Linear Programming Examples using Julia/JuMP

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Example 1: Avocado Plant

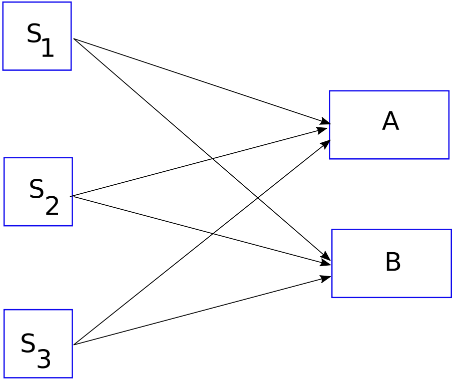
An avocado oil company owns two A and B processing plants. Plants A and B can process a maximum of 460 and 650 Ton, respectively. The labor cost turns is 26 and 21 $/Ton for plants A and B, also respectively. The avocado oil sale price turns out to be $50/T regardless the manufacturing plant.
To meet the avocado oil manufacturing aims, the company can purchase avocado raw material from three different sellers: S_1, S_2 and S_3. In the following table, maximum avocado supply and purchase cost from each seller are shown.

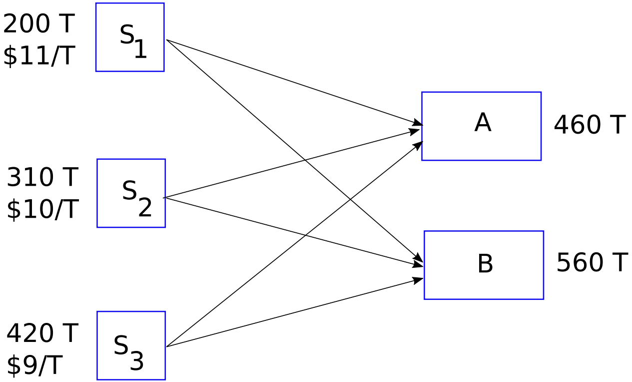
Seller	Maximum Supply [T]	Purchase cost [$/T]
S_1	200	11
S_2	310	10
S_3	420	9

Moreover, transportation costs [$/T] should also be taken into account to get a realistic net profit. Transportation cost are shown in next table.

Seller	Plant A	Plant B
S_1	3	3.5
S_2	2	2.5
S_3	6	4

Problem: We would like to compute the avocado amount to be purchase from each seller and the amount to be sent to each manufacturing plant such that net profit is maximized.


S1
S2
S3
A
B


200 T
$11/T
S_1
310 T
$10/T
S_2
420 T
$9/T
S_3
A
460 T
B
560 T

Results

- Amount [Ton] of avocado shipped to each plant

Seller	Plant A	Plant B
S_1	60	140
S_2	310	0
S_3	0	120

- Amount of avocado oil [Ton] manufactured at each plant

Plant	Amount [Ton]
A	370
B	560

- Economic Analysis

Gross Profit	46500
Labor Cost	21380
Raw Material Cost	9080
Transport Cost	2970.0
Net Profit	13070

- JuMP code

```
using JuMP, Clp
avocado_model = Model(solver=ClpSolver())
@variable(avocado_model, s1a >= 0, start = 100)
@variable(avocado_model, s2a >= 0, start = 150)
@variable(avocado_model, s3a >= 0, start = 200)
@variable(avocado_model, s1b >= 0, start = 100)
@variable(avocado_model, s2b >= 0, start = 150)
@variable(avocado_model, s3b >= 0, start = 200)
@variable(avocado_model, pa >= 0, start = 150)
@variable(avocado_model, pb >= 0, start = 200)
@objective(avocado_model, Max, 50pa+50pb-26pa-21pb-11(s1a+s1b)-10(s2a+s2b)
-9(s3a+s3b)-3s1a-3.5s1b- 2s2a -2.5s2b - 6s3a - 4s3b)
@constraint(avocado_model, c1, s1a+ s1b <= 200)
@constraint(avocado_model, c2, s2a+ s2b <= 310)
@constraint(avocado_model, c3, s3a+ s3b <= 420)
@constraint(avocado_model, c4, s1a + s2a + s3a <= 460)
@constraint(avocado_model, c5, s1b + s2b + s3b <= 560)
@constraint(avocado_model, c6, s1a + s2a + s3a == pa)
@constraint(avocado_model, c7, s1b + s2b + s3b == pb)
print(avocado_model)
status_avocado_model = solve(avocado_model)
println("Status of solution:", status_avocado_model)
println("s1a =", getvalue(s1a))
println("s2a =", getvalue(s2a))
println("s3a =", getvalue(s3a))
println("s1b =", getvalue(s1b))
println("s2b =", getvalue(s2b))
println("s3b =", getvalue(s3b))
println("pa =", getvalue(pa))
println("pb =", getvalue(pb))
```

