

## Optimization I Project 1

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### Objective

This report's goal is to provide the best recommendation for how much the marketing division should invest in each of the different media channels to give the company the highest potential return on investment (ROI) while staying within the marketing division's set of limitations and its total budget of \$10 million. This report will explain how the problem was formulated, how it was solved for the optimal allocation strategy, and how the solution's sensitivity analysis was handled.

### Problem Formulation

*Objective function:*

Our objective is to maximize ROI by finding the optimal allocation for our \$10 million marketing budget on the various advertising mediums.

$$ROI = \sum (\text{Estimated ROI of mediums}) * (\text{Allocated amount to the medium})$$

*Constraints:*

The project is limited by a few other management-imposed restrictions in addition to the \$10 million budget, including:

- The amount invested in print and TV should be no more than the amount spent on Facebook and Email.
- The total amount used in social media (Facebook, LinkedIn, Instagram, Snapchat, and Twitter) should be at least twice of SEO and AdWords.
- For each platform, the amount invested should be no more than \$3M.

*Rationale behind third constraint:*

If we did not put a cap on medium-level allocations, the budget gets equally split into two mediums in case of either ROI data. However, there could be other factors at play that make investing in multiple different marketing mediums a smarter move. For example, maybe we reach different market segments in Facebook than through email, and we do not want to sacrifice that exposure in return for maximizing ROI in the short term, by only investing in email advertising because the ROI is high. Effects of diminishing returns could also be at play. It is possible that as ad spend increases past \$3 million in the TV medium the ROI starts to decrease.

### Optimal Allocations

ROI data:

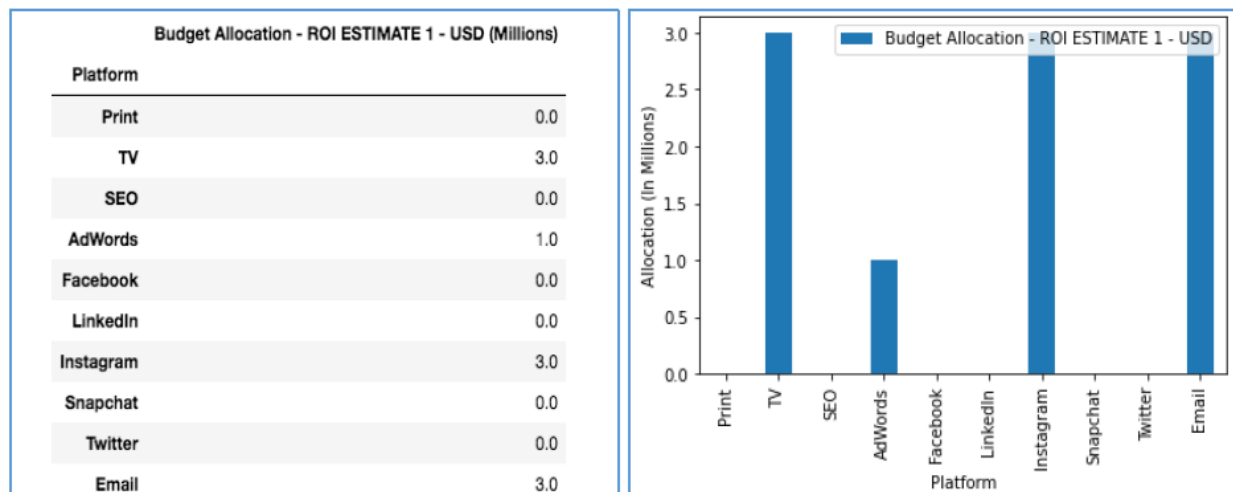
The two consulting firms provided the following ROI estimates. We contrast the results of these estimates in our analysis. Below numbers in absolute ROI terms -

	Print	TV	SEO	AdWords	Facebook	LinkedIn	Instagram	Snapchat	Twitter	Email
Platform										
ROI	0.031	0.049	0.024	0.039	0.016	0.024	0.046	0.026	0.033	0.044
Second Firms ROI Estimate	0.049	0.023	0.024	0.039	0.044	0.046	0.026	0.019	0.037	0.026

**Funds allocation as per ROI 1 data:**

Our optimal ROI after solving the model was 4.56% and the optimal allocation is displayed below:

Medium	Print	TV	SEO	AdWords	Facebook	LinkedIn	Instagram	Snapchat	Twitter	Email
Allocation (in millions)	0	3	0	1	0	0	3	0	0	3



The total expected ROI from the optimal allocation is:

Amount (USD) - ROI estimate 1 (In Millions)	
Summary	
Total Budget or Investment	10.000
Optimized ROI	0.456

