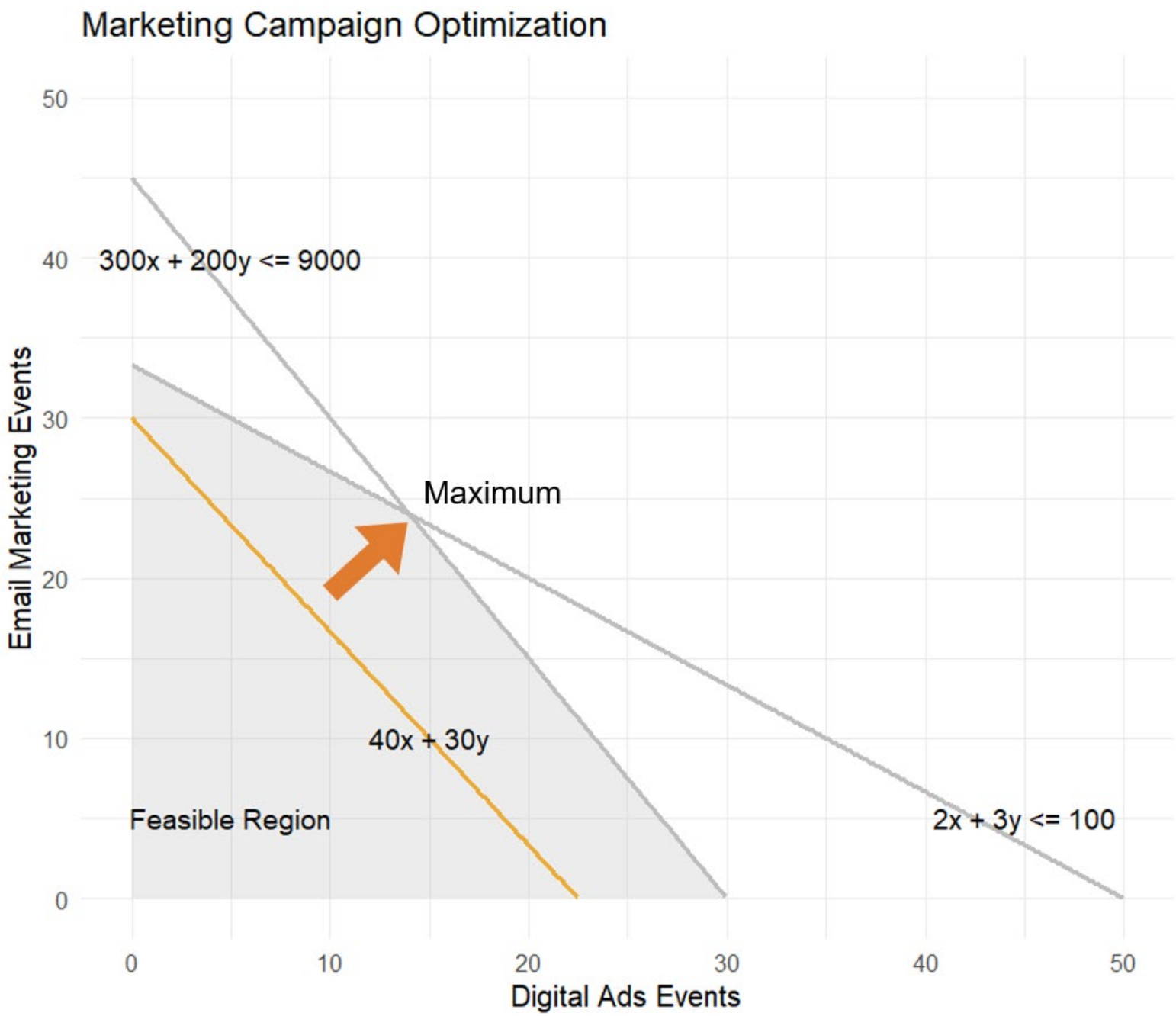
