MGMT: 572_01
Adv. Modeling for Decision Making
Group Case

ICEBERGS FOR KUWAIT

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Part I: Understanding the problem (Do this part before you read my detailed instructions for Part II below! Use case write-up format only for Part II and attach answers to part I separatly.)

1. Explore the mess by answering the following questions:
2. *What do we know?*
   A: Our task is to evaluate the most cost-effective option to transport ice from the South Pole to be converted into water. We know how much water we will be able to harvest per cubic meter of ice. We are aware we must rent a special towing vessel to transport the ice, all of which come in different sizes at different rental rates. Our fuel efficiency will be different depending on what speed the driver travels. Our speed also effects how long it will take to transport the ice, and we know the rate at which the ice will melt each day, depending on how far the driver is from the South Pole at that point. As the ice melts, we lose the amount of viable water. We will find the best option by evaluating all these factors.
3. *What can we assume?*
   A: We will assume that there will not be any variation in the rental price of the towing vessels or fuel. The amount transported in the trip is equal to the maximum volume the towing vessel can carry. We will also assume speed and fuel economy does not vary during the trip, and that there will be no variation or detours during transport. We will evaluate this for three given speeds. We are assuming the distance to the point to collect the ice is always the same from the final destination. Lastly, we will assume that no matter the conditions, the ice will always melt at the exact same rate per day depending on the distance from the South Pole in 1000 km intervals after the diver is more than 4000 km away from the beginning point in the trip. We will also assume the cost for desalinating for salt water, the gas and electricity are not o

4. *What could the results look like?*
   A: Our results will reveal the most cost-effective way to transport ice and how much water we will be able to harvest as a result. This solution will include the optimal size of the travel vessel and the most efficient speed to travel for fuel efficiency and maximum product.

5. *What can we ask the client?*
   A: While our model will reveal the most cost-effective option, we must be sure to ask the client details about their budget, time frame, and expected minimum amount of water per excursion. While we may find the cheapest option, these factors could influence the decisions of the client because they may have a stricter time table for delivery of product than our original solution, or they may require more water per trip.

6. *Formulate one or more problem statements.*
   A:

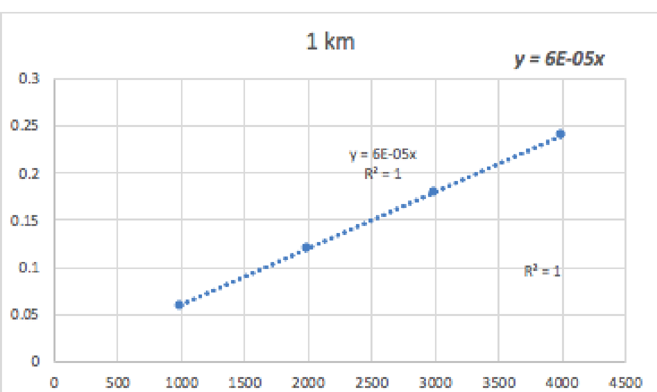
- What would be the optimum speed to minimize fuel cost but optimize the amount of ice we are left with once the vessel reaches the destination?
- What size vessel should we use to transport the ice?
- What is the largest amount of water we could feasibly transport per trip?

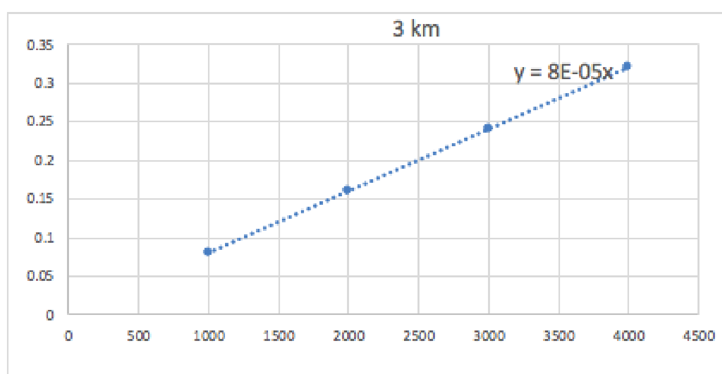
7. *For one of the problem statements you developed in (1e) above, answer the following questions:*
   A:1e: What would be the optimum speed to minimize fuel cost but optimize the amount of ice we are left with once the vessel reaches the destination?
8. What are the inputs, decisions, and output?
   A:Input: melting rate by distance traveled, total days traveled, cost of fuel based on speed, volume of ice transported
   Decision: Optimal speed
   Output: Maximum volume of ice transported
9. In what ways could we simplify the problem?
   A:Break down melting rate by m/day and fuel cost by cost/km traveled.