### ***Funds allocation as per ROI 2 data:***

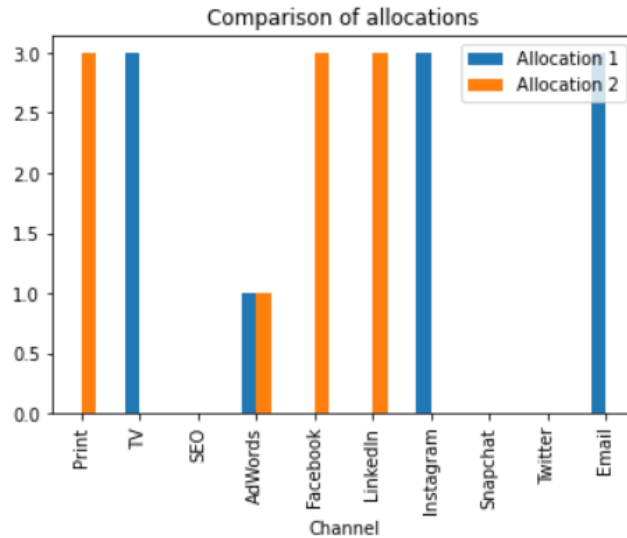
In order to compare the two versions of ROI data we ran the same model again, this time using the new ROI breakdown. The resulting optimal ROI was still 4.56% however the allocation did change. The allocation no longer includes TV, Instagram, or Email, and instead includes Print, Facebook, and LinkedIn. The only consistent investment is for \$1 million in AdWords.

Medium	Print	TV	SEO	AdWords	Facebook	LinkedIn	Instagram	Snapchat	Twitter	Email
Allocation (in millions)	3	0	0	1	3	3	0	0	0	0

### **Allocations Comparison**

Both the first and second set of ROI data yield an optimal ROI of 4.56% resulting in a ROI in dollars of \$456,000. However, each ROI data informs different allocation strategies for the mediums.

Budget Allocation - ROI ESTIMATE 1 - USD (Millions)		Budget Allocation - ROI ESTIMATE 2 - USD (Millions)	
Platform			
Print	0.0		3.0
TV	3.0		0.0
SEO	0.0		0.0
AdWords	1.0		1.0
Facebook	0.0		3.0
LinkedIn	0.0		3.0
Instagram	3.0		0.0
Snapchat	0.0		0.0
Twitter	0.0		0.0
Email	3.0		0.0



Assuming the first ROI data is correct, and we use the allocations obtained from the second ROI data, the return is \$0.204 million lower than the optimal returns.

Assuming the second ROI data is correct, and we use the allocations obtained from the second ROI data, the return is \$0.192 million lower than the optimal returns.

### Sensitivity Analysis

Platform	ROI		
	Minimum	Current	Maximum
Print	-inf	0.031	0.049
TV	0.039	0.049	0.062
SEO	-inf	0.024	0.039
AdWords	0.033	0.039	0.046
Facebook	-inf	0.016	0.029
LinkedIn	-inf	0.024	0.039
Instagram	0.039	0.046	inf
Snapchat	-inf	0.026	0.039
Twitter	-inf	0.033	0.039
Email	0.029	0.044	inf

Above table highlights how much can we tweak the ROI for each platform one at a time, to maintain the same optimal solution. The values of -inf and inf represent that there is no value that the ROI can be decreased and increased, respectively, that will produce a change in allocations.

## Monthly Allocations with reinvestment

We have calculated allocation using ROI 1 data. Based on the allocation received the overall best ROI is fetched from the optimization model and half of the returns of prior month reinvested for every month. Code snippet below -

```
roi_val = model.ObjVal  
budget = 10+0.5*roi_val # adding half of the roi to next month's budget
```

Also, each month's ROI estimate is updated based on prior month's optimal ROI obtained from the model. So the consulting firm's ROI estimates are only being used for January.

Solving the optimization problem resulted in the following allocations -

Months	January	February	March	April	May	June	July	August	September	October	November	December
Print	3.00	3.00	0.00	0.0	1.8	3.00	1.12	3.00	1.36	0.00	3.00	3.00
TV	0.00	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	3.00
SEO	0.00	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
AdWords	1.33	2.40	3.00	3.0	0.0	0.00	3.00	1.83	3.00	3.00	2.06	0.43
Facebook	0.00	3.00	0.00	0.0	0.0	0.00	1.12	0.00	0.00	0.00	0.00	3.00
LinkedIn	0.00	0.00	3.00	3.0	0.0	0.00	0.00	0.65	3.00	3.00	1.11	0.00
Instagram	2.67	0.00	1.39	3.0	3.0	3.00	3.00	0.00	0.00	3.00	3.00	0.00
Snapchat	0.00	0.00	0.00	0.0	0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Twitter	0.00	1.79	3.00	1.6	3.0	2.02	3.00	3.00	3.00	0.00	0.00	0.00
Email	3.00	0.00	0.00	0.0	3.0	3.00	0.00	3.00	1.36	2.96	3.00	3.00

## Conclusion

From the above, we can see that there are certain months where the budget allocation fluctuates by more than \$1M. Hence, the allocations are not stable. This is not ideal in the sense that we can't keep jumping from one platform to another - it might cause an adverse effect on customer reach since we are stopping the marketing campaigns abruptly.

Our solution is not stable due to the methodology that we have adopted. We are trying to allocate the budgets by maximizing each month's ROI by considering that month's ROI, hence there is too much variation.

To get a stable solution, we can use constant ROI estimates (from either of the consulting firms) to perform budget allocation for all months.