Optimization of Return Value and Handling Cost

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Abstract

This paper discusses the application of Operations Research methodology in aiding manager in decision making regarding assignment and transportation problem. The project involved here is a case study done at a medium sized plantation run by Bumiputras. There are two objectives to be achieved namely to maximize the return value in assigning types of plants to the appropriate categories of land plot and to minimize transportation and service costs to respective market center. The methods being applied are the transportation technique and the Hungarian method.

Keywords : Operations Research, Assignment problem, Transportation problem, SAS procedure, Hungarian method, Proc trans, Proc assign.

Abstrak

Kertaskerja ini membincangkan tentang penggunaan kaedah Penyelidikan Operasi di dalam membantu pengurus di dalam membuat kataputus mengenai masalah umpukan dan pengangkutan. Projek melibatkan satu kes kajian di suatu ladang saiz sederhana yang diuruskan oleh bumiputra. Terdapat dua objektif yang hendak dicapai iaitu memaksimakan nilai pulangan di dalam mengumpukkan jenis tanaman kepada jenis bidang tanah tertentu dan untuk meminimakan kos pengangkutan dan kos perkhidmatan untuk pusat pemasaran tertentu. Kaedah yang digunakan ialah teknik pengangkutan dan kaedah Hungarian.

Introduction

As the preamble of the introduction, the paper discusses a brief [illegible] the transportation model and the assignment model.

Transportation problem is a special type of linear programming prob[illegible]nsportation model deals with the determination of a minimum-cost plan for transporting [illegible]modity from a number of sources to a number of destination. The model can be modifi[illegible]nt for multiple commodities. The model can also be extended to the areas of inventory, assignment, scheduling and many others.

Kertaskerja ini disunting oleh: Dr Ghazali Sulong.

Assignment Problem (AP) arises in a variety of decision making situations such as assigning jobs to machines, workers to tasks or projects, contracts to bidders and others. It is a special case of the transportation problem where in general an assignment problem is a balanced transportation problem with the supplies and demands equal to 1. The method used in solving this assignment problem is the Hungarian method.

Problem definition

Kebun Niaga is a medium-sized plantation run by Bumiputras. The main plants grown at Kebun Niaga are as follows:

1.	Guava	7.	Pineapple
2.	Starfruit	8.	Mangosteens
3.	Papaya	9.	Langsat
4.	Cempadak	10.	Mangos
5.	Durian	11.	XY1
6.	Rambutan	12.	XY2

Note that XY1 and XY2 are the cross-breed category. In the effort to expand the market, the owner bought another piece of land. The land is divided into plots area named PLOT1, PLOT2, PLOT3, PLOT4, PLOT5, PLOT6, PLOT7, PLOT8 ,PLOT9, PLOT10 and PLOT11 respectively. These categories are made with reference to soil content and ground level. In distributing plant types to respective plot category, the owner has to face a few restriction such as Guava cannot be planted at plot 3, Durian cannot be planted at plot 5 and Papaya cannot be planted at plot 8. The owner needs to placed the plantation at its respective appropriate plot to get the optimum return value. Refer to Table 1.2 for the matrix table of return value.

The return value is scaled between 1-10. The values are calculated as the difference between the average sale and the average cost involved. The maximum profit reported per batch is approximately M$1000 . Following is the category of return value determined using profit per batch obtained.

Profit per batch in Malaysian Ringgit	Return value
0 - 100	1
101-200	2
201-300	3
301-400	4
401-500	5
501-600	6
601-700	7
701-800	8
801-900	9
901-1000	10

In transporting the product later the owner has to make sure that most of the fruits produced be sent to the 10 best market centers, MC1, MC2, MC3 and MC4, MC5, MC6, MC7, MC8, MC9 and MC10 with the minimum cost. Refer to Table 1.4 for the Cost Matrix table. The fruits which are not send to the market centre mentioned above will be sent to its second choice market centers, PASAR A or PASAR B PASAR C and PASAR D. However, **XY1 must be sent to market center 6.** The management is not concerned with the later market centers due to their proximity to the plantation and there is no restriction on types of fruits delivered.

