

PROJECT
Assigning Sales representatives to a territory

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Note: The information regarding the pharmaceutical sector and the company are accurate as collected from various cited sources. The problem contains all the characteristics of the underlying problem faced by Pfizer. It has been simplified for the purpose of keeping the model size manageable as a case study and the data has been altered for reasons of confidentiality. The authors created the case material based on past collaboration with Pfizer. All the characters introduced throughout the case are fictional.

Merih Caner, the vice president of logistics, has been thinking that it is about time to renew the territories of the SRs countrywide. It has been several years since the last update and the demand structure for pharmaceutical products has changed substantially. He knows that it is important to keep the total travel distance short and it is not a good idea to make drastic changes in the existing territories. He also knows that maintaining a somewhat balanced workload among the SRs is important. They have always considered these issues when updating the territories and he is confident that they are still crucial. What he is not so sure about is whether or not they could adopt a more structured approach than trial and error to come up with satisfactory territories. He calls his assistant, Serdar Altan, to a meeting to discuss these issues.

1 Company Background: Pfizer Global

Pfizer Inc, founded in 1849 in Brooklyn-NY, aims to help people and animals live longer and healthier lives. To attain this goal, the company “discovers and develops breakthrough medicines; provides information on prevention, wellness, and treatment; and carries out high-quality manufacturing of medicines.” Pfizer employs approximately 81,800 people worldwide. The company operates in over 150 countries, reflecting its influence and scale in the global pharmaceutical industry. More precisely, Pfizer has employees in 60 countries, and the medicines developed and manufactured by the company are marketed/sold in more than 150 countries.

Pfizer’s 2023 revenue is estimated at \$58 billion to \$61 billion. That’s down from the prior year, primarily due to lower revenue from COVID-19 products, such as the Comirnaty vaccine and the Paxlovid antiviral treatment. However, non-COVID products posted 6% to 8% operating growth driven by several new launches and strategic acquisitions.

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Pfizer invested approximately \$10.7 billion in research and development (R&D) in 2023. This significant investment highlights the company’s commitment to advancing its pipeline of medicines and vaccines, including those beyond its COVID-19 portfolio. Additionally, Pfizer pursued strategic acquisitions, including the \$43 billion purchase of Seagen, aimed at bolstering its cancer treatment capabilities.

2 The Pharmaceutical Sector in Turkey

The emergence of pharmaceutical companies in Turkey dates back to the early nineteen hundreds. Large-scale manufacturing started around 1923, and the manufacturing of pharmaceuticals shifted from drug-stores to laboratories and small plants after 1928. Especially in the last 40 years, investments by foreign companies have increased substantially because of Turkey’s proximity to the European market and its qualified workforce.

The pharmaceutical industry in Turkey holds a significant position as an emerging market globally. It is ranked as the 16th largest pharmaceutical market globally and the 6th largest in Europe, reflecting its growing influence. The Turkish pharmaceutical market is characterized by its focus on generic drugs and local production. Still, it also serves as a regional hub for multinational companies (Pfizer, but also Sanofi, and Bayer. These companies often base their regional operations and R&D centers in Turkey, taking advantage of the country’s strategic geographic location.

The annual sales of top pharmaceutical companies in Turkey, including Pfizer, indicate a highly competitive market. In 2023, Abdi İbrahim led with significant revenue, followed by global players like Novartis and Pfizer. Pfizer’s sales in Turkey were estimated at approximately \$250 million in 2023, contributing to the company’s robust presence in the region. Overall, the Turkish pharmaceutical market reached around \$21.3 billion in 2023, showing steady growth. Figure 1 shows annual sales in 2022 and 2023 of the top pharmaceutical companies in Turkey.

