, refinery production, and total product demand per region for 2017 only. These were all provided to us by the Department of Energy. Furthermore, our data for this analysis will include only the oil products, gasoline and diesel, due to time constraints. The Philippines has two refineries namely, the Petron Bataan Refinery (PBR) and the Pilipinas Shell Corporation - Tabangao Refinery. Throughout the paper, we will refer to them as Petron and Shell, respectively. These two will serve as the supply points in our model. During 2017, Petron had a total of 32 oil depots (Petron, 2017). Figure 1 shows a geographic coverage of the company's oil depots. However, since we only need to consider those that hold up gas and diesel, we eliminated the depots which stores only LPG and the airport installations which stock up on aviation fuel primarily. This helped us trim down our data to 25 Petron depots. Similarly, Shell sends its oil products to a total of 27 depots (Pilipinas Shell, 2017). Figure 2 identifies the location of their depots. Among these 52 depots combined, there are 16 which stores oil products from both refineries. Thus, the total number of depots (demand points) considered in this study is 36.

Fig. 1. Geographic Coverage of Petron's Oil Depots (Source: https://www.petron.com/who-we-are/our-facilities/)

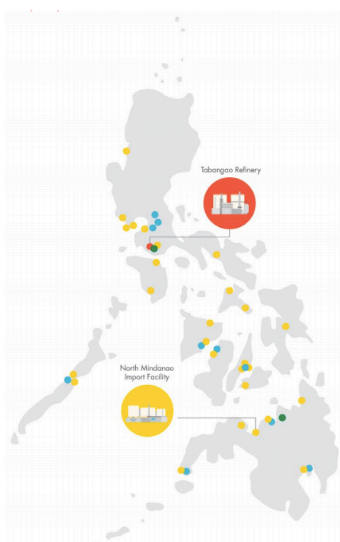

Fig. 2. Geographic Coverage of Shell's Oil Depots (Source:https://s07.staticshell.com/content/dam/royaldutchshell/documents/businessfunction/sustainability/asia-pacific/2017-pspc-asr-full-report.pdf)

The refinery production volume is comprised of only crude oil imported and refined by the local refiners Petron and Shell. Thus, to get the total number of oil products available for each refinery, we need to add the total number of imported gasoline and diesel with the locally refined gasoline and diesel. The total volume is shown in Table 1. Note that throughout the study, the measurement of oil products is in thousand barrels (KB). From here, we compute for the supply of oil products at each refinery. Petron shares 33% of the total gasoline and diesel volume, Shell with 25% and the remaining percentage divided among other oil companies. So, we obtain 33% of 103585.6 and 25% of 103585.6. Table 2 presents the total supply of gasoline and diesel combined for each refinery, Petron and Shell.

Table 1. Total Gasoline and Diesel Volume

Product	Volume
Gasoline	35,719.0
Diesel Oil	67,866.6
Total Output	103,585.6

Table 2. Petron and Shell's Total Gasoline and Diesel Supply

Refinery	Gas and Diesel Volume
Petron	34,183.25
Shell	25,896.40
Total	60,079.65

The data we obtained were the petroleum products demand for the regions reported to the different oil companies. However, we need the demand per depot. Since we were not able to acquire data on this due to Oil Deregulation Law, we used the data on regional demands. We identified the region to which each depot belongs. Given that Petron had a 27.62% share on the total demand and Shell with 19.98% (Rivera, 2018) we used the sum of these percentages (47.6%) to compute for the total demand of gasoline and diesel per region of both refineries. For instance, the gasoline demand for NCR amounts to 10,233.80 KB. We computed 47.6% of this and obtained 4,871.29 KB. We did the same for the rest of the amounts of gasoline and diesel per region. Then, we made an approximation of the demands of each depot. We considered those regions with more than one depot. We divided the total gasoline and diesel demand of Petron and Shell for that specific region by the number of depots belonging to that region. For example, there are two depots under NCR so we divided 13,761.74 KB by two. This gives us 6,880.7 KB. This will be the demand of oil products for the two depots in NCR. We did this for all the other regions with more than one depot. Furthermore, we excluded the regions CAR and ARMM which did not have any depot to avoid confusion in the interpretation of results.

Finally, the distance values were obtained from Google maps to determine the distance (in kilometers) between each refinery to each depot. Since the refinery of Petron is in Limay and the refinery of Shell is in Tabangao, we assumed a distance of 1km for Petron to Limay and Shell to Tabangao to differentiate it from those with 0 distance. A zero means that the refinery does not have a depot in that area.