	Plot category											MC	Cost of transp
	1	2	3	4	5	6	7	8	9	10	11		
Plant type													
Guava	7	2	.	10	7	7	10	6	10	4	2	5,6,7,8	30,35,25,40
Starfruit	5	1	5	6	6	2	8	2	4	6	5	5,6,7	15,32,25
Papaya	8	7	6	5	5	4	7	.	3	10	5	5,6,7	21,25,20
Cempadak	2	5	2	4	5	10	2	3	6	2	5	7,9,10	18,35,60
Durian	3	3	5	8	.	4	7	3	4	3	4	7	42
Rambutan	6	2	4	3	4	3	3	3	1	1	3	6,7	22,18
Pineapples	6	7	5	8	9	10	3	6	7	9	4	1,2,4	25,21,35
Mangosteen	10	8	7	2	3	3	2	3	7	3	3	1,2,3,4	65,55,51,63
Langsat	4	4	5	1	6	8	2	6	3	2	3	1,2,3,4	57,63,72,35
Mango	5	3	8	3	3	4	4	5	2	4	6	1,2,3,4,9	36,48,32,28,75
XY1	3	2	1	10	3	7	9	1	8	10	10	6	33
XY2	5	5	5	5	5	5	8	1	1	5	5	6	33

Table 1.1 Overall information

Applying the procedure of Hungarian method

To apply the assignment procedure in meeting the two objectives, Table 1.1 which consists of the overall information is break up into respective appropriate table. Refer to Table 1.2 for the return value with respect to plant type and plot category and Table 1.3 fot the cost of transportation and service with respect to fruit type and market center. Table 1.3 is further broken down to Table 1.4 which display the cost of transportation and service for pineapple, mangosteens, langsat and mangos.

Plant type	Plot category										
	1	2	3	4	5	6	7	8	9	10	11
Guava	7	2	.	10	7	7	10	6	10	4	2
Starfruit	5	1	5	6	6	2	8	2	4	6	5
Papaya	8	7	6	5	5	4	7	.	3	10	5
Cempadak	2	5	2	4	5	10	2	3	6	2	5
Durian	3	3	5	8	.	4	7	3	4	3	4
Rambutan	6	2	4	3	4	3	3	3	1	1	3
Pineapple	6	7	5	8	9	10	3	6	7	9	4
Mangosteen	10	8	7	2	3	3	2	3	7	3	3
Langsat	4	4	5	1	6	8	2	6	3	2	3
Mangos	5	3	8	3	3	4	4	5	2	4	6
XY1	3	2	1	10	3	7	9	1	8	10	10
XY2	5	5	5	5	5	5	8	1	1	5	5

Table 1.2 Matrix table of Return Value

The objective functions of this project are as follows:

1. Maximize return value in assigning plant type to plot category.
2. Minimize cost of transportation and service with respect to market center.

Plant type	Market Center 1	2	3	4	5	6	7	8	9	10
Guava				30	35	25	40			
Starfruit					15	32	25			
Papaya					21	25	20			
Cempadak							18		35	60
Durian							42			
Pineapples	25	21		35						
Mangsteens	65	55	51	63						
Langsat	57	63	72	35						
Mangos	36	48	32	28					75	
XY1						33				
XY2						33				

Figure 1.3 Cost Matrix Table

Maximizing return value in assigning plant type to plot category.

Refering to Table 1.2 the number of rows and columns is unequal with 12 and 11 respectively. To apply the Hungarian method, the number of rows and columns must be equal. As a preamble, a dummy column with zero value is inserted as follows.

