Marketing Budget Analysis

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RM 294

Marketing Budget Allocation Analysis

Introduction

Marketing budgets comprise 11% of total company budgets according to a recent survey. Knowing how to allocate the budget is a key part of maximizing the biggest return on your investment. For this analysis, we will be looking at how we can optimally allocate our $10 million budget to maximize our return. To perform our analysis, we reached out to two outside consulting firms to hand us projected ROIs(return on investments) for 10 mediums. These mediums include social media, legacy media, and other marketing mediums. Below are the estimated ROIs per medium according to the outside consulting firms.

Firm	Print	TV	SEO	AdWords	Facebook
First	3.1%	4.9%	2.4%	3.9%	1.6%
	LinkedIn	Instagram	Snapchat	Twitter	Email
	2.4%	4.6%	2.6%	3.3%	4.4%

Firm	Print	TV	SEO	AdWords	Facebook
Second	4.9%	2.3%	2.4%	3.9%	4.4%
	LinkedIn	Instagram	Snapchat	Twitter	Email
	4.6%	2.6%	1.9%	3.7%	2.6%

Before we can conduct our analysis, the boss has handed down the following three constraints concerning the optimal allocation:

1. The amount invested in Print and TV should not be greater than the amount invested in Facebook and Email.
2. The total amount invested in social media(Facebook, LinkedIn, Instagram, Snapchat, and Twitter) should be at least twice the amount invested in SEO and AdWords.
3. Do not invest more than $3 million in any platform.

Optimal Allocation and Objective Value

There are two steps in optimization, model development and then optimization. First, we formulate the problem in python by assigning our decision variables, constraints, and objective function.

```
names = list(roi.columns)
obj = np.array(roi.iloc[0][1:]) # First firm ROIs is our objective measure
A = np.zeros((13,10))
A[0,] = [1]*10 # Total budget constraint
A[1,] = [-1,-1,0,0,1,0,0,0,0,1] #Print/TV and Facebook/Email constraint
A[2,] = [0,0,-2,-2,1,1,1,1,1,0] #Social media and AdWords/SEO constraint
A[3:13,] = np.diag(np.ones(10)) # Individual platform budget constraint
b = np.array([10,0,0,3,3,3,3,3,3,3,3,3,3]) |
sense = np.array(['<','>','>','<','<','<','<','<','<','<','<','<','<'])
```

Next, we finally optimize our code to get our optimal objective value and optimal budget allocation.

```
Roi1Mod = gp.Model()
Roi1 = Roi1Mod.addMVar((10))
Roi1ModCon = Roi1Mod.addMConstrs(A, Roi1, sense, b)
Roi1Mod.setMObjective(None,obj,0,sense=gp.GRB.MAXIMIZE)
Roi1Mod.Params.OutputFlag = 0
Roi1Mod.optimize()
```

Based on the initial budget constraints and estimated ROIs given to us by the first firm, the optimized marketing budget allocation and return are displayed below:

```
The company should spend the following on each type of marketing:
$ 0.0 million on Print
$ 3.0 million on TV
$ 0.0 million on SEO
$ 1.0 million on AdWords
$ 0.0 million on Facebook
$ 0.0 million on LinkedIn
$ 3.0 million on Instagram
$ 0.0 million on Snapchat
$ 0.0 million on Twitter
$ 3.0 million on Email
This budget allocation has a ROI of 4.56 % from the original investment of $10 million.
```

We do the analysis again, but we change our objective function to use the ROIs given to us by the second firm. After conducting our analysis with the new ROIs, we received the following allocation and objective value:

```
The company should spend the following on each type of marketing:
$ 3.0 million on Print
$ 0.0 million on TV
$ 0.0 million on SEO
$ 1.0 million on AdWords
$ 3.0 million on Facebook
$ 3.0 million on LinkedIn
$ 0.0 million on Instagram
$ 0.0 million on Snapchat
$ 0.0 million on Twitter
$ 0.0 million on Email
This updated budget allocation has a ROI of 4.56 % from the original investment of $10 million.
```

Each ROI produces the same return, but they have a different optimal allocation. Here is a side-by-side comparison of the optimal allocation given the different ROIs.

