Introduction to Optimization Through the Lens of Data Science Course Exercises

Sexercises - Section 4: Lecture 12 – Constraints with Two Subscripts – Questions - Part 2

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

DESCRIPTION	MATH	GUROBIPY
Car types: $i=1$ (small), $i=2$	i	i
(midsize), i =3 (luxury), i =4		
(SUV), i=5 (minivan)		
Rental locations (100 locations,	j	j
so <i>j</i> =1,2,,100)		
Forecasted annual rental	D_{ij}	$D = \{(i, j): d \text{ for } i \text{ in} \}$
demand for car type i at	-	range(1, 6) for j in range(1, 101)}
location <i>j</i> (forecasted data)		
		NOTE: This assumes d is
		defined elsewhere in the code.
Cost per car for car type i	C_i	$C = \{i: c \text{ for } i \text{ in } \}$
(known data; same cost		range(1, 6)}
regardless of location)		NOTE: This assumes c is
		defined elsewhere in the code.
Number of cars of type i to	x_{ij}	x = model.addVars([(i, j)
purchase for location <i>j</i>		for i in range(1, 6) for j in range(1, 101)],
(variable)		name="x")

NOTE: You might have noticed that in the table above, the gurobipy code is not color-coded like it could be in some editors. We want you to get comfortable with different views of the code, so sometimes you'll see color and sometimes not; it doesn't affect the execution of the code. Similarly, you'll sometimes see different ways of doing the same thing in gurobipy, and different allowable syntaxes. For example, in the table above the name of the variables is defined in double quotes and in the table below it's defined in single quotes. There isn't an execution difference, so we want you to see and be comfortable with both ways.

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

CONSTRAINT	MATH	GUROBIPY
1. Must purchase at least 200		
luxury cars across all locations		
2. Number of luxury cars		
purchased across all locations		
can be no more than 10% of all		
vehicle purchases		



Introduction to Optimization Through the Lens of Data Science Course Exercises

3. Number of midsize cars	!	
purchased at location 4 must be		
at least 1% of the forecasted		
annual demand for midsize cars	!	
at that location		
4. Number of midsize cars		
purchased at each location must		
be at least 1% of the forecasted		
annual demand for midsize cars		
at that location		
5. Number of vehicles of each		
type purchased at location 4		
must be at least 1% of the		
forecasted annual demand for		
that type of vehicle at location 4		
6. Number of vehicles of each		
type purchased at each location		
must be at least 1% of the		
forecasted annual demand for		
that type of vehicle at the		
location		
7. At location 71, the number of		
cars of each type (small,		
midsize, luxury) purchased must		
be at least 1% of the forecasted	!	
annual demand for that type of		
vehicle at the location		
8. Free upgrades are allowed.		
When purchasing cars (small,		
midsize, luxury) at location 71,		
enough cars of each type need		
to be purchased to meet at least		
1% of the forecasted annual		
demand with a car of that size		
or an upgrade. (So, for example,		
demand for midsize cars could		
be met by having midsize and		
luxury cars available.)		



Introduction to Optimization Through the Lens of Data Science Course Exercises

9. Free upgrades are allowed.	
When purchasing cars (small,	
midsize, luxury) at each location,	
enough cars of each type need	
to be purchased to meet at least	
1% of the forecasted annual	
demand with a car of that size	
or an upgrade. (So, for example,	
demand for midsize cars could	
be met by having midsize and	
luxury cars available.)	
10. The average cost of all	
vehicles purchased at location	
12 can be no more than \$40,000	
11. The average cost of all	
vehicles purchased across all	
locations can be no more than	
\$40,000	
12. The average cost of all	
vehicles purchased <u>at each</u>	
location can be no more than	
\$40,000	
13. The cost of all vehicles per	
forecasted rental can be no	
more than \$100	

NOTES:		
NOTES.		

This is an open education course, and we encourage faculty and students to use the exercises and materials included to help meet educational and instructional goals. Gurobi Optimization, LLC ("Gurobi") is the owner of the content (all right, title, and interest) of this course ("Content"). Content is not designed or intended for commercial use or for the sale of courses. Gurobi makes this Content available at no cost for educational and instructional use via faculty and student download and use of Content in courses offered at your institution/organization; provided that such use does not scale or otherwise result in the use of Content for monetary gain including in any other online course. Content is offered as-is and all risk of use resides with you. Gurobi makes no warranties or guarantees of a particular outcome and accepts no liability, direct, consequential, or otherwise, arising from the access to or use of the course and Content contained in it.