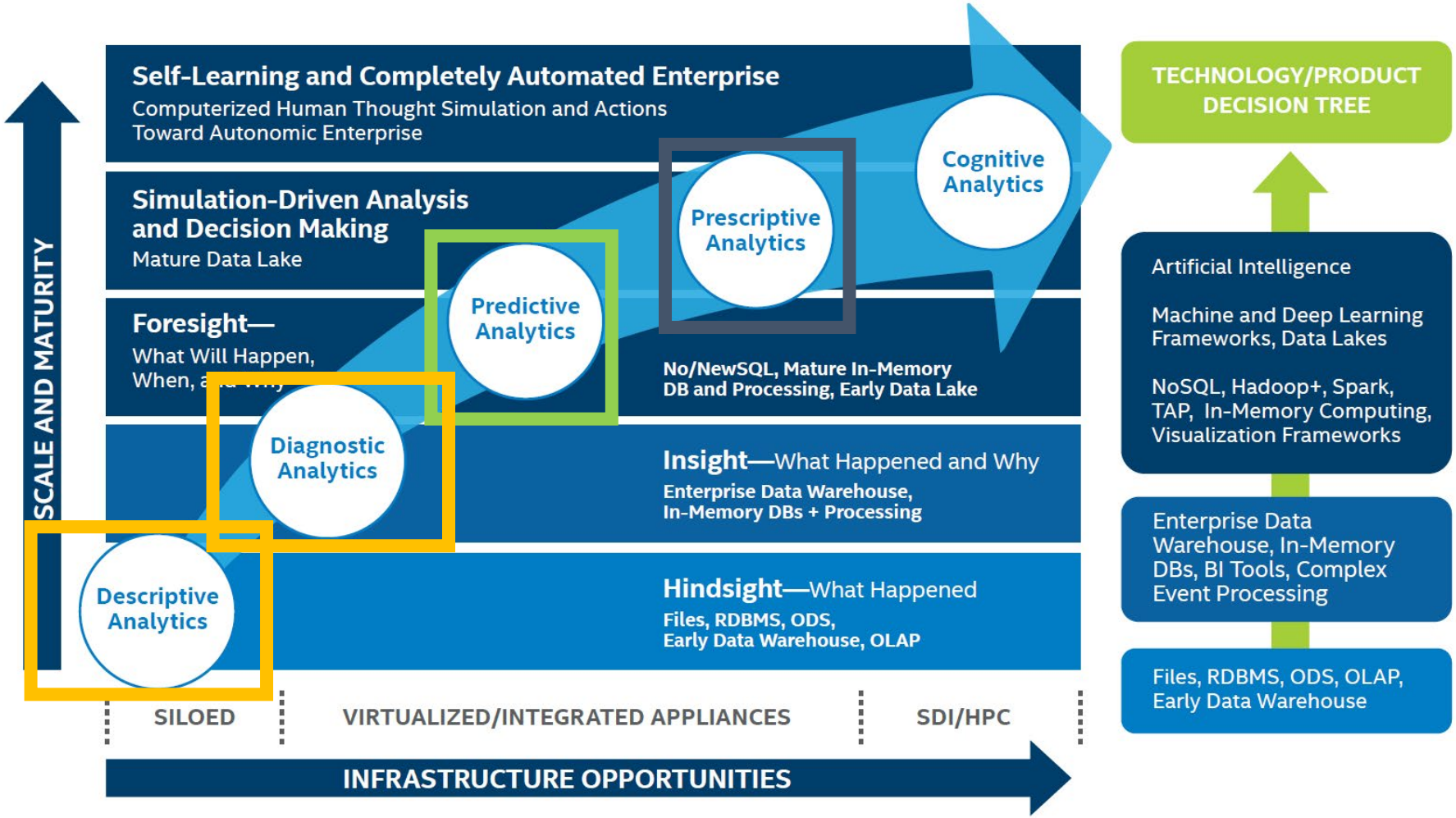
Prescriptive Analytics

