FACULDADE DE CIÊNCIAS
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Métodos de Apoio à Decisão - 2020/2021

Relatório do 2º Trabalho de MAD

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Files description

spaceFood.mod: AMPL source code to solve question 1 of the assignment

spaceFood.dat: Data file for exercise 1

spaceFood.run: AMPL script to generate solution for question 1

solutionQuestion1: Solution output for question 1

spaceFood2.mod: AMPL source code to solve exercise 2

spaceFood2.run: AMPL script to generate solution for question 2

spaceFood2.dat: data file for exercise 2

spaceFood2.sol: solution output for question 2

Question 1

Mathematical formulation

Sets:

$f \in \{R, C, I\}$; $p \in \{Venus, Mars, Mercury\}$; $o \in \{Cleaning, Packing, Cooking\}$

Variables:

Let $make_{tf}$ be the amount of food, *f* ,produced in month t

Let $sell_{tpf}$ be the amount sold of food, *f,* on planet, *p,* on month, *t*

Let $invt_{tf}$ be the amount of inventory space occupied by marmelade of type f, on month t

Let $transportOut_{tpf}$ be the amount of food transported from earth to planet p

Let $transportIn_{tpf}$ be the amount of food arriving from earth to planet p

Let $trans_{tp}$ be 1 if some quantity was transported in month t, to planet p

Data:

Let pc_{of} be the cost of operation, *o,* for food of type, *f*

Let $price_{tpf}$ be the sale price of food, *f,* on planet, *p,* on month *t*

Let transportationCost be the fixed cost of transporting food to a planet in a given month

Let montlyMaxTransport be the max amount of food we can transport to a planet in a given month

Restrictions:

nonNegative: $make_{tf} >= 0$, $invt_{tf} >= 0$, $sell_{tpf} >=0$, $transportOut_{tpf} >= 0$,

line: $\sum_{f} make_{tf} / pc_{of} \leq 1$

invtStart: $\sum_{f} invt_{1f} = 0$

earthInvtQuantity: $invt_{(t+1)f} = invt_{tf} + make_{tf} - \sum_{p} transportOut_{tpf}$

transportTime: $transportOut_{tpf} == transportIn_{tpf}$ Note: Transportation is instantaneous

sellQuantity: $sell_{tpf} == transportIn_{tpf}$

transportMinCost: $\sum_{f} transportOut_{tpf} <= \mathit{montlyMaxTransport} * trans_{tp}$

Objective:

maximize z: $\sum_{t}\sum_{p}\sum_{f} \mathbf{sell_{tpf} * price_{tpf}} - \sum_{t}\sum_{f} \mathbf{invt_{(t+1)f}} - \sum_{t}\sum_{p} \mathbf{trans_{tp}} * \mathbf{\mathit{transportationCost}}$

To solve this exercise, we adapted exercise 4 from our previous work, adding some new restrictions, since now we have to pay for each trip 10000 solarcoin. Once again we came to the conclusion that the only planets that are worth selling marmalade to are Mars and Venus, and that in the three first months, we should not sell to any planets. We should sell marmalade to Mars on the other 9 months, and sell marmalade to Venus in only three months (as shown in the following table).

Month	Type Marmalade	Quantities Produced	Inventory (Earth)	Sold
1	C	850	0	0
	I	0	0	0
	R	0	0	0
2	C	850	850	0
	I	0	0	0
	R	0	0	0
3	C	850	1700	0
	I	0	0	0
	R	0	0	0
4	C	850	2550	1000 (Mars)
	I	0	0	0
	R	0	0	0

5	**C**	283,333	2400	1000 (Mars)
	I	657,143	0	0
	R	220,238	0	0
6	**C**	0	1683,33	1383,33 (1000 - Mars; 383,33 - Venus)
	I	942,857	657,143	0
	R	396,429	220,238	616,667 (Venus)
7	**C**	0	300	0
	I	1200	1600	2000 (1000 - Mars; 1000 - Venus)
	R	0	0	0
8	**C**	0	300	0
	I	1200	800	2000 (1000 - Mars; 1000 - Venus)
	R	0	0	0
9	**C**	850	300	1000 (Mars)
	I	0	0	0
	R	0	0	0
10	**C**	850	150	1000 (Mars)
	I	0	0	0
	R	0	0	0
11	**C**	485,714	0	485,714 (Mars)
	I	514,286	0	514,286 (Mars)
	R	0	0	0
12	**C**	0	0	0
	I	1000	0	1000 (Mars)
	R	0	0	0

With this optimization plan, we would have a profit of 426985 solarcoins, and if we compare this profit with the one that we got in our first assignment (560562.0 solarcoins), we can conclude that our final profit is smaller. That is due to the fact that each of the trips to the planets, if ordered, will have a cost of 10000 solarcoins.

