

**ITY512E OPERATIONS RESEARCH
FINAL EXAM**

Özgür Kabak, Ph.D

March 28, 2019

- Please submit your answers to Ozgur Kabak (Room number: A311) on April 4, 2019 at 17:00.
- Only hard copy (printout) or handwritten output submission is allowed (except Open Solver files).
- Please solve the problems in Questions 1 and 2 using OpenSolver in different sheets of a single excel file. Send the excel file via e-mail to ozgurkabak@gmail.com.
- Model formulations and interpretations related to Questions 1 and 2 should be included in the hardcopy submission.
- You may ask your questions regarding the exam via ozgurkabak@gmail.com.
- This is an individual exam! Do not plagiarize your peers' answers or others' thoughts. The work you hand in is to be your own.

QUESTIONS

1. (50 Points) The ATK Oil Company controls five oil fields. The maximum production levels of the fields are given in Table 1. For instance, Field 1 can produce up to 45 million barrels of oil per day. In order to operate a field, a startup cost should be paid as a fixed cost. The startup costs of the fields are presented in Table 2. The company has \$160 million available cash for starting the operations in the fields. There is also cost of extracting and refining oil in the fields as variable cost per a barrel of oil. The variable costs are given in Table 1. For example, at Field 1, it costs \$4 to extract and refine one barrel of oil. ATK sells oil to three countries: US, Canada and China. The shipping cost per barrel is shown in Table 2. Each day, US is willing to buy up to 65 million barrels (at \$6.6 per barrel), Canada is willing to buy 75 million barrels (at \$7.4 per barrel) and China is willing to buy up to 50 million barrels (at \$7.1 per barrel). According to the company's policy Field 1 and Field 2 cannot be operated at the same time.

Table 1. Information for the fields

	Production level (million barrels)	Startup cost (million \$)	Extracting and refining cost (\$/barrel)
Field 1	45	70	4.0
Field 2	85	50	3.0
Field 3	30	40	3.5
Field 4	90	65	2.7
Field 5	70	80	4.5

Table 2. Information for shipping cost

From (\$)	To (\$)		
	US	Canada	China
Field 1	0.9	1.5	2.1
Field 2	1.5	2.5	1.6
Field 3	2.1	1.9	0.9
Field 4	3.3	2.1	2.9
Field 5	0.8	1.5	2.0

- a. Formulate an Integer program (IP) for maximizing the profit of ATK.
- b. Solve IP formulated in part (a) using OpenSolver. (Please send the excel file to ozgurkabak@gmail.com)
- c. Interpret the solution.

2. AEK-Pizza wants to determine the locations of franchise partnerships in Şişli to be the recognized leader in pizza delivery. There are 10 sub-districts in Şişli and the populations of sub-districts are given in Table.1. AEK-Pizza wants to group these sub-districts to construct 4 main districts for their franchisees. The geographical center of franchisee will be one of the centers of sub-districts in each district. Each sub-district should be assigned one of the franchises to deliver pizza for people in these sub-districts. The workload of each franchisee should be balanced so that the working conditions of each franchisee would be similar to each other. In order to balance the workload of a franchisee, total population of the sub-districts assigned to the franchisee should be between 15,000 and 20,000. 3 franchise partnerships have already built in Harbiye, Mecidiyeköy and Fulya. AEK-Pizza can close existing franchisees and open new one. However, opening a new franchisees cost ₺50.000 and closing an existing one costs ₺25.000. AEK has ₺150.000 available for opening and closing franchises. AEK-Pizza wants to minimize total the distance between the sub-districts and centers of franchisee. In Table 2, the distance between the centers of each sub-districts are given.

Table 1: Population sub-districts

ID	1	2	3	4	5	6	7	8	9	10
Sub-Districts	Harbiye	Mecidiyeköy	Fulya	Feriköy	Kuştepe	Esentepe	İnönü	Merkez	Halaskargazi	İzzetpaşa
Population	11256	10769	10485	10144	9223	8732	5764	3561	2769	2514

Table 2: Distance between sub-districts

	1	2	3	4	5	6	7	8	9	10
1	0	1701	2161	1876	2394	3514	1101	2790	1529	1938
2	1701	0	2813	483	734	1864	1625	1249	2072	2828
3	2161	2813	0	2558	3110	3880	1263	3110	757	392
4	1876	483	2558	0	591	1650	1489	917	1856	2634
5	2394	734	3110	591	0	1133	2079	577	2430	3209
6	3514	1864	3880	1650	1133	0	3053	793	3303	4061
7	1101	1625	1263	1489	2079	3053	0	2263	514	1210
8	2790	1249	3110	917	577	793	2263	0	2513	3276
9	1529	2072	757	1856	2430	3303	514	2513	0	779
10	1938	2828	392	2634	3209	4061	1210	3276	779	0

- Formulate an Integer program for the given problem.
- Solve IP formulated in part (a) using OpenSolver. (Please send the excel file to ozgurkabak@gmail.com)
- Interpret the solution.
(hint: Define y_i as an binary integer variable to indicate if the region center i is chosen as franchise center. Define x_{ij} as an binary integer variable to indicate if the sub-district j is assigned to the franchise i .)