- JuMP code

```
gross_profit = 50*getvalue(pa)+50*getvalue(pb)
labor = 26getvalue(pa)+21getvalue(pb)
raw_material = 11(getvalue(s1a)+getvalue(s1b))+10(getvalue(s2a)+getvalue(s2b))
+9(getvalue(s3a)+getvalue(s3b))
transport = 3getvalue(s1a)+3.5getvalue(s1b)+ 2getvalue(s2a) +2.5getvalue(s2b)
+ 6getvalue(s3a) + 4getvalue(s3b)
println("Gross Profit = ", gross_profit)
println("Labor cost = ", labor)
println("Raw Mat. cost = ", raw_material)
println("Transport cost = ", transport)
```

Example 2: Polymer Plant

A chemical company runs a polymer plant where three different grades A, B, C are manufactured. There are available 4 different batch reactors (denoted as R_1, R_2, R_3 and R_4) for polymers manufacture. Although the manufactured batch size for each grade is the same regardless of the type of reactor, each reactor requires different processing time [min/batch] for polymer production as shown in the next table.

Grade	R_1	R_2	R_3	R_4
A	5	7	4	10
B	6	12	8	15
C	13	14	9	17

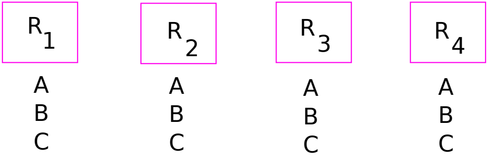
The sale price [$/batch] of each polymer is different depending on the reactor where it was manufactured as shown in the next table:

Grade	R_1	R_2	R_3	R_4
A	10	8	6	9
B	18	20	15	17
C	15	6	13	7

Polymer manufacture should meet the following grades demand:

Grade	Demand [number of batches]
A	100
B	150
C	100

How many batches of each grade should be manufactured such that polymer demands are met, assuming a 40 h/week working load, such that process profit is maximized?


R1
R2
R3
R4
A
B
C
A
B
C
A
B
C
A
B
C

Results

We have solved the problem under the following 2 operating scenarios:

- No Inventory is allowed

Profit = \$5500

Grade	R_1	R_2	R_3	R_4	$\sum$
A	100	0	0	0	100
B	0	150	0	0	150
C	100	0	0	0	100

- Some kind of inventory would be available

Profit = \$17882.5

Grade	R_1	R_2	R_3	R_4	$\sum$
A	0	0	100	0	100
B	400	200	137.5	160	897.5
C	0	0	100	0	100

- JuMP code

```
using JuMP, Clp
polymer_plant = Model(solver=ClpSolver())
@variable(polymer_plant, bar1 >= 0, start = 50)
@variable(polymer_plant, bar2 >= 0, start = 50)
@variable(polymer_plant, bar3 >= 0, start = 50)
@variable(polymer_plant, bar4 >= 0, start = 50)
@variable(polymer_plant, bbr1 >= 0, start = 50)
@variable(polymer_plant, bbr2 >= 0, start = 50)
@variable(polymer_plant, bbr3 >= 0, start = 50)
@variable(polymer_plant, bbr4 >= 0, start = 50)
@variable(polymer_plant, bcr1 >= 0, start = 50)
@variable(polymer_plant, bcr2 >= 0, start = 50)
@variable(polymer_plant, bcr3 >= 0, start = 50)
@variable(polymer_plant, bcr4 >= 0, start = 50)
@objective(polymer_plant, Max, 10bar1+8bar2+6bar3+9bar4+18bbr1+20bbr2+15bbr3
+17bbr4+15bcr1+6bcr2+13bcr3+7bcr4)
@constraint(polymer_plant, c1, bar1 + bar2 + bar3 + bar4 >= 100)
@constraint(polymer_plant, c2, bbr1 + bbr2 + bbr3 + bbr4 >= 150)
@constraint(polymer_plant, c3, bcr1 + bcr2 + bcr3 + bcr4 >= 100)
@constraint(polymer_plant, c4, 5bar1 + 6bbr1 + 13bcr1 <= 2400)
@constraint(polymer_plant, c5, 7bar2 + 12bbr2 + 14bcr2 <= 2400)
@constraint(polymer_plant, c6, 4bar3 + 8bbr3 + 9bcr3 <= 2400)
@constraint(polymer_plant, c7, 10bar4 + 15bbr4 + 17bcr4 <= 2400)
print(polymer_plant)
status_polymer_model = solve(polymer_plant)
```

- JuMP code

```
println("Objective function value = ", getobjectivevalue(polymer_plant))
println("bar1 =", getvalue(bar1))
println("bar2 =", getvalue(bar2))
println("bar3 =", getvalue(bar3))
println("bar4 =", getvalue(bar4))
println("bbr1 =", getvalue(bbr1))
println("bbr2 =", getvalue(bbr2))
println("bbr3 =", getvalue(bbr3))
println("bbr4 =", getvalue(bbr4))
println("bcr1 =", getvalue(bcr1))
println("bcr2 =", getvalue(bcr2))
println("bcr3 =", getvalue(bcr3))
println("bcr4 =", getvalue(bcr4))
```