An Engineering Problem: Case Study at Supply Chain Sector

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1 Problem Definition

The facilities are needed to be opened to new location in different parts of Turkey. Based on this knowledge, engineers of the company are trying to find the new locations where the facilities are going to be located. Facility location problem is to find locations for new facilities such that the conveying cost from facilities to customers is minimized. Engineers are trying to find the place that minimizes the cost in terms of money, but the cost is transformed to currency (TL) from distance between old facility, vehicle labor, distance between the demand points and facility, and etc. Each demand point has different sales volume, so not just distance is important also sales volume is important.

2 Problem Data Set

The study utilizes a realistic dataset consisting of major industrial hubs as suppliers and high-end urban/tourist centers as demand points.

- Have 10 candidate supply points

- Have 30 demand points

- All of the points are located in Turkey with corresponding coordinates

2.1 Cost Components & Parameters

Following the classical Facility Location formulation, the total cost is decomposed into:

- **Locating cost** (single): moving from the current facility (old site) to the candidate site β

- **Fixed operating cost** (annual): rent, utilities, maintenance, taxes, etc. (location-specific).

- **Transportation cost** (annual): delivering demand from the selected facility to demand points.

2.2 Candidate Supply Points

The following 10 locations represent candidate sites for the new facility, chosen based on their proximity to raw materials (livestock, agriculture) or logistics infrastructure.

2.3 Demand Points

The 30 demand points represent major restaurant locations and urban consumption centers across Turkey.

ID	Name	Province	Lat (x)	Long (y)
S_1	Şekerpınar	Kocaeli	40.8603	29.3884
S_2	Afyonkarahisar	Afyon	38.7500	30.5400
S_3	Balıkesir	Balıkesir	39.6400	27.8800
S_4	Konya Merkez	Konya	37.8800	32.5000
S_5	Erzurum	Erzurum	39.9000	41.2700
S_6	Tekirdağ	Tekirdağ	40.9700	27.5100
S_7	Manisa	Manisa	38.6100	27.4200
S_8	Gemlik	Bursa	40.4300	29.1500
S_9	Mersin Port	Mersin	36.8100	34.6300
S_{10}	Polatlı	Ankara	39.5800	32.1400

Table 1: Candidate supply point locations and specializations.

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Table 2: Demand point locations with assigned Order Volumes.

ID	Point Name	Province	Lat (x)	Long (y)	Order Volume (v_i)
D_1	Etiler	Istanbul	41.0806	29.0339	7.2
D_2	Nişantaşı	Istanbul	41.0520	28.9900	6.8
D_3	Bebek	Istanbul	41.0787	29.0452	6.5
D_4	Galataport	Istanbul	41.0276	28.9870	8.1
D_5	Çankaya	Ankara	39.9000	32.8600	5.4
D_6	Kavaklıdere	Ankara	39.9080	32.8550	4.9
D_7	Alsancak	Izmir	38.4370	27.1400	5.1
D_8	Alaçatı	Izmir	38.2800	26.3700	7.5
D_9	Yalıkavak	Muğla	37.1000	27.2900	8.4
D_{10}	Marmaris	Muğla	36.8500	28.2700	4.2
D_{11}	Lara	Antalya	36.8500	30.7500	4.8
D_{12}	Belek	Antalya	36.8600	31.0500	5.9
D_{13}	Nilüfer	Bursa	40.2100	28.9500	4.5
D_{14}	Seyhan	Adana	36.9900	35.3200	5.0
D_{15}	Şehitkamil	Gaziantep	37.0600	37.3800	5.3
D_{16}	Tepebaşı	Eskişehir	39.7800	30.5000	3.2
D_{17}	Ortahisar	Trabzon	41.0000	39.7200	2.8
D_{18}	Atakum	Samsun	41.3200	36.2600	2.5
D_{19}	Yenişehir	Mersin	36.8000	34.6000	3.8
D_{20}	Kayapınar	Diyarbakır	37.9300	40.1500	3.1
D_{21}	Kuşadası	Aydın	37.8500	27.2500	4.1
D_{22}	Pamukkale	Denizli	37.7800	29.0800	2.9
D_{23}	Melikgazi	Kayseri	38.7200	35.4800	3.4
D_{24}	Selçuklu	Konya	37.8700	32.4800	3.9
D_{25}	İzmit	Kocaeli	40.7600	29.9300	4.4
D_{26}	Serdivan	Sakarya	40.7600	30.3600	3.7
D_{27}	Edirne Merkez	Edirne	41.6700	26.5500	2.1
D_{28}	Çanakkale Merkez	Çanakkale	40.1500	26.4000	2.4
D_{29}	Antakya	Hatay	36.2000	36.1600	3.3
D_{30}	Fethiye	Muğla	36.6200	29.1100	4.6