3. RESULTS AND DISCUSSION

In this section, we briefly analyze how the distribution of oil products from the refineries to different regions of the Philippines must be transported. After which, we will discuss and analyze the results obtained after using Microsoft Excel's Solver. The results of the model are only estimates and cannot provide a definite solution since most of the values used in the model were approximations only.

From the data described in Section 2.2, we now formulate our transportation model. We will specify the values for each variables. We start with our objective function. Here, we only need the values of c_{ij} since the values of the decision variables x_{ij} are the ones to be determined. These are the distance values obtained from Google maps in kilometers between each refinery to each depot. Next, we identify the values of s_i. There are only two refineries. Hence, $i = 2$. The supply s_1 from Petron is 34,183.25 KB and the supply s_2 from Shell is equal to 25,896.40 KB. The demand per depot computed earlier are the values for d_j. As mentioned in Section 2.2, $j = 36$. After substitution, the Transportation Model was formulated.

With the use of Microsoft Excel Solver, we were able to determine the values of our decision variables. These represent the amount of oil products transported by Petron to each depot and Shell to each depot. Furthermore, we were able to see if the supply and demand constraints were satisfied. The Answer Report provided by Microsoft Excel enumerated all the results. Based from this report, all constraints are binding except for the first supply constraint. Non-binding constraints imply that there is either an extra resource left or the required supply was exceeded. In our case, the first constraint is not binding since the amount of oil products transported by Petron to all depots is equal to 24,762.08KB but its available supply is 34,183.25KB. Therefore, there is an extra 9,421.17KB of oil products. On the other hand, all of Shell's supply (25,896.4KB) was used. This means that to transport 50,658.48KB of oil products per year from the two refineries to the 36 depots, the minimum possible transportation distance is 26,183,605.38km.

We have observed from the results that in order to minimize distance, only one refinery should transport the amount of oil products demanded by a particular depot regardless if both Petron and Shell have depots in the same area. For instance, from the data provided, Petron is the only refinery that supplies Navotas. The results $x_{11} = 6{,}880.7$ and $x_{21} = 0$ imply that Petron will be the one to deliver to

Navotas and not Shell. However, our results suggest that even if both Petron and Shell have a depot located in the same area, only one refinery should transport the oil products to that depot. Consider Poro, both Petron and Shell can transport oil products to this depot. However, from our findings, $x_{13} = 1{,}793.04$ while $x_{23} = 0$. This means that delivery from Petron is sufficient. The demand of 1,793.04KB of oil products to Poro would be transported by Petron.

We now associate our results with the regional demands. We start with NCR. The depots in NCR are Navotas and North Harbour. From the results, Petron should transport 6,880.7KB to Navotas and 0 for Shell. Meanwhile, for North Harbour, Shell is responsible for transporting all of the depot's demand which is also 6,880.7KB. Therefore, we can conclude that for NCR, Petron and Shell should transport oil products equally. The same is true for Region 5 and the CARAGA region. For Regions 1, 2, 11, and 12, Petron is the only refinery to transport the needed oil products. Region 3 has three depots, however, the results indicate that two of which (Clark and Subic) must be supplied by Shell only. The remaining depot, Limay, will be Petron's responsibility. This means that majority of the oil products for Region 3 should be transported by Shell. Same analysis could be done for Region 4B, Region 7, and Region 10. On the other hand, Petron should transport more oil products than Shell for Region 4A and Region 8. Lastly, the oil products demanded by Region 6 and Region 9 should all come from Shell. From the results obtained, either Petron or Shell must supply to a particular depot but not both. If the data used were close to the actual ones, the optimal solution should be for Petron and Shell to accept the results obtained. However, in reality, there are depots which store up oil products from both refineries. If both refineries will adopt the results, then no depot will be supplied by two refineries.

4. CONCLUSIONS

We have shown in this paper that transportation models can be useful for oil companies. We were able to determine how much oil products Petron and Shell must transport to each depot to achieve the minimum transportation distance of 26183605.38 km. In real life, we know that cooperation between Petron and Shell is not possible given that they compete with one another in the oil industry. However, for this particular study only, our results suggest that Petron and Shell should cooperate with each other when it comes to transporting their oil products to a particular depot. The results we obtained show that even if a particular depot holds up oil from both refineries, there should only be one refinery to supply the said depot.

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