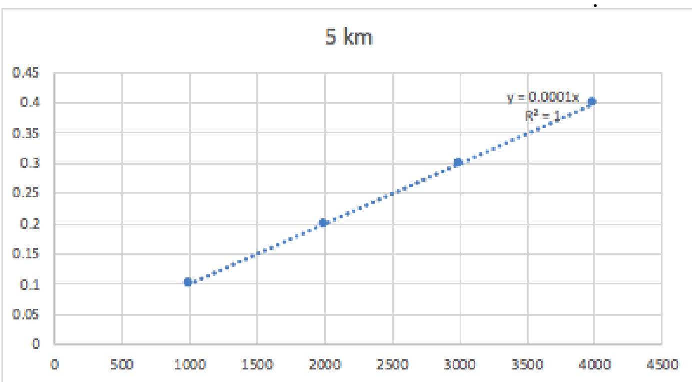
10. What modules will we need to build?
    A:Calculate distance traveled for a given speed and then use the fuel cost for given speed. Based on days traveled and distance from the South Pole, calculate the ice left. Evaluate figures for all 3 given speeds.

11. What are the parameters of the problem?
    A:Fuel cost, melting rate by distance from the South Pole, rental rate of towing vessel, volume of towing vessel, speed traveled.

12. What are the key relationships in the problem? Draw their graphs
    ***A:** Melting Rates and Distance.*

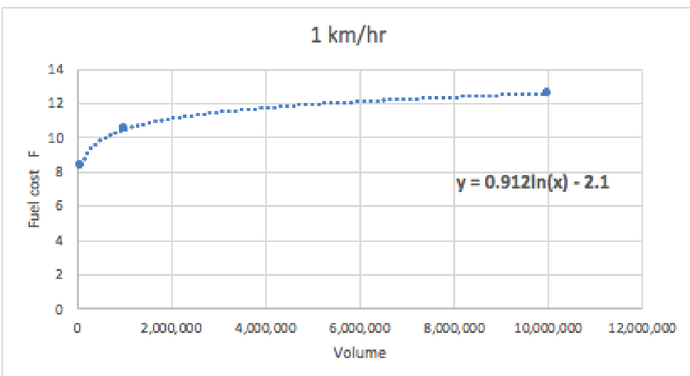


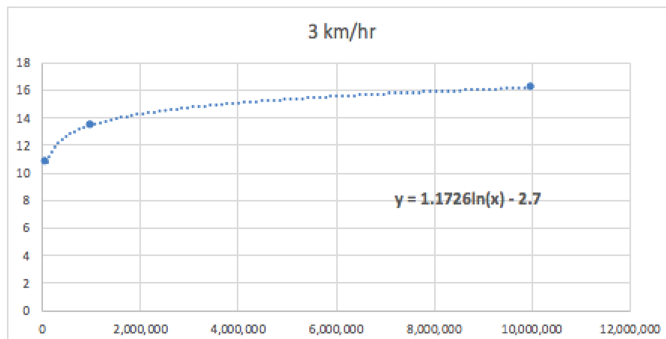


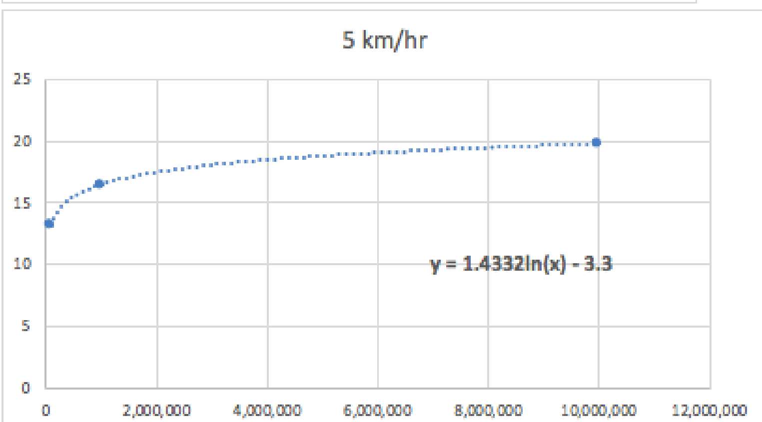


Melting rate increases with distance from the South Pole. Melting rate is accelerated at a higher speed, but a higher speed will take less days to complete.