	Plot category											
	1	2	3	4	5	6	7	8	9	10	11	12
Plant type												
Guava	7	2	.	10	7	7	10	6	10	4	2	0
Starfruit	5	1	5	6	6	2	8	2	4	6	5	0
Papaya	8	7	6	5	5	4	7	.	3	10	5	0
Cempadak	2	5	2	4	5	10	2	3	6	2	5	0
Durian	3	3	5	8	.	4	7	3	4	3	4	0
Rambutan	6	2	4	3	4	3	3	3	1	1	3	0
Mangosteen	10	8	7	2	3	3	2	3	7	3	3	0
Langsat	4	4	5	1	6	8	2	6	3	2	3	0
Mangos	5	3	8	3	3	4	4	5	2	4	6	0
Pineapple	6	7	5	8	9	10	3	6	7	9	4	0
XY1	3	2	1	10	3	7	9	1	8	10	10	0
XY2	5	5	5	5	5	5	8	1	1	5	5	0

Table 1.4 Plot Category table with dummy column

Notice that in our example the objective is to minimize the number of days spent on a project. Whereas in the first objective of our project is to maximize the return value. Thus, to apply the same procedure all the return values in Table 1.5 should be multiplied by -1. Refer to Table 1.6 for the resulted table after the modification.

	Plot category											
	1	2	3	4	5	6	7	8	9	10	11	12
Plant type												
Guava	-7	-2	.	-10	-7	-7	-10	-6	-10	-4	-2	0
Starfruit	-5	-1	-5	-6	-6	-2	-8	-2	-4	-6	-5	0
Papaya	-8	-7	-6	-5	-5	-4	-7	.	-3	-10	-5	0
Cempadak	-2	-5	-2	-4	-5	-10	-2	-3	-6	-2	-5	0
Durian	-3	-3	-5	-8	.	-4	-7	-3	-4	-3	-4	0
Rambutan	-6	-2	-4	-3	-4	-3	-3	-3	-1	-1	-3	0
Mangosteen	-10	-8	-7	-2	-3	-3	-2	-3	-7	-3	-3	0
Langsat	-4	-4	-5	-1	-6	-8	-2	-6	-3	-2	-3	0
Mangos	-5	-3	-8	-3	-3	-4	-4	-5	-2	-4	-6	0
Pineapple	-6	-7	-5	-8	-9	-10	-3	-6	-7	-9	-4	0
XY1	-3	-2	-1	-10	-3	-7	-9	-1	-8	-10	-10	0
XY2	-5	-5	-5	-5	-5	-5	-8	-1	-1	-5	-5	0

Table 1.5 Plot category table after modification

Going through the steps in the procedure of the Hungarian method. the optimal solution as to maximize the return value is shown below.

Plant type	Plot category	Return value
Guava	9	-10
Starfruit	7	-8
Papaya	10	-10
Cempadak	6	-10
Durian	4	-8
Pineapple	5	-9
Rambutan	.	.
Mangosteen	1	-10
Langsat	8	-6
Mango	3	-8
XY1	11	-10
XY2	2	-5

Table 1.6 Optimal solution of return value

Thus the optimal assignment is as above with the maximum return value of (-10+ -8 + -10 +....+ -8 + -10 + -5) X (-1) = 94. From the result it is recommended to discard rambutan.

To verify the optimal result obtained, the problem is also solved using Proc Assign in SAS. Figure 1.0 displays the source code of the program. The results from the SAS log and SAS listing are agreeable with the optimal result obtained manually.

```
Data Rvalue;
Input ptype $ RP1 RP2 RP3 RP4 RP5 RP6 RP7 RP8 RP9 RP10 RP11;
Cards;
Guava       -7  -2   .   -10  -7   -7   -10  -6   -10  -4   -2
Starfruit   -5  -1   -5  -6   -6   -2   -8   -2   -4   -6   -5
Papaya      -8  -7   -6  -5   -5   -4   -7    .   -3   -10  -5
Cempadak    -2  -5   -2  -4   -5   -10  -2   -3   -6   -2   -5
Durian      -3  -3   -5  -8    .   -4   -7   -3   -4   -3   -4
Rambutan    -6  -2   -4  -3   -4   -3   -3   -3   -1   -1   -3
Mangosteen  -10 -8   -7  -2   -3   -3   -2   -3   -7   -3   -3
Langsat     -4  -4   -5  -1   -6   -8   -2   -6   -3   -2   -3
Mangos      -5  -3   -8  -3   -3   -4   -4   -5   -2   -4   -6
Pineapple   -6  -7   -5  -8   -9   -10  -3   -6   -7   -9   -4
XY1         -3  -2   -1  -10  -3   -7   -9   -1   -8   -10  -10
XY2         -5  -5   -5  -5   -5   -5   -8   -1   -1   -5   -5
;

Proc Assign data= Rvalue;
  Cost RP1-RP11;
  ID Ptype;
Proc Print;
```

Figure 1.0 Assignment program

Minimizing the cost of transportation and service .

