

Introduction to Optimization Through the Lens of Data Science Course Exercises



Exercises - Section 4: Lecture 11 - Notation Subscripts Summations - Solutions

Traditionally, optimization experts use letters at the beginning of the alphabet to denote data – things that the optimization model can't suggest changes to, like the cost of purchasing a raw material or the forecasted demand for a product. The tradition for variables is to start with x, y, and z, and then go back to w and work backwards.

I'm not sure exactly where the tradition came from, but by now this is what we're stuck with - so let's go ahead and embrace it!

[Note, though, that there are exceptions. For example, some modelers use letters that match what's being modeled – for example, P for price, C for cost, T for temperature, etc. You can use whatever you want, as long as you clearly define the terms.]

Suppose we have the following notation for a rental car fleet planning model:

DESCRIPTION	MATH	GUROBIPY
Forecasted rental demand for	A	A
small cars (forecasted data)		(typically declared with a value, e.g., A = 10,
		or read from a file)
Forecasted rental demand for	В	В
midsize cars (forecasted data)		
Forecasted rental demand for	С	С
luxury cars (forecasted data)		
Forecasted rental demand for	D	D
SUVs (forecasted data)		
Forecasted rental demand for	E	E
minivans (forecasted data)		
Cost per small car (known data)	F	F
Cost per midsize car (known	G	G
data)		
Cost per luxury car (known data)	Н	Н
Cost per SUV (known data)	I	I
Cost per minivan (known data)	J	J
Number of small cars to	X	<pre>X = model.addVar(name = 'X')</pre>
purchase (variable)		
Number of midsize cars to	Y	Y = model.addVar(name = 'Y')
purchase (variable)		
Number of luxury cars to	Z	<pre>Z = model.addVar(name = 'Z')</pre>
purchase (variable)		
Number of SUVs to purchase	W	<pre>W = model.addVar(name = 'W')</pre>
(variable)		
Number of minivans to purchase	V	<pre>V = model.addVar(name = 'V')</pre>
(variable)		



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Fill in the table below, using the notation above to describe each of the following quantities mathematically and in Python.

QUESTION	MATH	GUROBIPY	
1. Forecasted rental demand	С	С	
for luxury cars			
2. Forecasted rental demand	D	D	
for SUVs			
3. Cost per SUV	I	I	
4. Number of small cars to	X	X	
purchase		(or $X \cdot x$ if you want the value of	
		X)	
5. Forecasted demand for	B+E	B+E	
midsize cars and minivans			
6. Forecasted rental demand	A+B+C	A+B+C	
for cars (not SUVs or minivans)			
7. Total cars to purchase above	Z + W + V	Z+W+V	
midsize			
8. Total vehicles to purchase	X + Y + Z + W + V	X+Y+Z+W+V	
9. Cost of midsize cars	GY	G*Y	
purchased			
10. Cost of SUVs purchased	IW	I*W	
11. Cost of midsize cars and	BY + JV	B*Y+J*V	
minivans purchased			
12. Cost of SUVs and minivans	IW + JV	I*W+J*V	
13. Cost of all cars (not SUVs or	FX + GY + HZ	F*X+G*Y+H*Z	
minivans) purchased			
14. Cost of all vehicles	FX + GY + HZ + IW + JV	F*X+G*Y+H*Z+I*W+J*V	
purchased			
15. Forecasted purchase cost	IW	I*W / D	
per rental of SUVs	\overline{D}		
16. Forecasted purchase cost	JV	J*V / E	
per rental of minivans	\overline{E}		
17. Average purchase cost over	IW + JV	(I*W+J*V)/(W+V)	
all SUVs and minivans	W + V		
18. Average purchase cost of	FX + GY + HZ	(F*X+G*Y+H*Z)/(X+Y+Z)	
all cars (not SUVs or minivans)	X+Y+Z		
19. Forecasted purchase cost	FX + GY + HZ	(F*X+G*Y+H*Z)/(A+B+C)	
per rental over all cars (not	A+B+C		
SUVs or minivans)			
20. Forecasted purchase cost	FX + GY + HZ + IW + JV	(F*X+G*Y+H*Z+I*W+J*V)/	
per rental over all vehicles	A+B+C+D+E	(A+B+C+D+E)	

NOTES:		

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