Firm	Print	TV	SEO	AdWords	Facebook	LinkedIn	Insta	Snapchat	Twitter	Email
First	$0	$3M	$0	$1M	$0	$0	$3M	$0	$0	$3M
Second	$3M	$0	$0	$1M	$3M	$3M	$0	$0	$0	$0

The allocations are specific to the ROIs provided by each firm. If we calculated the return using the budget allocation of the first firm's ROI data and the actual ROI of the second firm, our optimal return would go down 1.92% or $192,000. The code for that solution is pictured below:

```
firstAlloSecROI = Roi1Mod.objval - sum((Roi1.x*obj2)) # First distribution and second ROI
```

On the other hand, if we calculated the return using the budget allocation of the second firm's ROI data and the actual ROI of the first firm, our optimal return would go down 2.04% or $204,000. The code for that solution is pictured below:

```
firstRoiSecAllo = Roi2Mod.objval - sum((Roi2.x*obj)) #second distribution and first ROI
```

Our manager was interested in the importance/use of the third constraint, which said that no medium should get more than $3 million in investment. Below is the code for calculating the new optimal allocation and objective value using the ROIs provided by the first firm.

```
# Without 3rd Constraint
A2 = np.zeros((3,10))
A2[0,] = [1]*10 # Budget constraint
A2[1,] = [-1,-1,0,0,1,0,0,0,0,1]
A2[2,] = [0,0,-2,-2,1,1,1,1,1,0]
b2 = np.array([10,0,0])
sense2 = np.array(['<','>','>'])

Roi3Mod = gp.Model()

Roi3 = Roi3Mod.addMVar(10)
Roi3ModCon = Roi3Mod.addMConstrs(A2, Roi3, sense2, b2)
Roi3Mod.setMObjective(None,obj,0,sense=gp.GRB.MAXIMIZE)
Roi3Mod.Params.OutputFlag = 0
Roi3Mod.optimize()
```

Without the third constraint, the return goes up from $456,000 to $465,000. The new optimal allocation follows the two constraints and maximizes the investment in mediums with high ROIs like TV and Email.

Firm	Print	TV	SEO	AdWords	Facebook	LinkedIn	Insta	Snapchat	Twitter	Email
First	$0	$5M	$0	$0	$0	$0	$0	$0	$0	$5M

The third constraint is very important to our analysis and requires the company to diversify its investments.

Sensitivity Analysis

The boss is satisfied with our return of $456,000, but he is interested to know how much the ROI for each medium can fluctuate and return the same objective value. The range for each medium is listed below:

Range	Print	TV	SEO	AdWords	Facebook
	-inf	3.9%	-inf	3.3%	-inf
Lower Bound	LinkedIn	Instagram	Snapchat	Twitter	Email
	-inf	3.9%	-inf	-inf	2.9%

Range	Print	TV	SEO	AdWords	Facebook
	4.9%	6.2%	3.9%	4.6%	2.9%
Upper Bound	LinkedIn	Instagram	Snapchat	Twitter	Email
	3.9%	inf	3.9%	3.9%	inf

Budget Reinvestment and Allocation

The boss has given us the opportunity to reinvest half of our returns after every month. To do this we will allocate using the ROI given to us by the first firm as the objective variable, but we will update the budget with the actual ROIs for the different mediums every month. This is how we formulated the problem:

```python
budget = 10
budget_list = []
allocation = []
for i in range(1,13):
    b3 = np.array([budget,0,0,3,3,3,3,3,3,3,3,3])
    sense = np.array(['<','>','>','<','<','<','<','<','<','<','<','<'])
    ojModel = gp.Model()

    ojModX = ojModel.addMVar(10)
    ojModCon = ojModel.addMConstrs(A, ojModX, sense, b3)
    ojModel.setMObjective(None,obj,0,sense=gp.GRB.MAXIMIZE)

    ojModel.Params.OutputFlag = 0
    ojModel.optimize()
    ojModel.objVal
    allocation.append(ojModX.x)
    ror = (ojModX.x@df_monthly.iloc[i-1,1:]*0.01*0.5)
    budget_list.append(budget)
    budget = budget + ror

months = ['Jan','Feb','Mar','Apr','May','Jun','Jul','Aug','Sep','Oct','Nov','Dec']
opt_allocation = pd.DataFrame(allocation, index=months ,columns=names[1:])
opt_allocation['budget'] = budget_list
opt_allocation = opt_allocation.round(3)
```

Over the year the budget has increased by 21.49%, but the allocation only changed with AdWords and Twitter receiving more investment. Below is a table that displays the change in allocation every month and the new budget.

	Print	TV	SEO	AdWords	Facebook	LinkedIn	Instagram	Snapchat	Twitter	Email	Budget
Jan	0.0	3.0	0.0	1.000	0.0	0.0	3.0	0.0	0.000	3.0	10.000
Feb	0.0	3.0	0.0	1.180	0.0	0.0	3.0	0.0	0.000	3.0	10.180
Mar	0.0	3.0	0.0	1.354	0.0	0.0	3.0	0.0	0.000	3.0	10.354
Apr	0.0	3.0	0.0	1.505	0.0	0.0	3.0	0.0	0.011	3.0	10.516
May	0.0	3.0	0.0	1.565	0.0	0.0	3.0	0.0	0.130	3.0	10.695
Jun	0.0	3.0	0.0	1.630	0.0	0.0	3.0	0.0	0.260	3.0	10.889
Jul	0.0	3.0	0.0	1.700	0.0	0.0	3.0	0.0	0.399	3.0	11.099
Aug	0.0	3.0	0.0	1.773	0.0	0.0	3.0	0.0	0.547	3.0	11.320
Sep	0.0	3.0	0.0	1.846	0.0	0.0	3.0	0.0	0.692	3.0	11.537
Oct	0.0	3.0	0.0	1.908	0.0	0.0	3.0	0.0	0.817	3.0	11.725
Nov	0.0	3.0	0.0	1.973	0.0	0.0	3.0	0.0	0.947	3.0	11.920
Dec	0.0	3.0	0.0	2.050	0.0	0.0	3.0	0.0	1.099	3.0	12.149