Business Intelligence



Terry College of Business
UNIVERSITY OF GEORGIA

Advanced Analytics Maturity Path



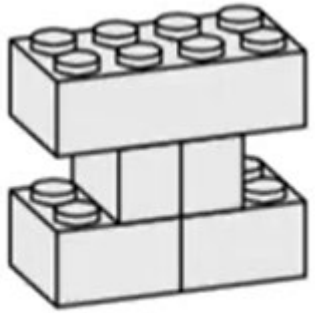
https://www.intel.com/content/www/us/en/analytics/getting-started-advanced-analytics-planning-guide.html

Prescriptive Analytics Tools

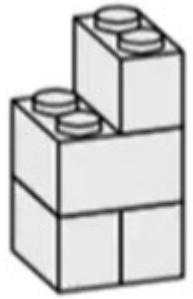
- Decision Analysis under Uncertainty
  - Decision Trees
  - Simulation
- Optimization
- Among others

Lego Furniture – Adapted from Tallys Yunes' Class

You have been hired by a company that makes and sells two products, which must look *exactly* as depicted here:



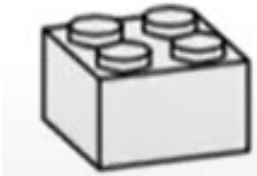
The Brickell bench



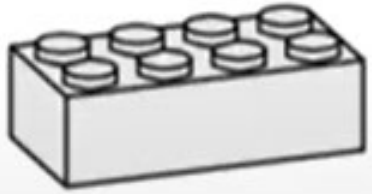
The Wynwood chair

Your supplier can provide you with the following parts, up to the quantities indicated, and for the costs shown below:

Up to 20, $1 each



Up to 10, $2 each



Up to 4, $4 each

What is the best collection of benches and chairs that can be made with the available parts?

Lego Furniture – Continued

What is the most profitable collection of benches and chairs that can be made with the available parts?

Each bench sells for $40, and each chair sells for $21.

What if your supplier now offers to sell you an additional 2×1 for $1? Would you buy it? How about two additional, or three, or four additional 2 × 1's for $1 each?

What if they lowered the price to $0.75 each?

Optimization - Linear programming

A mathematical technique for determining the optimum allocation of resources subject to a linear objective function and linear constraints

Linear programming is an entry point to the general field of mathematical programming and optimization

What's in a Linear Problem?

$$z = c_1x_1 + c_2x_2 + \cdots + c_px_p$$

$$a_{11}x_1 + a_{12}x_2 + \cdots + a_{1p}x_p \leq b_1$$

$$a_{21}x_1 + a_{22}x_2 + \cdots + a_{2p}x_p \leq b_2$$

$$\vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mp}x_p \leq b_m$$

$$x_1 \geq 0; \quad x_2 \geq 0; \quad \ldots \quad x_p \geq 0$$

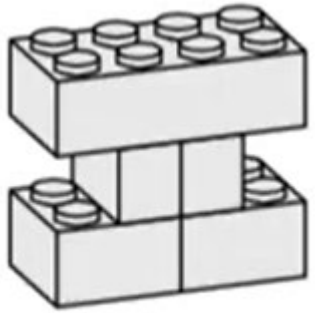
Objective: What needs to be optimized?

Variables: What are the things that can change in our model?

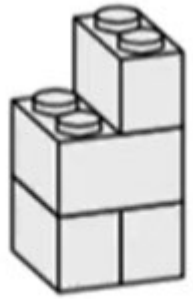
Constraints: What are the rules I must meet such as supply constraints or end-product specifications?

Lego Furniture

You have been hired by a company that makes and sells two products, which must look *exactly* as depicted here:



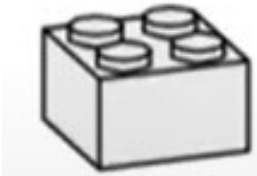
The Brickell bench



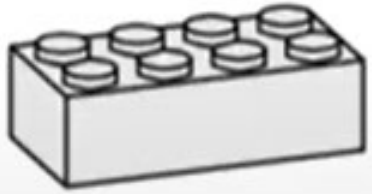
The Wynwood chair

Your supplier can provide you with the following parts, up to the quantities indicated, and for the costs shown below:

Up to 20, $1 each



Up to 10, $2 each



Up to 4, $4 each

If each bench sells for $40 and each chair sells for $21, what is the most profitable collection of benches and chairs that can be made with the available parts?