Fuel costs and volume



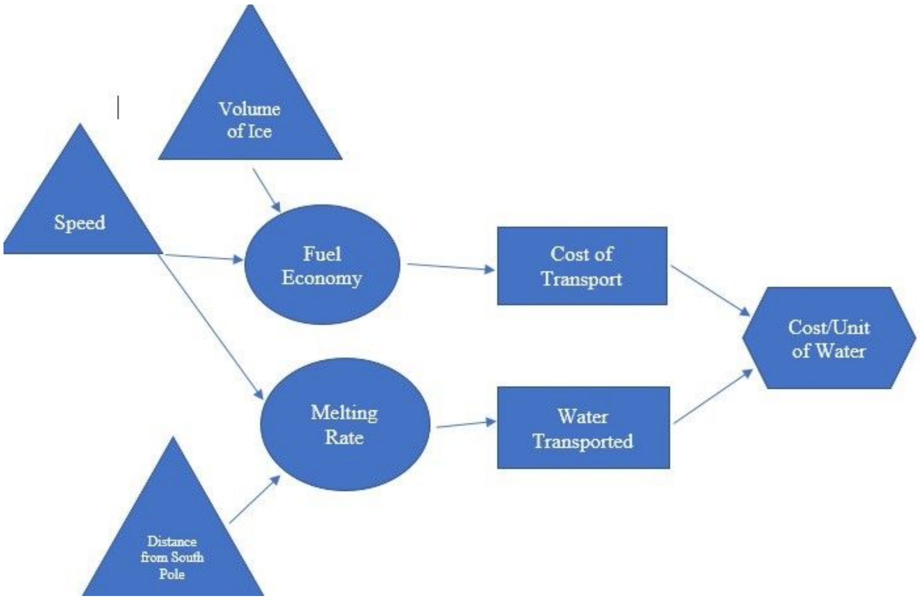




Fuel Cost depends on the speed traveled and the size of the load of ice we are transporting. A slower speed gives us a better fuel economy. The bigger the load, the worse the fuel economy.

5.

6. For one of the problem statements you developed in (1e) above, draw an influence chart



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PROTOTYPE II

Questions for part II

A. Develop a spreadsheet that takes as input the speed and the volume of the iceberg at the origin. It must calculate the volume of the iceberg at the destination and the profit as the output.

B. Since the speeds are restricted to 1, 3, and 5 km/hr., the minimum and maximum days for the journey is 80 and 400. Your spreadsheet should calculate the Distance, Melting Rate, Radius, Volume, and Fuel Cost for each day up to 400 days, irrespective of the speed, so that you do not create separate tables for each speed. It is possible that for some combinations the iceberg will melt fully before the ship reaches the destination; your spreadsheet should allow for such scenarios.

C. Develop a two-way Data Table for the profit attained, with volume of iceberg at origin (500,000 to 10,000,000 in steps of 500,000) along the column and the speed (1, 3, and 5) along the row.

The fact that you have to create on two-way Data Table with speed along the row and initial volume along th column ensures that you must have one set of calculations with 400 days that captures the settings for all speed (e.g., travel will end in 80 days if the speed is 5 km/hr). You should not create a separate set of calculations for each speed; you will lose points if you do it this way. If you cannot think of any way to put them together, only then do with separate tables. Refer to the Retirement Planning case where we used one set of calculations to model any retirement age.

D. If the Large ship travels at 5 km/hr, what is the volume of the iceberg at the origin so that it will breakeven?

8,413,565 m^3

(reference - Excel M49:Q70 | or the lower 2-way data table)

Executive Summary

Case Briefing:

Kuwait is a middle-eastern country with a population of just over four million. Its government is tasked with supplying a sufficient amount of water to all of its inhabitants in the most cost-effective way possible. There are two options: (a) gather saltwater from a nearby body of water and desalinate it. (b) Travel to the north pole and take back frozen glaciers that will melt into freshwater.

