Profit optimization for Rainfactory

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Abstract

The task at hand is to maximize monthly profit for Rainfactory, a marketing agency which offers multiple types of services to its clients, under the presence of both deterministic and stochastic revenue factors. We are currently focused on solving the deterministic problem through discrete optimization. In the future we will consider using the Monte-Carlo Simulation to solve the stochastic problem. Using the solution we derive, we also hope to identify bottlenecks in the revenue making process. The strategy currently used produces a profit of $ 188087.00 per month.

Introduction

Problem Description

Rainfactory is a marketing agency based in Oakland, California. They offer three different types of marketing services to potential clients. Two of these services pertain to Crowd-Funding (CF) clients and the third to Ads-Only clients. All CF services, once started, take four months to complete. Ads-only services depend wholly on the need of the client and their time-frame can vary from 2 months to an indefinite amount of time. Each service earns Rainfactory a fixed amount of revenue plus a certain percentage of the revenue generated for the clients. Each service type has different labour and resource requirements which vary on a monthly basis.

At the present moment the company is taking on all clients that approach them. This is a poor strategy as they have a limited number of resources which should be allocated in a way that maximizes the company's profit. The company has different number of clients each month which makes it difficult to find a good strategy for the number of clients of each type to take on every month.

Goal

The goal of the project is to find an optimal strategy that maximizes profit over all potential client types given minimum and maximum constraints on labor and on client availability in the presence of unknown revenue factor and fixed fees.

Once a solution has been identified we must also report the bottlenecks that limit the generation of profit and are in direct control of the company. Identifying these bottlenecks will enable Rainfactory to make efficient hiring decisions while allowing them to take on more clients and have a higher ceiling for maximum profit.

Simplification

We will be making two simplifications in total.

- We shall be assuming that all Ads-only campaigns last 4 months. Thus, making the period of the campaign same as that of a CF campaign.
- The company has the option of outsourcing some work in-case there is an overflow while dealing with a client. For the purposes of this paper, we will not be considering this option as a possibility.

The first assumption was made as the modal value of the duration of the Ads Only campaign was 4 months.
The second assumption was made as our community partner desires the company to be more independent and would prefer to expand its size rather than outsource work.

Mathematical Model

We treat the deterministic problem as an integer modeling problem and use a Monte Carlo simulation to solve for the stochastic part of the problem.

Problem Statement

Rainfactory is trying to figure out how many clients of each service type they should be taking on to maximize their profit. They have three different types of services. The CF 1 service earns $12,500 (plus 5% of total revenue made) per month, the CF 2 service earns $6,250 (plus 10% of total revenue made) per month and the Ads-Only service earns $5,000 per month.

The labour constraints are given in the table below.

Employee Type	Number	Pay per Employee ($)	Total pay per month ($)
Project Manager (PM)	4	7000.00	28000.00
Email Staffer (ES)	1.25	4300.00	5375.00
Ads Team Employee (ADS)	5	6000.00	30000.00
Social Networking Employee (SN)	3	1666.67	5000.00
Designer (DSN)	3	6300.00	18900.00
Developer (DEV)	1	2800.00	2800.00
Copy Writing Employee (CW)	0.5	4000.00	2000.00
Management	1	40000.00	40000.00
Other(Lease, Office Use, etc)	1	13000.00	13000.00

All projects take 4 months to complete and are divided into monthly stages, with each stage having different labor requirements. For Ads-Only, the last 3 months have identical requirements.

The weekly ratio of work hours required for both Crowd Funding and Ads Only services for each employee type is given below.

For CF:

Month	PM	ES	SN	ADS	DSN	DEV	CW
1	$\frac{1}{6}$	0	0	$\frac{1}{10}$	$\frac{3}{20}$	$\frac{3}{40}$	$\frac{3}{40}$
2	$\frac{1}{4}$	$\frac{1}{16}$	$\frac{1}{4}$	$\frac{1}{5}$	$\frac{3}{10}$	$\frac{1}{40}$	$\frac{1}{20}$
3	$\frac{1}{8}$	$\frac{3}{20}$	$\frac{1}{4}$	$\frac{1}{10}$	$\frac{1}{10}$	$\frac{1}{40}$	0
4	$\frac{1}{8}$	$\frac{3}{20}$	$\frac{1}{4}$	$\frac{1}{10}$	$\frac{1}{20}$	0	0

For Ads Only:

Month	PM	ES	SN	ADS	DSN	DEV	CW
1	0	0	0	$\frac{1}{5}$	$\frac{1}{20}$	$\frac{1}{10}$	0
2	0	0	0	$\frac{1}{8}$	$\frac{1}{40}$	0	0
3	0	0	0	$\frac{1}{8}$	$\frac{1}{40}$	0	0
4	0	0	0	$\frac{1}{8}$	$\frac{1}{40}$	0	0

Each employee works full time and has 40 hours of work time per week. Thus, we interpret the weekly ratio tables as follows:

In month 2 of the Crowd Funding campaign a Project Manager puts in $\frac{1}{4}$ of their work time per week. This means that a Project Manager puts in 10 hours per week in month 2. Since, as per the labour constraints table, there are 4 Project Managers thus, there is a total of 160 hours of Project Management time available each week. This approach can be generalised to interpret the table for all departments and services.

