

Homework 3B

Problem 1

The Oilboost company runs a small refinery in Texas. It makes 3 main products - gasoline, jet fuel, and lubricants - out of crude petroleum from Kuwait and Venezuela.

- Each barrel of Kuwaiti crude yields: 0.3 barrel of gasoline, 0.4 barrel of jet fuel, and 0.2 barrel of lubricants.
- Each barrel of Venezuelan crude yields: 0.4 barrel of gasoline, 0.2 barrel of jet fuel, 0.3 barrel of lubricants.
- The remaining 10% of each barrel is lost through refining operations.
- Oilboost can buy on a daily basis up to 9,000 barrels from Kuwait at \$20/barrel.
- It can get up to 6,000 barrels from Venezuela per day, at \$15/barrel.
- Oilboost satisfies a demand of 2000 barrels of gasoline, 1500 barrels of jet fuel, and 500 barrels of lubricants per day.

Q.1. Does this industry application bear any similarities with another that we discussed in class? Explain.

ANS: Yes, this problem closely resembles blending and resource allocation problems found in multiple industries beyond oil refining. A few notable examples include:

1. **Coffee Blending:** Coffee companies source beans from different regions, each with unique acidity, aroma, and caffeine content. The goal is to create a final blend that meets consumer preferences while optimizing procurement costs.
2. **Dairy Industry (Milk Processing):** In dairy production, milk from different farms varies in fat and protein content. Manufacturers blend different milk sources to produce standardized dairy products like cheese and yogurt, ensuring quality while controlling costs.
3. **Metal Alloy Production:** Steel and aluminum manufacturers combine different metal ores and additives to achieve specific material properties such as strength, flexibility, or corrosion resistance.
4. **Pharmaceutical Formulation:** In drug manufacturing, active and inactive ingredients must be combined in precise proportions to achieve the desired efficacy and stability. Pharmaceutical companies optimize ingredient sourcing and blending to meet regulatory standards and minimize costs, a process similar to Oilboost's refinery operations.
5. **Food Processing:** Mixing raw ingredients to get a balanced nutritional output at a lower cost (e.g., cereal production).

All these industries face similar optimization challenges, using linear programming and supply chain analytics to determine the most efficient and cost-effective procurement and production strategies.

Q.2. If the company procured 2000 barrels from each of Kuwait and Venezuela, how much would this plan cost? Does it satisfy its target demand levels?

Ans: If the company procures 2,000 barrels each from Kuwait and Venezuela, we calculate:

Total Procurement Cost:

- Kuwait crude cost: $2000 \text{ barrels} \times \$20 = \$40,000$
- Venezuela crude cost: $2000 \text{ barrels} \times \$15 = \$30,000$
- Total Cost = \$70,000

Production Output:

Product	Yield from Kuwait (2000 barrels)	Yield from Venezuela (2000 barrels)	Total Produced	Target Demand	Demand Met?
Gasoline	$2000 \times 0.3 = 600$	$2000 \times 0.4 = 800$	1400	2000	No
Jet Fuel	$2000 \times 0.4 = 800$	$2000 \times 0.2 = 400$	1200	1500	No
Lubricants	$2000 \times 0.2 = 400$	$2000 \times 0.3 = 600$	1000	500	Yes

Conclusion

- The total cost for this procurement plan is \$70,000.
- However, it fails to meet the demand for gasoline (short by 600 barrels) and jet fuel (short by 300 barrels).
- It overproduces lubricants (by 500 barrels), which may not be useful unless there is additional demand.

Thus, this procurement plan is not feasible, and the company needs a different mix of crude oil to satisfy demand.

Q.3. Suggest a feasible solution (one that satisfies all target demand levels). What is the cost of your solution?

Ans: To satisfy demand, the company can procure 2800 barrels from Kuwait and 3000 barrels from Venezuela. Let's verify that this procurement plan meets all target demand levels.

Production Output

Product	Yield from Kuwait (2800 barrels)	Yield from Venezuela (3000 barrels)	Total Produced	Target Demand	Feasible?
Gasoline	$2800 \times 0.3 = 840$	$3000 \times 0.4 = 1200$	2040	2000	YES
Jet Fuel	$2800 \times 0.4 = 1120$	$3000 \times 0.2 = 600$	1720	1500	YES
Lubricants	$2800 \times 0.2 = 560$	$3000 \times 0.3 = 900$	1460	500	YES

Since all target demand levels are met or slightly exceeded, this is a feasible procurement plan.