Analysis:

In order to determine which option is more cost-effective, we first need to maximize profit for option (b) by controlling a set of factors. These include: Size (volume) of the glacial deposit, size of the ship transporting the glacier, fueling costs, and the speed at which the driver travels with the glacial mass on the way back. The larger the glacier brought back, the more water can be sold (however, there a maximum limit for each ship size. Larger ships can carry more ice but comes at the expense of higher rental costs. Lower speeds result in a greater fuel economy but experience a faster melting rate. See appendix, figure II.d and II.d.f. The sources of the data can be seen in figure II.e and Figure II.f in appendix.

In order to control all of these factors, we had to create a massive, amendable table that tracked daily distance traveled, days, melting rate, radius/volume, fuel economy, and total fuel cost. These factors are all interchangeable by a series of formulas (appendix: figure II.d). The two input variables, speed of the ship traveled and size of the iceberg, changed each entry.

Recommendation:

In order to maximize total profit, it is best to gather ice from glacial deposits by renting a large ship, having it carry the maximum 10 million m^3 worth of ice. The ship will travel 5 mph on its way back. See appendix, figure II.g. Also, See appendix, figure II.a and figure II.a.f. Also, use to see preferred methods and resulting profits for varying speeds and volume of the iceberg considering given assumptions see appendix, figure II.b, figure II.c. However, it should be noted that recommendation is based on the assumption that there is high demand (over 500,000 m^3 worth). The problem doesn't specify a time period over which the demand must be satisfied. If the demand over time period x is lower than this benchmark, option (b) results in negative profit, making option (a) more cost-effective.

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APPENDIX

Figure II.a

	L	M
5	**Calculation Table**	
6	no. of days	134.00
7	Volume of the iceberg	5,142.52
8	Amount of Water	4,371.14
9	**Calculations**	
10	Revenue	437.11
11	Total rent	107,200.00
12	Total gas price	115,072.69
13	Cost of Desailiation fresh water	-
14	Total Expense	(222,272.69)
15	Profit	(221,835.57)
16	Cost of Desailiation	(437.11)
17		
18	Method preferred	Seasalt

Figure II.a.f

	L	M
5	**Calculation Table**	
6	no. of days	=INDEX($A$25:$A$424,MATCH(0,$C$25:$C$424,0),1)
7	Volume of the iceberg	=INDEX($F$25:$F$424,MATCH(0,$C$25:$C$424,0),1)
8	Amount of Water	=$M$7*$G$3
9	**Calculations**	
10	Revenue	=$M$8*$G$7
11	Total rent	=$M$6*$C$5
12	Total gas price	=SUM(H26:H424)
13	Cost of Desailiation fresh water	=$M$8*0
14	Total Expense	=-SUM(M11:M13)
15	Profit	=M10+M14
16	Cost of Desailiation	=-$M$8*$G$4
17		
18	Method preferred	=IF(M15>=0,"Iceberg",IF(M15>=M16,"Iceberg","Seasalt"))

Figure II.b

	S	T	U	V	W
19			**Method preferred**		
20				**Speed(km/hr)**	
21		Seasalt	1	3	5
22	**Volume of the iceberg (m^3)**	500,000	Seasalt	Seasalt	Seasalt
23		1,000,000	Seasalt	Seasalt	Seasalt
24		1,500,000	Seasalt	Seasalt	Seasalt
25		2,000,000	Seasalt	Seasalt	Seasalt
26		2,500,000	Seasalt	Seasalt	Seasalt
27		3,000,000	Seasalt	Seasalt	Seasalt
28		3,500,000	Seasalt	Seasalt	Seasalt
29		4,000,000	Seasalt	Seasalt	Seasalt
30		4,500,000	Seasalt	Seasalt	Seasalt
31		5,000,000	Seasalt	Seasalt	Seasalt
32		5,500,000	Seasalt	Seasalt	Iceberg
33		6,000,000	Seasalt	Seasalt	Iceberg
34		6,500,000	Seasalt	Seasalt	Iceberg
35		7,000,000	Seasalt	Seasalt	Iceberg
36		7,500,000	Seasalt	Seasalt	Iceberg
37		8,000,000	Seasalt	Iceberg	Iceberg
38		8,500,000	Seasalt	Iceberg	Iceberg
39		9,000,000	Seasalt	Iceberg	Iceberg
40		9,500,000	Seasalt	Iceberg	Iceberg
41		10,000,000	Seasalt	Iceberg	Iceberg