Since the objective is minimization of the transportation and service cost and the number of rows and columns are unequal, Hungarian Method (manually) or the Proc Assign in SAS cannot be applied. Rather, transportation technique (manually) or the Proc Trans in SAS can easily be used to solve such problem. Table 2.0 displays the cost requirement table.

	Market Centers										
	1	2	3	4	5	6	7	8	9	10	Supply
Fruit type											
Guava	.	.	.	.	30	35	25	40	.	.	50
Starfruit	.	.	.	.	15	32	25	.	.	.	60
Papaya	.	.	.	.	21	25	20	.	.	.	50
Cempadak	.	.	.	.	.	.	18	.	35	60	50
Durian	.	.	.	.	.	.	42	.	.	.	30
Rambutan	.	.	.	.	.	22	18	.	.	.	70
Pineapple	25	21	.	35	.	.	.	.	.	.	50
Mangosteen	65	55	51	63	.	.	.	.	.	.	75
Langsat	57	63	72	35	.	.	.	.	.	.	20
Mango	36	48	32	28	.	.	.	.	.	.	30
XY1	.	.	.	.	.	33	.	.	.	.	60
XY2	.	.	.	.	.	33	.	.	.	.	60
Demand	30	20	70	30	60	30	20	50	50	25	

Table 2.0 Cost requirement table

Since the problem is solved manually, the initial step is to modify tahe cost requirement table so that Supply is equal to demand. Presently the demand is 38500 cartons and the supply is 60500 cartons. This is accomplished by introducing a dummy demand as follows:

	Market Centers											
	1	2	3	4	5	6	7	8	9	10	Dummy	Supply
Fruit type												
Guava	.	.	.	.	30	35	25	40	.	.	.	50
Starfruit	.	.	.	.	15	32	25	.	.	.	.	60
Papaya	.	.	.	.	21	25	20	.	.	.	.	50
Cempadak	.	.	.	.	.	.	18	.	35	60	.	50
Durian	.	.	.	.	.	.	42	.	.	.	.	30
Rambutan	.	.	.	.	.	22	18	.	.	.	.	70
Pineapple	25	21	.	35	.	.	.	.	.	.	.	50
Mangosteen	65	55	51	63	.	.	.	.	.	.	.	75
Langsat	57	63	72	35	.	.	.	.	.	.	.	20
Mango	36	48	32	28	.	.	.	.	.	.	.	30
XY1	.	.	.	.	.	33	.	.	.	.	.	60
XY2	.	.	.	.	.	33	.	.	.	.	.	60
Demand	30	20	70	30	60	30	20	50	50	25	225	

Table 2.1 Cost Requirement table after adding dummy demands

The next step before going through the algorithm to check whether the solution is optimal, Vogel approximation method is used to get the initial feasible solution. Refer to Appendix I for Vogel Approximation procedure. Figure 2.0 shows the source codes of the transportation program.

```
Data Ladang;
Input source$    Mktctr1-Mktctr10  capacity;
cards;
Forecast      30  20  70  30  60  30  20  50  50  25  .
Guava          .   .   .   .  30  35  25  40   .   .  50
Starfruit      .   .   .   .  15  32  25   .   .   .  60
Papaya         .   .   .   .  21  25  20   .   .   .  50
Cempedak       .   .   .   .   .   .  18   .   .   .  50
Durian         .   .   .   .   .   .  42   .   .   .  30
Rmbutan        .   .   .   .   .  22  18   .   .   .  70
Pineaple      25  21   .  35   .   .   .   .   .   .  50
Mngosten       5  55  51  63   .   .   .   .   .   .  75
Langsat       57  63  72  35   .   .   .   .   .   .  20
Mango         36  48  32  28   .   .   .   .  75   .  30
XY1            .   .   .   .   .   0   .   .   .   .  60
XY2            .   .   .   .   .  33   .   .   .   .  60
;
Proc trans   cost =ladang   out=result   nothrunet;
Tailnode      source;
Headnode      Mktctr1-Mktctr10;
Supply        Capacity;
Proc print  data= result;
```