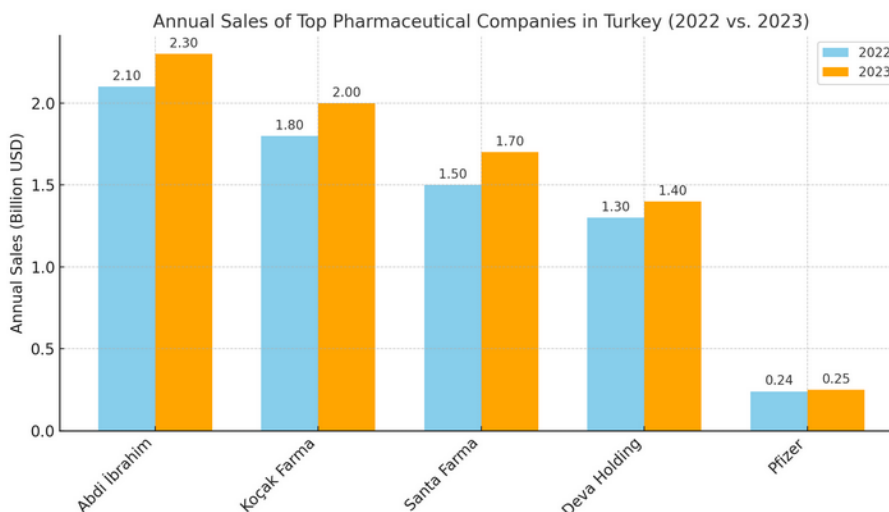


Figure 1: annual sales in 2022 and 2023 of the top pharmaceutical companies in Turkey

3 Pfizer Turkey

As a part of Pfizer’s global expansion, Pfizer Turkey was founded in Istanbul in 1957. Despite initially having a small plant designed to manufacture a few products, Pfizer Turkey expanded its capacity gradually to satisfy the increasing demand. In 2023, Turkish pharmaceutical exports reached approximately \$2.23 billion, showcasing the sector’s growth potential and strategic importance within the national economy. Pfizer Turkey had 7% of Turkey’s pharmaceutical exports. According to the activity reports of 2024, the exports are increasing. Together with the imported products, Pfizer Turkey supplied 121 different products with 356 different presentations, amounting to 144 million boxes of supply volume.

4 Assigning Regions to Sales Representatives

Pfizer Turkey’s immediate customers are medical doctors (MDs) since a vast majority of its products are prescription drugs. Pharmaceutical sales representatives (SRs) of Pfizer regularly visit MDs. They provide information such as indications and adverse effects of drugs, supply samples, discuss and obtain feedback, and keep a close relationship with the MDs. There is strong evidence that this strategy helps the sales of Pfizer’s products.

Each SR is assigned a working region, called a “sales territory” or simply a “territory,” which is a list of MDs to be visited by him/her. Territories are formed by combining smaller geographical units, called “bricks.” A brick is the smallest geographical region for which relevant information, such as sales data, number of MDs, and MD profiles is available. Based on this information, Pfizer calculates an index value for each brick. The index value is a composite figure developed at Pfizer that captures various factors to show the workload of the brick in terms of the number of SRs required to work there. Typically, the index value is less than one and a territory is composed of several bricks.

Each SR is located in an office at a certain brick. This brick is considered as the center of his/her territory. The sum of index values of the bricks of an SR corresponds to his/her total workload and it should be approximately 1. Naturally, it is not possible to achieve a workload of exactly 1 unit to each SR as partial assignments of bricks to multiple SRs are undesirable.

In order to maintain overall travel efficiency, it is necessary to minimize the total distance traveled by the SRs. The total distance traveled by an SR (within his/her territory) can be measured by the sum of distances between the office (i.e., the center brick) and the (centers of the) bricks assigned to it as demonstrated in Figure 2.



Figure 2: Territory of an SR

Due to the dynamic structure of the market, i.e., changes in number of customers or changes in the sales of products in each brick, the index values change over time. Hence, sales territories should be periodically reconstructed in order to maintain workload balance between territories. Another concern, minimizing disruption, emerges at this point due to changing some of the existing territories and reconstructing new ones. Disruption is defined as the inclusion of new bricks in the territories of SRs. Disruption is undesirable as some of the established relationships between SRs and MDs cannot be utilized anymore.

Serdar Altan has an M.B.A. degree and Merih Caner has a lot of confidence in his skills. Merih asked him to bring Sevil Korkmaz along to the meeting as well. Sevil has an M.S. degree in Industrial Engineering. Serdar and Sevil recently completed a production-planning project and earned a good reputation in the company despite their youth. Merih thinks that this is a good time to get them involved and start the reorganization study of the territories.

Merih: You know the territories of our SRs were determined several years ago. Things have changed quite a lot since then and we should be able to improve this. The variation between the workloads of SRs seems to have increased a lot and I hear that some SRs are already complaining. I am not sure we are doing the best we can do in terms of total travel distance either. We should be able to measure and improve these as much as possible without creating too much disruption. I believe the timing is just right to make some changes. In the past, we have done this with trial and error but I have always felt that there should be a better way.

Sevil: I have also been thinking about this. It resembles a problem we have seen in our M.S. program. We need to assign each brick to an SR and each SR has a work capacity. We can try to define a mathematical model.