How many clients of each type should the company take on, per month, to maximize profit?

Approach to Solution

We employ a two-fold approach to arrive at a solution. First we use the Monte Carlo Simulation to find the average revenue generated by both the CF 1 and CF 2 type services. Once we have this information, we create an integer modelling problem to maximize profit.

Monte Carlo Simulation

A portion of the the Crowd Funding Campaigns' revenue depends on how much money Rainfactory raises for their Crowd Funding clients. CF 1 type clients add 5% of the money raised for them to Rainfactory revenue while CF 2 type clients add 10%. Since the money generated for any client is non deterministic we shall be using the Monte Carlo Simulation to find the average value of money that is generated for a Crowd Funding client.

We managed to get a year's worth of data on the Crowd Funding clients taken on by Rainfactory. Shown in the table below.

Amount Raised ($)	Number of Clients	Probability of Raising Amount
100000-250000	15	63%
250000-500000	2	7%
500000-1000000	1	7%
1000000-1500000	2	7%
1500000-2000000	3	7%
2000000+	1	7%

Since we do not have that much data, it seems logical to assume that other range occur with the same probability. We make a simplifying assumption that a Crowd Funding project will raise $ 100000.00 with a probability of 63%, $ 250000.00 with a probability of 7%, $ 500000.00 with a probability of 7% and so on. After 5000 simulations, we get an average result of $ 459480.00.

We check the validity of our simulation by simulating RainFactory's 2018 revenue. In our revenue simulation, we make a simplifying assumption where the probability of acquiring a CF 1 client is 3%, CF 2 client is 6.6% and Ads Only client is 5% every day. This was calculated by letting the expected value to be equal to the actual number of clients during 2018. The data for the number of clients Rainfactory had in 2018 is given in the table below.

Month ($)	CF1	CF2	Ads Only
Jan	0	1	0
Feb	1	4	1
Mar	1	3	3
Apr	1	1	1
May	1	0	1
Jun	1	2	2
Jul	2	3	0
Aug	1	3	1
Sep	2	2	1
Oct	0	1	3
Nov	0	1	3
Dec	0	0	0
Total:	10	21	16
Mean:	0.833	1.7500	1.333
SD:	0.7177	1.288	1.155

The actual annual revenue for the Rainfactory during 2018 was $ 2150688.00. We were able to simulate its revenue within the standard deviation which was $ 2516448.00 with standard deviation being $ 436056.00. We infer that the number is higher than the actual value because of lack of data in amount raised by Crowd Funding projects. Thus, an amount in the higher price range probably has lower probability of occurring. With this information, we lower the probability of higher price range, as shown in the table below.

Amount Raised ($)	Number of Clients	Probability of Raising Amount
100000-250000	15	63%
250000-500000	2	12%
500000-1000000	1	10%
1000000-1500000	2	7%
1500000-2000000	3	5%
2000000+	1	3%

With the new probabilities, we have better approximation of this year's revenue, which is $ 2251193.00 with standard deviation being $ 230669.50.

Thus, the added monthly revenue for CF 1 type clients is $ 5743.50 and the added monthly revenue for CF 2 type clients is $ 11487.00.

Integer Modeling Problem

The standard structure of an integer modeling problem is as follows:

We first identify the **decision variables**. The decision variables are elements who's values we would like to determine to achieve our goal.

We then identify the **objective function** which needs to be maximized or minimized. The objective function is representative of the goal which in our case is maximization of revenue. It is defined in terms of the decision variables.

Finally, we list the **constraints** that the decision variables are subject to. These constraints help put bounds on the values of the decision variables and finally the objective function.

Decision Variables

x_i is the number of new CF 1 clients to take on in month i
y_i is the number of new CF 2 clients to take on in month i
z_i is the number of new Ads-Only clients to take on in month i
$i \in \{1, 2, 3, 4\}$

Objective Function

Maximize:

$$Revenue - Cost$$

Where,

$$Revenue = 18243.50(\sum_{i=1}^{4} x_i) + 17737.00(\sum_{i=1}^{4} y_i) + 5000(\sum_{i=1}^{4} z_i)$$

and

$$Cost = (7000PM + 4300ES + 6000ADS + 4000SN + 6300DSN + 4000CW + OP + OTHER)$$

Since the cost is fixed, we will focus on maximizing only the revenue as maximization of the revenue will automatically entail maximization of the profit.