Question 2

Mathematical formulation

For exercise 2 we have the same sets and data. We also have the same variables plus one more: Let $planetInvt_{tpf}$ be the amount of food, f, stored on planet p per month. The restrictions are also the same expect sellQuantity: $sell_{tpf} == transportIn_{tpf}$ is not part of this formulation (we don't need to sell everything we receive due to the addiction of inventories on each planet), and we have the following new restrictions: planetInvtStart: $\sum_{f} planetInvt_{1pf} = 0$ and planetInvtQuantity: $planetInvt_{(t+1)pf} = planetInvt_{tpf} + transportIn_{tpf} - sell_{tpf}$.

Objective:

$$\text{maximize } z: \sum_t \sum_p \sum_f sell_{tpf} * price_{tpf} - \sum_t \sum_f invt_{(t+1)\,f} - \sum_t \sum_p trans_{tp} * transportationCost$$

$$- \sum_t \sum_p \sum_f planetInvt_{tpf} * \ planetInvtCostPerUnit$$

For our last exercise, we adapted the previous one and added the possibility of an inventory on each of the planets (for local delivery), at the cost of 2 solarcoins per month and per unit kept in stock at the end of a period. This means that now not everything that is sent to the planets will be necessarily sold, it can simply stay at the local inventory. Once again, to optimize the problem we should not sell any marmalade to Mercury (the inventory of this planet is never used). We can also see in the following table that we only should sell in Mars on the last 4 months (even thoughwe should send marmalade to Mars on the last 5 months), and that we should only sell in Venus on month 8 the marmalade type I (8000 units), but we should send to Venus 1000 units each month, from month 1 to month 8, and keep those units in storage.

Month	Type Marmalade	Quantities Produced	Inventory (Earth)	Sent	Inventory (Venus)	Inventory (Mercury)	Inventory (Mars)	Sold
1	C	0	0	0	0	0	0	0
	I	1200	0	1000 (Venus)	0	0	0	0
	R	0	0	0	0	0	0	0
2	C	0	0	0	0	0	0	0
	I	1200	200	1000 (Venus)	1000	0	0	0
	R	0	0	0	0	0	0	0
3	C	0	0	0	0	0	0	0
	I	1200	400	1000 (Venus)	2000	0	0	0
	R	0	0	0	0	0	0	0
4	C	0	0	0	0	0	0	0
	I	1200	600	1000 (Venus)	3000	0	0	0
	R	0	0	0	0	0	0	0
5	C	0	0	0	0	0	0	0
	I	1200	800	1000 (Venus)	4000	0	0	0
	R	0	0	0	0	0	0	0
6	C	0	0	0	0	0	0	0
	I	1200	1000	1000 (Venus)	5000	0	0	0
	R	0	0	0	0	0	0	0
7	C	0	0	0	0	0	0	0
	I	1200	1200	1600 (1000 - Venus; 600 - Mars)	6000	0	0	0
	R	0	0	0	0	0	0	0

8	**C**	0	0	0	0	0	0	0
	I	1200	800	2000 (1000 - Venus; 1000 - Mars)	7000	0	600	9600 (1600 - Mars; 8000 - Venus)
	R	0	0	0	0	0	0	0
9	**C**	850	0	850 (Mars)	0	0	0	850 (Mars)
	I	0	0	0	0	0	0	0
	R	0	0	0	0	0	0	0
10	**C**	850	0	850 (Mars)	0	0	0	850 (Mars)
	I	0	0	0	0	0	0	0
	R	0	0	0	0	0	0	0
11	**C**	485,714	0	485,714 (Mars)	0	0	0	485,714 (Mars)
	I	514,286	0	514,286 (Mars)	0	0	0	514,286 (Mars)
	R	0	0	0	0	0	0	0
12	**C**	0	0	0	0	0	0	0
	I	1000	0	1000 (Mars)	0	0	0	1000 (Mars)
	R	0	0	0	0	0	0	0

Our final profit is 626029, which is more than we ever got before. This is due to the fact that we have inventories on all the planets, and that means that we can sell more units on the month that benefit us the most, that is, previously we could only sell 1000 units of marmalade for each planet (no inventory to store them, so everything that was sent was sold), but now we have inventory on all the planets, so we can sell more than 1000 if needed.