Lego Furniture

Let x = number of benches to manufacture
Let y = number of chairs to manufacture

Piece	Bench	Chair
2x1's	2	3
2x2's	2	1
2x4's	1	0

Profit of a bench:
40 - (2*1 + 2*2 + 1*4) = 30

Profit of a chair:
21 - (3*1 + 1*2 + 0*4) = 16

$$Max\ 30x + 16y$$

$$2x + 3y \leq 20 \text{ (2x1's)}$$

$$2x + y \leq 10 \text{ (2x2's)}$$

$$x \leq 4 \text{ (2x4's)}$$

$$x \geq 0$$

$$y \geq 0$$

Profit Maximization

As a BI Analyst, you advise a small company planning marketing campaigns across two channels: *Digital Ads* (Channel A) and *Email Marketing* (Channel B). The goal is to maximize the return on investment (ROI) from these marketing efforts by determining the optimal allocation of the marketing budget and resources (e.g., time, effort, and staff) between the two channels.

Channel A (*Digital Ads*) is expected to generate $40 in profit per campaign event, while Channel B (*Email Marketing*) is expected to generate $30 in profit per event.

Resource requirements (Staff hours and Budget):

- Channel A requires 2 hours of staff time per event, and Channel B requires 3 hours. The company has 100 staff hours available for the campaign.
- Channel A requires $300 per event, and Channel B requires $200 per event. The total available budget for the marketing campaign is $9,000.

	Channel A	Channel B
Staff	2	3
Budget	300	200

Using the available resources (staff hours and budget), how many *Digital Ads* and *Email Marketing* events should the company launch to maximize total profit from the marketing campaign?

Profit Maximization

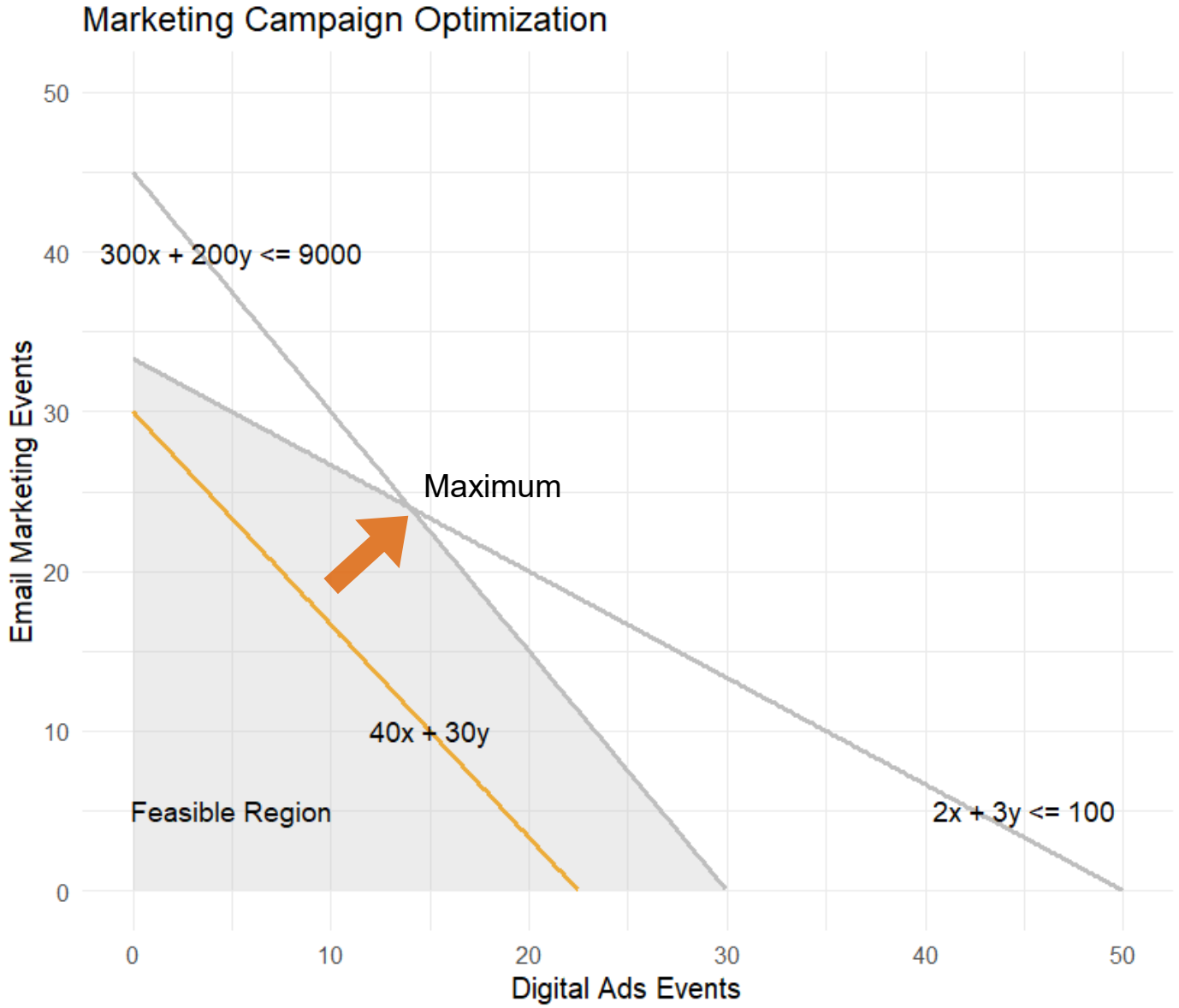
Let x = number of *Digital Ads* events
Let y = number of *Email Marketing* events

