**determining the best configuration of transportation of crops to a city, to achieve the lowest cost possible.**

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**abstract:**

This report gives exclusive insights into the solution of a real-life problem on determining the best configuration of transportation of crops to a city, to achieve the lowest cost possible, since transporting goods is one of the major costs of any business, then minimizing its cost is a necessity, it is not as simple as choosing the cheapest transportation method, we have to take into consideration the verity of options that our system can take and then determine the cheapest one of them, and that is done using the simplex Linear Programming methods in Excel solver.

**Introduction**

as the world progresses through time and started to develop cities and capitals, farms and factories had to be placed somewhere far from the city which space must be utilized for housing and hospitals and restaurants and supermarkets and other necessities.

this will cause major problems for business owners because now they have to worry about the cost of transportation of goods to the customer, where it was simple and nearby before the Industrial Revolution and the formation of cities.

with the development of cities, also came the development of transportation methods, such as trains and planes and trucks and ships that can carry tons worth of products.

nowadays, every one of us would go to the supermarket and buy whatever fruits and vegetables they want, without thinking about where it came from and how much effort was dedicated to getting this product to the shelves in a fresh condition, and most importantly, keeping the product cheap for the customers, by minimizing the cost of transportation, let's take tomatoes and Prickly pear (a form of cactus fruit) as an example:

tomatoes are cheap, you can get a few KG without paying more than 10 TL, but if you want to buy some Prickly pear, then you will have to pay a lot of money just to get half a KG of them, why?

it is not the cost of growth because Prickly pears don't cost anything to grow other than some labor, tomatoes might even cost more to grow in some cases, it is because of transportation, Prickly pears can't grow in turkey because of the soil, prickly pears require to be planted in well-draining soil (dry, sandy, or gravelly), which is hard to come by in Turkey, so it has to be an imported product which increases the cost.

in this report, we are going to simulate a real-life example of transporting fruits and vegetables from farms to warehouses around Istanbul city.

**Optimizing the transportation of fruits and vegetables:**

Istanbul is a big city with a population of over 15 million people, thus it requires a lot of crops, the crops are distributed from farms to **7 major warehouses** in the city, sellers and shop owners and supermarkets would go to the closest warehouse to them and buy the product that they want.  
there are **4 major farms** that supply these warehouses with fruits and vegetables, the demand and production capability and the cost of transporting the crops is shown in table(1) and (2), we will determine the best configuration of transporting **2 categories** (fruits and vegetables) to achieve the lowest cost possible, (demand and production are by KG, cost is by TL per 1GK). SIDE NOTE: usually, when crops are transported from one place to another, they are separated by the way they are meant to be handled, for example, grapes and berries can be transported together, but it is not efficient to transport grapes and coconuts together because they are handheld and packaged in a different way, separating the crops and calculating how much each type would cost to transport is possible, but it requires research and testing, in our study we are separating crops into fruits and vegetables to indicate that the source can produce more than one type of product.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| vegetables | WH1 | WH2 | WH3 | WH4 | WH5 | WH6 | WH7 | supply |
| Farm1 | 0.65 | 0.91 | 6.40 | 1.00 | 5.48 | 6.98 | 0.97 | 300KG |
| Farm2 | 0.80 | 1.03 | 6.40 | 0.76 | 5.10 | 4.30 | 1.89 | 550KG |
| Farm3 | 3.81 | 0.80 | 6.30 | 0.52 | 5.62 | 3.84 | 1.04 | 400KG |
| Farm4 | 3.23 | 3.48 | 8.40 | 3.02 | 1.23 | 5.89 | 0.81 | 400KG |
| demand | 250KG | 150KG | 200KG | 350KG | 150KG | 200KG | 350KG |  |