Constraints

Project Management Constraints :

$$\frac{1}{6}(x_1 + y_1) + \frac{1}{4}(x_2 + y_2) + \frac{1}{8}(x_3 + y_3) + \frac{1}{8}(x_4 + y_4) \leq PM$$

For all $i \in \{1, 2, 3, 4\}$

$$\frac{1}{4}(x_i + y_i) \leq PM$$

Email Staffer Constraint :

$$\frac{1}{16}(x_2 + y_2) + \frac{1}{10}(x_3 + y_3) + \frac{1}{10}(x_4 + y_4) \leq ES$$

For all $i \in \{1, 2, 3, 4\}$

$$\frac{3}{10}(x_i + y_i) \leq ES$$

Social Networking Employee Constraint :

$$\frac{1}{4}(x_2 + y_2) + \frac{1}{4}(x_3 + y_3) + \frac{1}{4}(x_4 + y_4) \leq SN$$

For all $i \in \{1, 2, 3, 4\}$

$$\frac{1}{4}(x_i + y_i) \leq SN$$

Ads Team Employee Constraint :

$$\frac{1}{10}(x_1+y_1)+\frac{1}{5}(x_2+y_2)+\frac{1}{10}(x_3+y_3)+\frac{1}{5}(x_4+y_4)+\frac{1}{5}(z_1)+\frac{1}{8}(z_2+z_3+z_4) \leq ADS$$

For all $i \in \{1,2,3,4\}$

$$\frac{1}{10}(x_i+y_i)+\frac{1}{5}z_i \leq ADS$$

$$\frac{1}{5}(x_i+y_i)+\frac{1}{8}z_i \leq ADS$$

Copy Writing Employee Constraint :

$$\frac{3}{40}(x_1+y_1)+\frac{1}{20}(x_2+y_2) \leq CW$$

For all $i \in \{1,2,3,4\}$

$$\frac{3}{40}(x_i+y_i) \leq CW$$

Designer Constraint :

$$\frac{1}{10}(x_1+y_1)+\frac{1}{5}(x_2+y_2)+\frac{1}{10}(x_3+y_3)+\frac{1}{5}(x_4+y_4)+\frac{1}{16}(z_1+z_2+z_3+z_4) \leq DSN$$

For all $i \in \{1,2,3,4\}$

$$\frac{3}{20}(x_i+y_i)+\frac{1}{20}z_i \leq DSN$$

$$\frac{3}{10}(x_i+y_i)+\frac{1}{40}z_i \leq DSN$$

Developer Constraint :

$$\frac{3}{40}(x_1+y_1)+\frac{1}{20}(x_2+y_2)+\frac{1}{10}(x_3+y_3)+\frac{1}{10}(z_1) \leq DEV$$

For all $i \in \{1,2,3,4\}$

$$\frac{3}{40}(x_i+y_i)+\frac{1}{10}z_i \leq DEV$$

$$\frac{1}{40}(x_i+y_i) \leq DEV$$

Client Restrictions :

For all $i \in \{1,2,3,4\}$

$$x_i \geq 0$$

$$y_i \geq 2$$

$$0 \leq z_i \leq 3$$

$$x_i, y_i, z_i \in Z$$

Results

We constructed the Monte Carlo simulation in python using the techniques learned in, Math 381. We used the **xlwt** package to store our results in Excel spreadsheets.

To solve the integer modeling problem we used the **Gurobi** optimization package in python.

The results outputted by the code are:

> The optimal value of profit per month is: $ 188087.00
>
> The company should take on 2 CF 1, 2 CF 2, and 1 Ads-only client in month 1.
>
> The company should take on 2 CF 1, 2 CF 2, and 3 Ads-only clients in month 2.
>
> The company should take on 2 CF 1, 2 CF 2, and 3 Ads-only clients in month 3.
>
> The company should take on 2 CF 1, 2 CF 2, and 0 Ads-only clients in month 4.

This 4 month cycle must then be repeated each month that follows.

Note that CF 1 type clients generate more profit than CF 2 type. Since CF 2 type clients are more abundant in nature we are forced to take them on. However CF 1 clients should be taken over CF 2 whenever possible.

Improvements

We spoke with Kaitlyn Witman, and according to her, our profits seem to match the current Rainfactory profits. We could conclude that Rainfactory is currently operating optimally and needs to expand the Copy Writing (CW) adn the Development (DEV) departments in order to take on more clients.

There are 2 improvements that could possibly be made. The first improvement would entail gathering more Crowd Funding client data to make our **Monte Carlo simulation** more accurate. The second improvement that can be made is observing the Rainfactory employees to accurately identify how much man power is required for each service. This would help us set our **Integer Programming** constraints more accurately.

Conclusion

We conclude that Rainfactory is capable of making a monthly profit of $ 188087.00 The bottlenecks we identified were the Development team and the Copy Writing team. Rainfactory could take on more clients and make a higher profit per month if they added more people to the development and the Copy Writing team.

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References

- Winston, Wayne L. Operations Research: Applications and Algorithms. Brooks/Cole, Cengage Learning, 2009.
- Okagbue, Hilary Edeki, S.O. Opanuga, Abiodun. (2014). A Monte Carlo Simulation Approach in Assessing Risk and Uncertainty Involved in Estimating the Expected Earnings of an Organization: A Case Study in Nigeria. American Journal of Computational and Applied Mathematics. 2014. 161-166. 10.5923/j.ajcam.20140405.02.
- Reeb, J Leavengood, Scott. (2018). Using the Simplex Method to Solve Linear Programming Maximization Problems.