Serdar: Yes, I am also familiar with such models. I am not sure what our objective will be though. We have different concerns. We need to consider the travel distance and make sure not to reassign too many bricks.

Merih: You also need to make sure that there is a reasonable balance of workload among SRs. Otherwise, they will all blame us. But it seems you have some ideas, why don't you work on those a bit. Let us schedule another meeting, would two days be enough to develop those ideas?

Serdar: We will do our best.

Sevil and Serdar were a bit worried after the meeting. Merih always expects quick results. On the other hand, he has a good intuition on these matters and they knew that he would be very supportive in case they had difficulties. They first collected the documents and studied the current situation. There were 1000 bricks and 196 SRs nationwide. Looking at the overall workload and the trends, they knew that there was no need for new SRs in the near future. They quickly realized that the model would have too many binary variables to be of practical value. They remembered that large integer models would cause computational difficulties and specialized software exploiting special structures could be necessary. They started further analyzing the current system on the map.

Serdar: Doesn't this problem have a special structure that would give integer results when solved as a linear program? We should be able to solve the large problem without difficulty then.

Sevil: I also thought about it and looked it up. Our problem resembles the "assignment problem" which has the structure you mentioned. But I think our different objectives will destroy this structure.

In order to see the trade-offs between the objectives and to obtain different solutions, we will have to introduce additional constraints to the problem. My experience is that such constraints usually cause problems. In any case, once we set up an example problem, we can solve the LP relaxation and see what happens.

Serdar: Okay. Even if it does not give an integer solution, I find the LP relaxation very useful. It yields a lot of insight.

Sevil: I agree. To reduce the problem size, we may perhaps use the geographical districts. It seems that there are very few common aspects between districts. The problem seems to be naturally separable.

Serdar: Great! Then we would need to solve many small problems. If there are neighboring districts for which this separation is not so clear, we can combine and solve them together.

They decided to take an example district and try to get some results before the meeting with Merih. They chose a typical district of Istanbul having 4 SRs and 22 bricks. Table 1 shows the current structure of the sales territories, i.e., the center brick of each SR and the bricks assigned to him/her. Tables 2 and 3 provide new index values of the bricks and the travel distances between these bricks and SR offices (center bricks), respectively. Note that the index values over all bricks sum up to 4; this means that a standard full-time job corresponds to a workload equal to 1. Figure 3 shows the brick locations.

SR	Center brick	Assigned bricks
1	4	4, 5, 6, 7, 8, 15
2	14	10, 11, 12, 13, 14
3	16	9, 16, 17, 18
4	22	1, 2, 3, 19, 20, 21, 22

Table 1: Current Structure of Sales Territories

brick	index value	brick	index value
1	0.1609	12	0.0828
2	0.1164	13	0.0975
3	0.1026	14	0.8177
4	0.1516	15	0.4115
5	0.0939	16	0.3795
6	0.1320	17	0.0710
7	0.0687	18	0.0427
8	0.0930	19	0.1043
9	0.2116	20	0.0997
10	0.2529	21	0.1698
11	0.0868	22	0.2531

Table 2: Index values (workload) of bricks

Sevil and Serdar decided to treat the workload balance objective as a constraint. They also decided to try to restrict the workload of each SR to the interval $[0.8, 1.2]$ because they believed this level of variation would be acceptable.

brick	SR			
	1	2	3	4
1	16.16	24.08	24.32	21.12
2	19.00	26.47	27.24	17.33
3	25.29	32.49	33.42	12.25
4	0.00	7.93	8.31	36.12
5	3.07	6.44	7.56	37.37
6	1.22	7.51	8.19	36.29
7	2.80	10.31	10.95	33.50
8	2.87	5.07	5.67	38.80
9	3.80	8.01	7.41	38.16
10	12.35	4.52	4.35	48.27
11	11.11	3.48	2.97	47.14
12	21.99	22.02	24.07	39.86
13	8.82	3.30	5.36	43.31
14	7.93	0.00	2.07	43.75
15	9.34	2.25	1.11	45.43
16	8.31	2.07	0.00	44.43
17	7.31	2.44	1.11	43.43
18	7.55	0.75	1.53	43.52
19	11.13	18.41	19.26	25.40
20	17.49	23.44	24.76	23.21
21	11.03	18.93	19.28	25.43
22	36.12	43.75	44.43	0.00

Table 3: Travel distances between SR offices and bricks (km)

Sevil: How do we measure the travel distance and the reassignment objectives? The travel distance objective would be straightforward if an SR returned to the office after visiting each brick. I suppose this is not a bad assumption. I believe this would not change the solutions much. If we try to incorporate the sequence of visiting the bricks into this problem, I am afraid it will be too complicated to solve.