\*table (1): the demand / supply and the cost of transporting the vegetables.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| fruits | WH1 | WH2 | WH3 | WH4 | WH5 | WH6 | WH7 | Supply |
| Farm1 | 0.28 | 0.81 | 5.46 | 5.52 | 6.54 | 0.72 | 1.47 | 350KG |
| Farm2 | 2.10 | 1.00 | 1.15 | 5.00 | 3.09 | 0.91 | 5.70 | 600KG |
| Farm3 | 0.33 | 1.07 | 6.76 | 3.72 | 1.49 | 0.94 | 5.38 | 550KG |
| Farm4 | 1.17 | 1.66 | 5.16 | 6.29 | 3.41 | 0.21 | 1.8 | 500KG |
| demand | 300KG | 250KG | 300KG | 500KG | 200KG | 100KG | 350KG | 1650 |

\*Table (2): the demand / supply and the cost of transporting the fruits.

We will solve this example using northwest corner method on Excel but first, we need to determine the constraints and the objective function for each type of crops, since we have 11 nods (4 farms and 7 warehouses), then the number of constraints should be 12 (with the sign constraint).

xij represents the number of KG of grown crops at farm i and sent to warehouse j.

Objective Function (vegetables):

Min z = 0.65x11 + 0.91x12 + 6.40x13 + 1x14 + 5.48x15 + 6.98x16 + 0.97x17 + 0.8x21 + 1.03x22 + 6.40x23 + 0.76x24 + 5.10x25 + 4.30x26 +1.89x27 + 3.81x31 + 0.80x32 + 6.3x33 + 0.52x34 + 5.62x35 + 3.84x36 + 1.04x37 + 3.23x41 + 3.48x42 + 8.40x43 + 3.02x44 + 1.23x45 + 5.89x46 + 0.81x47

Constraints (vegetables):

x11+x12+x13+x14+x15+x16+x17 ≤ 300KG

x21+x22+x23+x24+x25+x26+x27 ≤ 550KG (supply constraints)

x31+x32+x33+x34+x35+x36+x37 ≤ 400KG

x41+x42+x43+x44+x45+x46+x47 ≤ 400KG

x11+x21+x31+x41 ≥ 250KG

x12+x22+x32+x42 ≥ 150KG

x13+x23+x33+x43 ≥ 200KG

x14+x24+x34+x44 ≥ 350KG (demand constraints)

x15+x25+x35+x45 ≥ 150KG

x16+x26+x36+x46 ≥ 200KG

x17+x27+x37+x47 ≥ 350KG

xij ≥ 0 (i = 1,2,3,4 - j = 1,2,3,4,5,6,7)

Objective Function (fruits):

Min z = 0.28 x11+0.81 x12 +5.46 x13 +5.52 x14 +6.54 x15 +0.72 x16 +1.47 x17 +2.10 x21 +1 x22 +1.15 x23 +5 x24+3.09 x25+0.91 x26+5.70 x27+0.33 x31+1.07 x32+6.76 x34+1.49 x35+0.94 x36+5.38 x37+1.17 x41+1.66 x42+5.16 x43+6.29 x44+3.41 x45+0.21 x46+1.46 x47

Constraints (fruits):

x11+x12+x13+x14+x15+x16+x17 ≤ 350KG

x21+x22+x23+x24+x25+x26+x27 ≤ 600KG (supply constraints)

x31+x32+x33+x34+x35+x36+x37 ≤ 550KG

x41+x42+x43+x44+x45+x46+x47 ≤ 500KG

x11+x21+x31+x41 ≥ 300KG

x12+x22+x32+x42 ≥ 250KG

x13+x23+x33+x43 ≥ 300KG

x14+x24+x34+x44 ≥ 500KG (demand constraints)

x15+x25+x35+x45 ≥ 200KG

x16+x26+x36+x46 ≥ 100KG

x17+x27+x37+x47 ≥ 350KG

xij ≥ 0 (i = 1,2,3,4 - j = 1,2,3,4,5,6,7)

after implementing our constraints and objective functions in Excel and using northwest corner method, we will get these results.