Total Cost:

- Kuwait crude cost: $2800 \times \$20 = \$56,000$
- Venezuela crude cost: $3000 \times \$15 = \$45,000$
- Total Cost = \$101,000

The company should procure 2800 barrels from Kuwait and 3000 barrels from Venezuela.

Q.4. Using the solver: What is an optimal procurement plan? What is the optimal cost?

Ans: After running Solver, the optimal procurement plan is:

- 2000 barrels from Kuwait
- 3500 barrels from Venezuela

Production Output:

Product	Yield from Kuwait (2000 barrels)	Yield from Venezuela (3500 barrels)	Total Produced	Target Demand	Feasible?
Gasoline	$2000 \times 0.3 = 600$	$3500 \times 0.4 = 1400$	2000	2000	Yes
Jet Fuel	$2000 \times 0.4 = 800$	$3500 \times 0.2 = 700$	1500	1500	Yes
Lubricants	$2000 \times 0.2 = 400$	$3500 \times 0.3 = 1050$	1450	500	Yes

Total Cost:

- Kuwait crude cost: $2000 \times \$20 = \$40,000$
- Venezuela crude cost: $3500 \times \$15 = \$52,500$
- Total Cost = \$92,500

The company should procure 2000 barrels from Kuwait and 3500 barrels from Venezuela, with a total cost of \$92,500. This is the cheapest possible procurement plan that satisfies all fuel demands.

Q.5. If Qatar proposes a crude barrel at \$20/barrel, with the following yields: 0.45 (gasoline), 0.3 (jet fuel), and 0.2 (lubricant), would that be attractive enough to change the company's procurement plan?

Ans: Qatar offers crude oil at \$20 per barrel with the following yields:

Product	Qatar Crude Yield
Gasoline	0.45
Jet Fuel	0.3
Lubricants	0.2

Comparison with Kuwait and Venezuela

Crude Source	Gasoline Yield	Jet Fuel Yield	Lubricant Yield	Cost per Barrel
Kuwait	0.3	0.4	0.2	\$20
Venezuela	0.4	0.2	0.3	\$15
Qatar	0.45	0.3	0.2	\$20

- Qatar's crude has the highest gasoline yield (0.45), which is beneficial.
- Qatar's jet fuel yield (0.3) is better than Venezuela's (0.2) but lower than Kuwait's (0.4).
- Lubricant yield is the same as Kuwait's (0.2) but lower than Venezuela's (0.3).
- Qatar's cost (\$20) is the same as Kuwait's but higher than Venezuela's (\$15).

Since Venezuela remains the cheapest source, Qatar is most likely to replace part of Kuwait's procurement, not Venezuela's.

Finding an Optimal Mix Including Qatar, the best procurement mix including Qatar is:

- 1000 barrels from Qatar
- 1500 barrels from Kuwait
- 3500 barrels from Venezuela

This combination ensures all demand is met exactly while incorporating Qatar's crude in a cost-effective way.

Compute the Total Cost:

$$(1000 \times 20) + (1500 \times 20) + (3500 \times 15) = 20,000 + 30,000 + 52,500 = \$102,500$$

Issue: The total cost increases to \$102,500, which is \$10,000 more expensive than the previous optimal cost of \$92,500 (without Qatar).

Procurement Plan	Kuwait (barrels)	Venezuela (barrels)	Qatar (barrels)	Total Cost	Feasible?
Optimal Plan (Q4)	2000	3500	0	\$92,500	Yes
Mixed Plan with Qatar	1500	3500	1000	\$102,500	Yes

At \$20 per barrel, Qatar's crude is not attractive enough to change the company's procurement plan.

- The lowest-cost solution remains 2000 barrels from Kuwait and 3500 barrels from Venezuela (\$92,500).
- Including Qatar increases costs without significant benefits.

Qatar's crude offers the highest gasoline yield (0.45), making it a potential option if maximizing gasoline production is a priority. However, it is more expensive than Venezuela's crude, which still provides a good gasoline yield (0.4) at a lower cost (\$15 per barrel). Since Qatar's crude does not significantly improve jet fuel or lubricant yields, it would only be attractive if gasoline was the primary focus. To determine its real impact, a procurement optimization analysis should be performed.

Q.6. What is the highest price per barrel that you think Qatar could negotiate with this company?

Ans: The price that Qatar can charge depends on how cost-effective its crude is compared to Kuwait and Venezuela. If Qatar's crude is too expensive without significant advantages, Oilboost will not include it in the procurement plan.