Cost Type	Setup	Operating	Transportation Per Unit
Single	β	F_j	$\sum_i \alpha d_{1i}$
Annual	βD_{ij}	F_j	$\sum_i \alpha d_{2i} v_i$

Table 3: Cost table including *each* cost component (relocation + fixed + transportation).

Table 4: Cost Components for Candidate Facilities (TL)

Candidate	Setup Coefficient (β)	Operating (F_j)	Transportation (T_j)	Total Annualized
S_1 (Şekerpınar)	60,000	5,500,000	7.5	100,760,000
S_2 (Afyon)	145,000	2,100,000	6	84,695,000
S_3 (Balıkesir)	180,000	2,400,000	6	81,480,000
S_4 (Konya)	320,000	1,900,000	6	90,340,000
S_5 (Erzurum)	750,000	1,500,000	6	136,850,000
S_6 (Tekirdağ)	95,000	3,200,000	6	94,645,000
S_7 (Manisa)	210,000	2,600,000	6	76,910,000
S_8 (Gemlik)	115,000	3,800,000	6	90,355,000
S_9 (Mersin)	480,000	3,400,000	6	116,380,000
S_{10} (Polatlı)	290,000	2,200,000	6	92,290,000

Note: Transportation (T_j) is the sum of (Distance × Volume × 25 TL) for all 30 demand points.

An Engineering Problem: Case Study at Supply Chain Sector - Case II

3   Problem Definition

The facilities are needed to be opened to new location in different parts of Turkey. Based on this knowledge, engineers of the company are trying to find the new locations where the facilities are going to be located. Facility location problem is to find locations for new facilities such that the conveying cost from facilities to customers is minimized. Engineers are trying to find the place that minimizes the cost in terms of money, but the cost is transformed to currency (TL) from distance between new facility, vehicle labor, distance between the demand points and facility, and etc. Each demand point has different sales volume, so not just distance is important also sales volume is important.
You have to determine which facilites are going to be opened and their corresponding costs.

4   Problem Data Set

The study utilizes a realistic dataset consisting of major industrial hubs as suppliers and high-end urban/tourist centers as demand points.

- Have 10 candidate supply points

- Have 30 demand points

- The location of the candidate facilities are known (x,y) and at most you can open 5 due to budget

4.1   Cost Components & Parameters

Following the classical Facility Location formulation, the total cost is decomposed into:

- **Relocation cost** (single): moving from the current facility (old site) to the candidate site.

- **Fixed operating cost** (annual): rent, utilities, maintenance, taxes, etc. (location-specific).

- **Transportation cost** (annual): delivering demand from the selected facility to demand points.

4.2   Candidate Supply Points

The following 10 locations represent candidate sites for the new facility, chosen based on their proximity to raw materials (livestock, agriculture) or logistics infrastructure.