Maximize 40*x + 30*y
2*x + 3*y ≤ 100 (Staff hours)
300*x + 200*y ≤ 9,000 (Budget)

	Channel A	Channel B
Staff	2	3
Budget	300	200

Profit Maximization

Maximize 40*x + 30*y
2*x + 3*y ≤ 100 (Staff hours)
300*x + 200*y ≤ 9,000 (Budget)



Profit Maximization

Legend

R script input

Console output

```
library(lpSolveAPI)
lpmodel <- make.lp(0,2) # Start with 0 constraints and two variables
set.objfn(lpmodel, c(40, 30))
add.constraint(lpmodel, c(2, 3), "<=", 100)
add.constraint(lpmodel, c(300, 200),   "<=", 9000)
# set objective direction and hide the output
invisible(lp.control(lpmodel, sense = 'max'))
print(lpmodel)
Model name:
            C1    C2
Maximize    40    30
R1           2     3  <=   100
R2         300   200  <=  9000
Kind       Std   Std
Type      Real  Real
Upper      Inf   Inf
Lower        0     0
solve(lpmodel)
[1] 0
```

Profit Maximization

Profit

x=14
y=24

Shadow prices

```
p <-  get.objective(lpmodel)
paste0('Campaign profit: ',p[1])
Campaign profit: 1280

v <-  get.variables(lpmodel)
paste0('Digital Ads events: ', v[1])
Digital Ads events: 14
paste0('Email Marketing events: ', v[2])
Email Marketing events: 24

# Total number of events
paste0('Total number of events: ', v[1] + v[2])
Total number of events: 38
# Staff hours
paste0('Total staff hours used: ',2*v[1] + 3*v[2])
Total staff hours used: 100
# Budget
paste0('Total budget used: ',300*v[1] + 200*v[2])
Total budget used: 9000

d <-  get.dual.solution(lpmodel)
d
1.00 2.00 0.12 0.00 0.00

paste0('Having one more staff hour will increase profit by: ', d[2])
Having one more staff hour will increase profit by: 2
paste0('Having one more dollar in budget will increase profit by: ', d[3])
Having one more dollar in budget will increase profit by: 0.12
```

Legend

R script input

Console output