Figure 2.0 Transportation and service cost program

The summary of the results obtianed from the SAS listing program is as follows:

	Market Centers									
	1	2	3	4	5	6	7	8	9	10
Fruits										
Guava	.	.	.	.	.	.	.	50	.	.
Starfruit	.	.	.	.	60	.	.	.	.	.
Papaya	.	.	.	.	.	.	.	.	.	.
Cempedak	.	.	.	.	.	.	.	.	25	25

Durian	.	.	.	.	.	.	.	.	.	.	.
Rambutan	.	.	.	.	.	.	.	.	.	.	.
Pineaple	30	20	.	.	.	.	.	.	.	.	.
Mngosten	.	.	70	5	.	.	.	.	.	.	.
Langsat	.	.	.	20	.	.	.	.	.	.	.
Mango	.	.	.	5	.	.	.	.	75	.	
XY1	.	.	.	.	.	30	.	.	.	.	
XY1	.	.	.	.	.	.	.	.	.	.	.

Optimal solution (minimum transportation cost) = $ 13405. However, the actual optimal solution should be added by (33 X 300) $990 since the cost of transporting XY1 in the SAS program is forced to be zero so as to ensure that XY1 will be transported to Market Center 6.

Thus, the best assignment of fruit type to market center in the effort to minimize the cost of transportation and service is as shown above with the cost value of M$14395.

Conclusion

Management should assign guava to plot 9, starfruit to plot 7, papaya to plot 10, cempedak to plot 6, durian to plot 4, pineapple to plot 5, mangosteen to plot 1, langsat to plot 8, mango to plot 3, XY1 to plot 11 and XY2 to plot 12 with a total return value of 94. Thus, Kebun Niaga overall total maximum profit per batch is M$9400. In order to achieve the minimum transportation cost, guava should be sent to MC 8, starfruit to MC 5, papaya to MC 9 and MC 10, pineapple to MC 1 and MC2, mangosteen to MC 3 and MC 4, langsat to MC 4, mango to MC 4 and MC 9 and XY1 to MC 6 with total cost of M$14395.

Recommendation

The problem faced by Kebun Niaga is solved manually at the plantation due to its budget constraint. For validation and minimizing the time, SAS/OR module are used by the reseacher at Universiti Teknologi Malaysia However, for bigger sized problem, it is highly recommended to use SAS (Statistical Analysis System/ Strategic Application System) using the Assign procedure, Trans procedure in the OR module. This will enhance the efficiency of the management. ■

Biografi

Pn Faridah bt Maarof adalah pensyarah di Jabatan Penyelidikan Operasi, Fakulti Sains Komputer dan Sistem Maklumat, UTM Jalan Semarak. Beliau memperolehi ijazah B.Sc. di dalam Statisitics dan M.Sc. di dalam Operations Research, kedua-duanya daripada Western Michigan University, USA. Beliau giat menjalankan penyelidikan di dalam bidang olahperang dan komputer raksaksa. Beliau juga bergiat di dalam jawatankuasa seminar; Inst of Statistics of Malaysia Seminar, Julai '92 dan Seminar Komputer dan Islam, Ogos 92, kedua-duanya di UTM. Di antara kertaskerja yang telah dibentangkan adalah "OR/Statistics : Aid in Decision Making", Inst. of Statistics Malaysia Seminar Julai '92 dan " "Mathematical Modelling of Observation Module", Mathematical Science Conference, '92. ■