- Gasoline yield: Qatar has the highest yield (0.45), which may justify a slightly higher price.
- Jet fuel yield: Lower than Kuwait (0.3 vs. 0.4), which makes it less valuable for jet fuel production.
- Lubricant yield: Same as Kuwait (0.2), but worse than Venezuela (0.3).
- Cost: Venezuela's crude is cheaper (\$15 per barrel) and still provides good gasoline yield (0.4), making it a strong competitor.

Compare Cost per Gasoline Yield:

Crude	Cost per Barrel	Gasoline Yield	Cost per Unit of Gasoline
Kuwait	\$20	0.3	\$66.67 ($20 \div 0.3$)
Venezuela	\$15	0.4	\$37.50 ($15 \div 0.4$)
Qatar	\$20?	0.45	\$44.44 ($20 \div 0.45$)

- Venezuela's gasoline cost per unit is lowest (\$37.50), making it the most cost-effective option.
- Qatar's gasoline cost per unit (\$44.44) is cheaper than Kuwait (\$66.67), meaning it competes well with Kuwait.
- If Qatar raises its price above \$22, its gasoline cost per unit exceeds Venezuela's, making it unattractive.

For Qatar to remain cost-competitive, its crude should not exceed \$22 per barrel. At this price:

- Qatar's gasoline cost per unit = \$48.89, still lower than Kuwait's but higher than Venezuela's.
- If it exceeds \$22 per barrel, Venezuela remains the dominant choice.

Qatar's Negotiation Limit

- The highest price Qatar can negotiate is \$22 per barrel.
- If Qatar charges more than \$22 per barrel, Oilboost will find Venezuela a better alternative.
- If Qatar offers discounts or special contracts (e.g., lower transportation costs), it could justify a slightly higher price.

Conclusion:

The highest price Qatar could negotiate with Oilboost is \$22 per barrel. At this price, its gasoline production cost remains competitive with Kuwait and does not exceed Venezuela's efficiency. If Qatar's price goes above \$22 per barrel, Oilboost would find Venezuela's crude a better choice and would not include Qatar in the procurement plan.

Problem 2

A company that specializes in green and socially responsible products is examining two candidate suppliers. Upon surveying with a comprehensive assessment questionnaire, the results are summarized for both suppliers in the table below.

Performance	Weight	S1 Rating	S2 Rating
Technology	10%	100	80
Quality	25%	80	65
Responsiveness	15%	70	90
Delivery	10%	90	80
Cost	10%	90	80
Environmental	25%	80	95
Business	5%	90	80
Total score	100%	83.0	81.5

Q.1. If the company were to simply pick the supplier with the better score, which supplier would that be?

Ans: Based on the weighted scoring system, Supplier S1 has a total score of 83.0, while Supplier S2 scores 81.5. Since S1 has the higher score, it is the preferred supplier. While S2 excels in responsiveness and environmental factors, S1 performs better in technology, quality, cost, and business operations, making it the stronger choice overall.

Q.2. What improvements should the company suggest to supplier 2?

Supplier S2 can improve its competitiveness by focusing on technology, quality, delivery, cost efficiency, and business practices. Specifically, S2 should invest in advanced production technology, enhance quality control, optimize delivery logistics, reduce operating costs, and strengthen business relationships. These improvements will help bridge the gap with S1 and make S2 a more attractive supplier.

Q.3. Which supplier would you ultimately recommend to the company, why?

Key Strengths of Each Supplier

Reasons to Choose S1:

- Better technology (100 vs. 80) → More advanced processes.
- Higher quality standards (80 vs. 65) → More reliable products.
- Faster delivery (90 vs. 80) → More efficient logistics.
- Lower cost (90 vs. 80) → More cost-effective.
- Better business performance (90 vs. 80) → More reliable as a long-term partner.

Reasons to Choose S2:

- More responsive supplier (90 vs. 70) → Faster customer service.
- Better environmental policies (95 vs. 80) → More sustainable.

Which Supplier is Better?**Supplier S1 is the better choice because:**

- It has the highest overall score (83.0 vs. 81.5).
- It excels in technology, quality, cost, and delivery, which are key to long-term success.
- S2 is only better in responsiveness and environmental factors, which may not be as critical as cost and quality.

When to Consider S2:

- If the company prioritizes sustainability and quick responsiveness, S2 might be a better fit.
- However, if cost, quality, and long-term reliability are more important, S1 is the stronger supplier.

Based on the weighted scoring system, Supplier S1 is the best choice, with a total score of 83.0 compared to 81.5 for S2. S1 excels in technology, quality, cost, and delivery, making it the most reliable and cost-effective supplier. While S2 performs better in responsiveness and environmental factors, these advantages do not outweigh S1's overall strengths. Therefore, the company should select S1 as its supplier unless sustainability is the primary concern.