ID	Name	Province	Lat (x)	Long (y)
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S_3	Balıkesir	Balıkesir	39.6400	27.8800
S_4	Konya Merkez	Konya	37.8800	32.5000
S_5	Erzurum	Erzurum	39.9000	41.2700
S_6	Tekirdağ	Tekirdağ	40.9700	27.5100
S_7	Manisa	Manisa	38.6100	27.4200
S_8	Gemlik	Bursa	40.4300	29.1500
S_9	Mersin Port	Mersin	36.8100	34.6300
S_{10}	Polatlı	Ankara	39.5800	32.1400

Table 5: Candidate supply point locations and specializations.

4.3   Demand Points

The 30 demand points represent major restaurant locations and urban consumption centers across Turkey.

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Table 6: Demand point locations with assigned Order Volumes.

ID	Point Name	Province	Lat (x)	Long (y)	Order Volume (v_i)
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D_{10}	Marmaris	Muğla	36.8500	28.2700	4.2
D_{11}	Lara	Antalya	36.8500	30.7500	4.8
D_{12}	Belek	Antalya	36.8600	31.0500	5.9
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D_{16}	Tepebaşı	Eskişehir	39.7800	30.5000	3.2
D_{17}	Ortahisar	Trabzon	41.0000	39.7200	2.8
D_{18}	Atakum	Samsun	41.3200	36.2600	2.5
D_{19}	Yenişehir	Mersin	36.8000	34.6000	3.8
D_{20}	Kayapınar	Diyarbakır	37.9300	40.1500	3.1
D_{21}	Kuşadası	Aydın	37.8500	27.2500	4.1
D_{22}	Pamukkale	Denizli	37.7800	29.0800	2.9
D_{23}	Melikgazi	Kayseri	38.7200	35.4800	3.4
D_{24}	Selçuklu	Konya	37.8700	32.4800	3.9
D_{25}	İzmit	Kocaeli	40.7600	29.9300	4.4
D_{26}	Serdivan	Sakarya	40.7600	30.3600	3.7
D_{27}	Edirne Merkez	Edirne	41.6700	26.5500	2.1
D_{28}	Çanakkale Merkez	Çanakkale	40.1500	26.4000	2.4
D_{29}	Antakya	Hatay	36.2000	36.1600	3.3
D_{30}	Fethiye	Muğla	36.6200	29.1100	4.6

4.4   Euclidean Distance Formula

$$d_{ij} = \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \tag{1}$$

Where:

- d_{ij} is the geometric distance between facility i and demand point j.
- (x_i, y_i) represents the coordinates of the candidate supply facility.
- (x_j, y_j) represents the coordinates of the restaurant or demand location.