Figure II.c

	M	N	O	P	Q
20			**Two way data table**		
21				**Speed (km/hr)**	
22		(221,835.57)	1	3	5
23	**Volume of the Iceberg (m^3)**	500,000	-$386,214.45	-$208,527.92	-$195,375.71
24		1,000,000	-$393,594.83	-$221,835.57	-$204,575.17
25		1,500,000	-$398,584.09	-$226,657.27	-$203,918.32
26		2,000,000	-$402,456.31	-$227,103.71	-$198,555.13
27		2,500,000	-$405,663.22	-$224,748.20	-$190,202.12
28		3,000,000	-$408,422.21	-$220,330.57	-$179,701.21
29		3,500,000	-$410,855.80	-$214,286.73	-$167,545.67
30		4,000,000	-$413,042.49	-$206,905.10	-$154,056.50
31		4,500,000	-$415,031.99	-$198,390.78	-$139,457.78
32		5,000,000	-$416,862.40	-$188,896.99	-$123,913.96
33		5,500,000	-$418,560.52	-$178,542.50	-$107,550.35
34		6,000,000	-$420,145.61	-$167,421.91	-$90,465.35
35		6,500,000	-$421,634.54	-$155,612.32	-$72,738.01
36		7,000,000	-$423,020.68	-$143,177.70	-$54,433.14
37		7,500,000	-$424,272.33	-$130,171.93	-$35,604.70
38		8,000,000	-$425,305.86	-$116,640.94	-$16,298.26
39		8,500,000	-$426,078.18	-$102,624.39	$3,447.25
40		9,000,000	-$426,604.70	-$88,156.77	$23,598.21
41		9,500,000	-$426,893.18	-$73,268.38	$44,125.34
42		10,000,000	-$426,948.43	-$57,986.02	$65,002.94
43			shows max profit for each speed		
44			shows max profit for each volume		
45		$65,002.94	shows max profit for overall table		

Figure II.d

	A	B	C	D	E	F
23						
24	**Days**	**Distance left from kuwait(km**	**Distance left after day (km)**	**Melting rate**	**Radius (m)**	**Volume (m3)**
25	1	9600	9528	0	62.04	1,000,000
26	2	9528	9456	0.00576	62.03	999,721
27	3	9456	9384	0.01152	62.02	999,165
28	4	9384	9312	0.01728	62.00	998,330
29	5	9312	9240	0.02304	61.98	997,217

Calculations for each column shown below:

Melting Rate:

=IF((B25-B26)<$G$6,VLOOKUP($I$11,$B$17:$C$19,2,TRUE)*($B$25-B26),VLOOKUP($I$11,$B$17:$F$19,5,TRUE)*(B25-B26))

Radius: =IF(B25=0,0,((3*F25)/(4*PI()))^(1/3))

Volume=Initial Volume; =IF(B27=0,F26,E27^3*PI()*4/3)

Fuel Cost per km: 0;

=IF(B26=0,0,VLOOKUP($I$11,$B$10:$D$12,2,0)*LN(IF(F26<=1000,1000,F26))+VLOOKUP($I$11,$B$10:$D$12,3,0))

Total fuel cost for the day:0;

=IF(B26=0,0,VLOOKUP($I$11,$B$10:$D$12,2,0)*LN(IF(F26<=1000,1000,F26))+VLOOKUP($I$11,$B$10:$D$12,3,0))

Figure II.e

	B	C	D
4	*Large Ship*		
5	Daily rental (£)	800	
6	Maximum load (cu. mete	1,000,000	
7			
8	*Fuel Costs (£/km)*	Current Volume (cu. meter)	
9	Speed (km/hr)	Slope	Intercept
10	1	0.912	-2.1
11	3	1.1726	-2.7
12	5	1.4332	-3.3
13			
14			
15	Melting Rate		
16	Speed (km/hr)	Slope	Intercept
17	1	0.00006	0
18	3	0.00008	0
19	5	0.0001	0

Figure II.f

	F	G	H	I
2	**Data**			
3	1 cubic meter of ice	0.85	cubic meter of water	
4	Cost of desalianiting iceberg	0.10	cubic meter	
5	Maximum distance	9600	km	
6	Melting rate if distance(km)	4000	0.24	
7	Price for water	0.10		
8				
9				
10			Input	
11			Speed (km/hr)	3
12			Volume of the ice berg	1,000,000
13				
14				

Figure II.g