Serdar: I agree. The additional benefit will also be marginal. To measure the disruption, couldn't we just count the number of bricks for which the new assignment is different from the current assignment?

Sevil: Wouldn't we be counting them twice then? Assigning a brick to a new SR means removing it from another SR's territory. So, it may be more meaningful to count either the number of bricks assigned to a different SR, or the number of bricks removed from an SR's current territory.

Serdar: Yes, you're right. We should be careful about it. When we just count, we are treating all the bricks the same way. It is actually less desirable to disrupt a brick having a higher index value. New relationships will have to be established between more MDs.

Sevil: Yes, that's a good point. Why don't we use the index values of bricks while measuring the disruption? Would weighing each disrupted brick with its index value be a good metric to measure the disruption?

Serdar: It surely would.

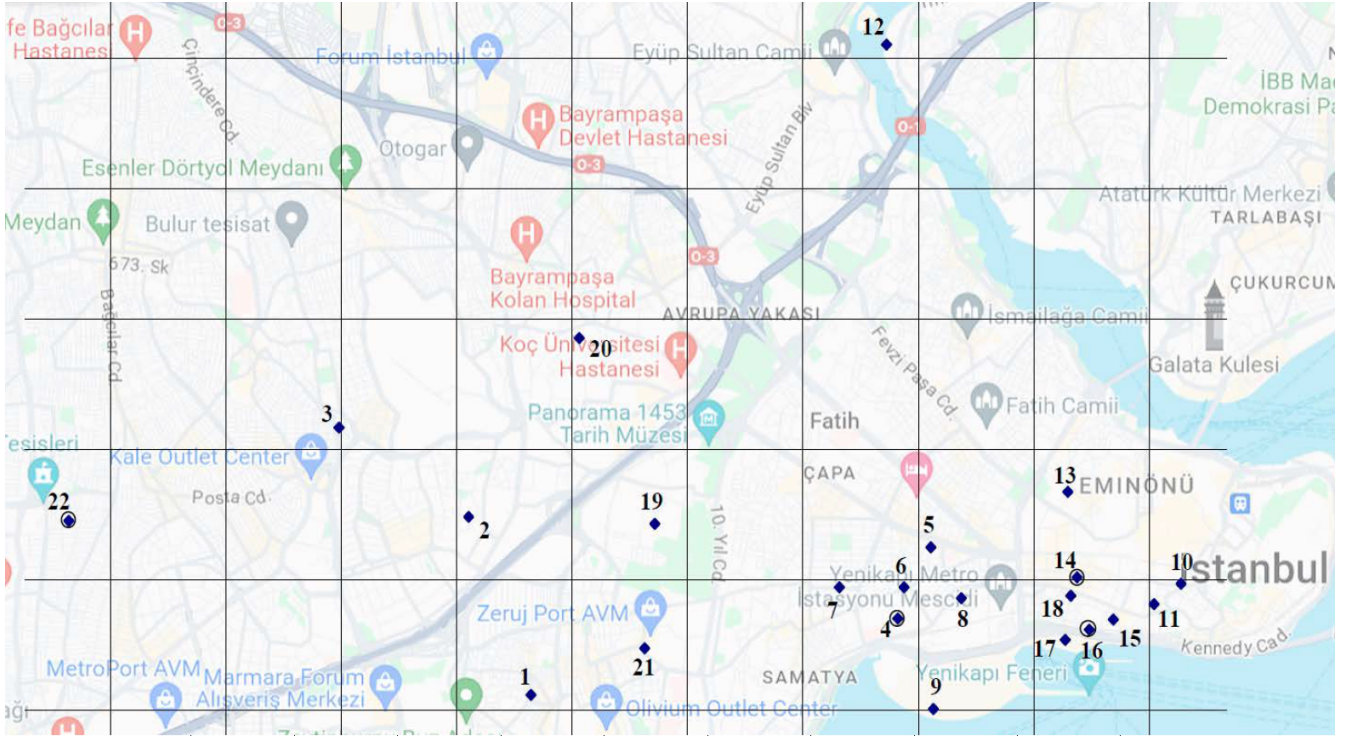


Figure 3: Brick Locations

They then discussed how to obtain different solutions. They checked their books and noted the definition that “a solution is efficient if there is no other feasible solution that is at least as good in every objective and strictly better in at least one objective.” They recalled from their graduate studies that they had to make sure to obtain efficient solutions. They decided to use a method that would put an upper bound on the disruption objective and minimize the distance traveled. By changing the upper bound value, they would obtain several solutions.