Table 7: Calculated Distances (km) between Demand (D_i) and Supply (S_j) Points

Demand Pt.	S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_8	S_9	S_{10}
D_1 (Etiler)	38.5	289.2	187.7	463.8	1042.2	128.4	307.3	73.0	677.7	311.7
D_2 (Nişantaşı)	39.7	288.1	183.0	463.8	1045.7	124.5	302.8	70.5	678.3	313.2
D_3 (Bebek)	37.7	288.6	188.0	463.0	1041.2	129.4	307.6	72.7	676.9	310.8
D_4 (Galataport)	38.5	285.8	180.6	461.9	1045.8	124.1	300.3	67.9	676.7	312.1
D_5 (Çankaya)	312.8	237.0	426.5	226.8	717.1	468.1	489.8	320.7	376.6	71.1
D_6 (Kavaklıdere)	312.1	237.1	426.2	227.6	717.5	467.4	489.6	320.1	377.6	71.2
D_7 (Alsancak)	331.1	297.5	148.2	472.6	1227.6	283.4	31.0	280.9	683.8	450.3
D_8 (Alaçatı)	386.3	366.5	199.8	538.3	1296.9	314.6	98.5	338.0	746.1	519.5
D_9 (Yalıkavak)	455.7	339.0	287.1	467.7	1254.3	430.7	168.3	403.8	652.8	504.8
D_{10} (Marmaris)	456.3	290.5	312.1	390.9	1181.6	462.8	209.5	405.3	566.0	454.3
D_{11} (Lara)	461.2	212.1	398.8	192.4	977.0	537.0	352.2	421.6	345.3	326.9
D_{12} (Belek)	467.5	214.9	414.9	171.1	952.1	550.0	373.8	429.9	318.6	317.1
D_{13} (Nilüfer)	81.2	212.1	111.1	401.3	1048.3	148.1	221.2	29.8	622.0	281.0
D_{14} (Seyhan)	669.4	462.9	712.5	267.9	610.7	806.7	716.8	657.7	64.5	399.9
D_{15} (Şehitkamil)	809.4	628.7	876.2	440.2	462.9	956.4	891.0	805.7	246.0	536.0
D_{16} (Tepebaşı)	152.7	114.6	224.6	273.2	919.1	285.7	295.6	135.7	488.7	142.1
D_{17} (Ortahisar)	867.6	821.9	1014.3	710.1	179.3	1024.1	1082.8	892.6	640.9	661.8
D_{18} (Atakum)	578.0	564.5	732.6	500.0	451.3	733.4	810.9	605.8	520.8	398.6
D_{19} (Yenişehir)	638.2	417.5	666.3	221.1	675.8	768.7	662.7	622.0	2.9	376.5
D_{20} (Kayapınar)	979.7	842.7	1079.5	671.0	239.5	1135.5	1113.0	987.3	503.4	718.1
D_{21} (Kuşadası)	381.9	304.0	206.4	460.8	1233.5	347.6	85.8	330.4	662.5	465.7
D_{22} (Pamukkale)	343.5	167.0	231.5	300.6	1080.8	379.5	171.9	294.7	502.6	332.6
D_{23} (Melikgazi)	572.1	428.4	662.8	276.3	515.0	724.6	699.7	574.7	225.1	303.4
D_{24} (Selçuklu)	425.6	195.5	444.7	2.1	793.2	548.5	449.4	404.3	223.6	192.4
D_{25} (İzmit)	46.9	229.5	214.1	389.1	965.3	204.8	321.4	75.4	598.9	229.1
D_{26} (Serdivan)	82.5	224.0	244.7	369.4	929.1	240.8	347.0	108.6	574.2	200.2
D_{27} (Edirne)	253.7	469.2	252.1	660.1	1253.3	111.7	348.2	257.9	880.4	525.8
D_{28} (Çanakkale)	264.7	388.0	138.4	584.2	1265.0	130.8	192.4	235.3	806.5	493.9
D_{29} (Antakya)	784.1	571.1	820.4	374.7	607.6	919.4	816.8	771.1	152.6	515.3
D_{30} (Fethiye)	472.1	268.2	352.6	331.1	1121.5	503.2	266.7	423.7	492.4	422.6

Cost Type	Setup	Operating	Transportation
Single	β	F_j	$\sum_i \alpha d_{1i}$
Annual	βD_{ij}	F_j	$\sum_i \alpha d_{2i} v_i$

Table 8: Cost table including *each* cost component (relocation + fixed + transportation).

Table 9: Cost Components for Candidate Facilities (TL)

Candidate	Setup Coefficient (β)	Operating (F_j)	Transportation Per Unit Per Km (T_j)
S_1 (Şekerpınar)	1500	5,500,000	7.5
S_2 (Afyon)	600	2,100,000	6
S_3 (Balıkesir)	800	2,400,000	6
S_4 (Konya)	300	1,900,000	6
S_5 (Erzurum)	1250	1,500,000	6
S_6 (Tekirdağ)	1650	3,200,000	6
S_7 (Manisa)	700	2,600,000	6
S_8 (Gemlik)	900	3,800,000	6
S_9 (Mersin)	900	3,400,000	6
S_{10} (Polatlı)	1000	2,200,000	6

Note: Transportation (T_j) is the sum of (Distance × Volume × 25 TL) for all 30 demand points.