Budget by Month

Twitter and AdWords Allocation by Month
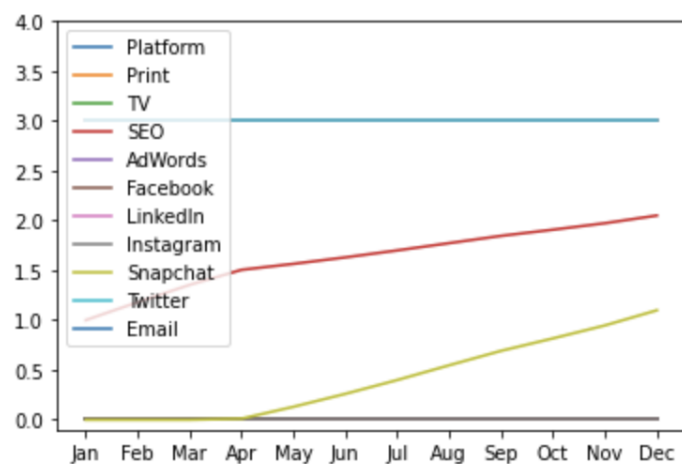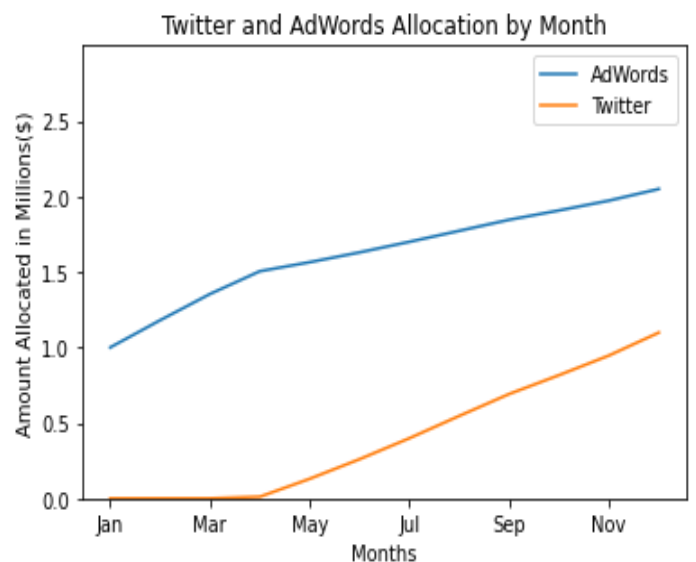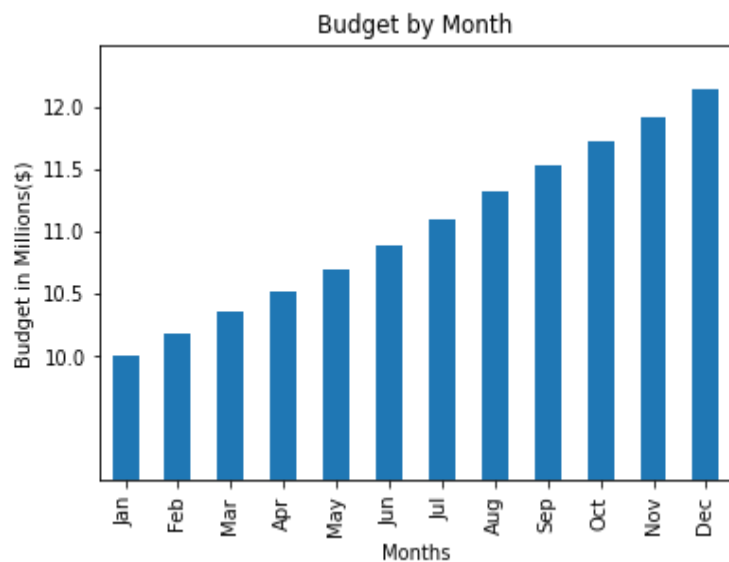
We wanted to determine if each medium had a stable budget so we set a threshold of no change greater than $1 million in any medium from month to month. Every medium is stable as the biggest budget increase in one month occurs when the AdWords budget increases by $180,000 in February. The allocation we found is stable.