Serdar: When we use this method, are we guaranteed to obtain an efficient solution? The second objective is treated as a constraint and it seems to me that the model would not differentiate between solutions that have the same minimum distance traveled but different disruption values so long as the upper bound is satisfied.

Sevil: Exactly. The book discusses this issue right here. It says the solution found can be inefficient because of this. But there is a practical solution. We can multiply the second objective’s value with a very small positive constant and add to the distance traveled in the objective function. This trick breaks ties in favor of solutions with better values in the “disruption” objective.

Serdar: I like this trick. Okay, we have very little time left before the meeting. It would be great if we could obtain some solutions we can show to Merih.

They were able to obtain several efficient solutions and they were pleasantly surprised to see how much they accomplished in two days. They explained what they did and showed their results to Merih.

Merih: These look good for a start. It gives me some idea about the possible solutions. Before making a decision, I would like to see more solutions though. Would it make sense to obtain all efficient solutions?

Would they be too many?

Sevil: I think they could be too many in general. There may not be too many for this problem, though. We can try and see.

Merih: I am also interested to see the effect of tightening the “balance” range. If the other objectives do not deteriorate too much, I would like to have the workload balanced a little more. Perhaps you can plot the solutions you obtain. I will also welcome any comments on the solutions that would facilitate the decision. If we can analyze this district well, then we can make the decisions for other districts in a similar way.

Serdar: We intended to prepare a plot but ran out of time. We will do it next time. Hopefully, we will not be pressed with time as much now!

Merih: I understand. I will not give you a deadline this time. You let me know when you are ready.

Leaving the meeting, Sevil and Serdar were not sure if they were better off with or without the deadline. They knew that they would work even harder now. It just occurred to them that Merih also knew it. “No wonder he is the vice president.” Sevil thought.

Project organization

- The project is to be realized in groups of three students. The composition of the group should be specified and sent by email to Vincent Mousseau before October 22, 2025, 5:00 p.m.
- A course session (October 22, 2025) is programmed to work on the project (the project will, however, require additional work).
- The project: the report, code, and data files should be posted on Edunao by November 26th, 23:59.
- The defense is scheduled to take place on November 28, 2025 (8:30-12:00). Each group will have 20 minutes (12 minutes for the presentation + 8 minutes for questions). All group members should be present and participate actively in the defense.

The work consists of three steps:

Step 1

In this first step, we consider the center bricks as fixed. You should:

- formulate two mono-objective linear optimization models to solve the assignment problem using a distance and a disruption objective,
- implement your two mono-objective models using GUROBI, and solve the instance with 22 Bricks and 4 Sales Representatives,
- implement the epsilon-constraint scheme to compute the set of all non-dominated solutions,
- compute and represent the corresponding sets of non-dominated solutions for the 4x22 problem, with interval workload constraints $[0.8, 1.2]$, $[0.85, 1.15]$, and $[0.9, 1.1]$,
- check how your model scales up with the instance with 10 SRs and 100 zones,
- propose a visual representation of the solution in the decision space,

Step 2

In this second step, we will consider extensions of the model developed in Step 1.

- Is your first model able to solve the 100 bricks / 10 SRs instances? compute and represent the corresponding sets of non-dominated solutions.
- How to model the case for partially assigning bricks (i.e., assign a brick to multiple SRs?). Implement this possibility and compare the results to your previous results.
- If the demand increases uniformly in all bricks (for example + 25%, it will be necessary to hire a new sales representative. There is the question of where to locate his/her office (center brick).

Step 3

The location of the “center bricks” (SR offices) has a significant impact on the distance traveled by the sales representatives. An important question is to generalize the model to allow a modification of the “center bricks”.

- Formulate a bi-objective optimization problem in which positions of offices are variables and in which the two objectives are the total distance (min), and the workload of SRs (MinMax),
- In this context of possibly modified center bricks, the disruption is redefined in terms of the number of relocated offices (without any consideration of the changes in the assignment of bricks to SRs). As this new disruption formulation (number of relocated offices) takes integer values in $[0, \text{number of SRs}]$, compute the sets of non-dominated solutions for the three-objective problem (total distance, workload fairness, and number of relocated offices).