Fruits:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| fruits | WH1 | WH2 | WH3 | WH4 | WH5 | WH6 | WH7 | production |
| Farm1 | 300 | 50 |  |  |  |  |  | 350KG |
| Farm2 |  | 200 | 300 | 100 |  |  |  | 600KG |
| Farm3 |  |  |  | 400 | 150 |  |  | 550KG |
| Farm4 |  |  |  |  | 50 | 100 | 350 | 500KG |
| demand | 300KG | 250KG | 300KG | 500KG | 200KG | 100KG | 350KG |  |

With total cost of 3747.50

**transporting the Fruits will cost 3747.50** **TL.**

farm 1: 300KG to WH 1 & 50KG to WH 2

farm 2: 200KG to WH 2 & 300KG to WH 3 & 100KG to WH 4

farm 3: 400KG to WH 4 & 150KG to WH 5

farm 4: 50KG to WH 5 & 100KG to WH 6 & 150KG to WH 7

Vegetables:

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| vegetables | WH1 | WH2 | WH3 | WH4 | WH5 | WH6 | WH7 | production |
| Farm1 | 250 | 50 |  |  |  |  |  | 300KG |
| Farm2 |  | 100 | 200 | 250 |  |  |  | 550KG |
| Farm3 |  |  |  | 100 | 100 | 200 |  | 400KG |
| Farm4 |  |  |  |  | 50 |  | 350 | 400KG |
| demand | 250KG | 150KG | 200KG | 350KG | 150KG | 200KG | 350KG |  |

With total cost of 3508

**transporting the Vegetables will cost 3508 TL.**

farm 1: 250KG to WH 1& 50KG to WH 2

farm 2: 100KG to WH 2 & 200KG to WH 3 & 250KG to WH 4

farm 3: 100KG to WH 4 & 100KG to WH 5 & 200KG to WH 6

farm 4: 50KG to WH 5 & 350KG to WH 7

**Discussions:**

why is the cost of transporting fruits higher than the cost of transporting vegetables?

Although fruits and vegetables use the same transportation since they are shipped from the same farms to the same warehouses the cost of these two are not the same this is happening for multiple reasons, one of the reasons is the fact that these cost in real life, will vary for different circumstances, one other logical reason is the fact that fruits are packaged and handled much more carefully than vegetables according to food and agriculture organization of the united nations. Fruits can easily be damaged unlike vegetables for example if you look at a strawberry minimum force could destroy it on the other hand if you look at carrot it can take a lot of force and can easily stacked in the shipping process and fruits can rotten faster than vegetables on average these difficulties may affect the cost of transporting these goods.

Should the transportation company keep shipping these good separately or combining them would be easier?

That might be fine, but we need to consider the damages that might happened if we ship both of them at the same time, but if the good was packaged according to what type of fruits or vegetables are, then it would be fine and it might make the process more complicated.

Advise for the shipping company:

We can see that warehouse 3 is way costly for fruits shipment this might be caused by the fact that warehouse 3 cannot storage fruits well unlike vegetables we can see that warehouse 3 is not that costly especially for the goods that are coming from farm 2 so we advise the company to find a more suitable warehouse for that area so the demand of fruits there increase and the cost of shipment decrease.

**References**

* Iannotti, M. (2021, February). *How to Grow Prickly Pear Cactus*. Marie Iannotti. <https://www.thespruce.com/growing-prickly-pear>.
* Winston, W. L. (1990). *Operations Research: Applications and Algorithms*. P.W.S.-Kent Publishing Co.,U.S. [https://itslearningakarmazyan.files.wordpress.com](https://itslearningakarmazyan.files.wordpress.com/).
* Topcu I. and Kabak O., 2016, Introduction to Operations Research, transportation problems.
* Paltrinieri, G. (2000). *(postharvest) handling of fresh fruits and vegetables*. food and agriculture organization of the united nations.