Summary

Each consulting firm provides expert services to different clients on projects within a specific timeframe. A variety of transaction parameters are agreed upon between two parties, including daily rates, locations, required expertise and so on. Our main objective is finding a consultants' allocation plan to maximize the company's profit, the secondary objective is utilizing satisfaction of client demands. Then we consider a trade-off between two objectives. Based on real-world rules and assumptions, our team establish two optimization models and present several allocation plans.

Let's start with a static model. We assume that all projects last 6 months and the consultants' status keep unchanged during one year. Our model makes four constraints: consultants' skillsets must satisfy project demand; consultants' hierarchy level must satisfy project demand; consultants' travel cost must be less than or equal to standard travel budget; idle consultants must be less than specified maximum BenchHeadcount. Based on the example data, we get a result in different objectives: when maximizing company profit, profit result is 428181.24 and maximizing utilizing satisfaction of client demands as objective, profit result is 303455.52. In the second plan, we notice that 61.9% of consultants need to travel working, and 16 consultants at high hierarchy level need to do much lower-level work. In reality, such long-term working far away from home and lower-level work may lead to a decrease in consultants' satisfaction with the company and work content, it may cause the dismission. Then we have some ideas for our model's further improvements.

We improve it as a dynamic model, adding new constraints to the static model. Introduce different project durations, consultants' hiring, promotion and unhappiness (caused by travelling outside or being assigned as lower hierarchy role) and analyze the newly introduced variables' performance. Some important assumptions we made: 52 projects have 4 kinds of durations from 3 to 6 months; Set up a candidate pool of 100 consultants for new hiring, each level of consultants is evenly distributed in three home bases and they have score 4 on three kinds of skills; Unhappiness is an accumulated value, which can be calculated by project length times unhappiness index; Once a consultant gets promoted and hired, the status keeps unchanged in the future. Compared to the static model, the result from the dynamic model gets less profit and more cost, due to the extended time period with corresponding increased salary but limited demand. The total profit here is 227174.58.

By adjusting the constraint and constants, our model can work in a scenario of a global crisis or other major events happen. For example, the 2007-2009 Global Recession impacts the company's financial situation and it needs to reduce its headcount. To solve this, we can modify our model by changing BenchHeadcount in constraints. And we deduce this will reduce our profit. In addition, during the COVID-19 pandemic, the amount of travel work is significantly reduced. And we think that in maximum profit plan, the profit will be slightly affected since only 9.3% consultants need to travel working. While in the minimum vacancy plan, in which 61.9% of consultants need to travel working, profit will be significantly influenced.

But there are still several points that need to be improved in future studies: We have considered to set an unhappiness threshold to judge whether the consultant leaves or not. However, the cost-free leaving caused by unhappiness will prompt the current model to force consultants to be intentionally assigned to inappropriate projects and positions in the end of a year to maximize profit (the reason may be saving the salary cost from the last few months). Finding an appropriate threshold and applying it in the model is significant. Also, we recommend adding a nonrecurring expense to prevent the company from taking advantage of cost-free leaving to force out consultants. By adding this cost, the optimization process is optimized with a minimum of consultants' unhappiness, ensuring the rights and interests of staff.

Technical Report

Problem Analysis

This consultants' allocation challenge is a real-life 'resource management' problem. We need to solve this optimization problem by building models which can produce optimized consultants' allocation strategies for a consulting company when data is given, providing and analysing optimal solutions for 2 objectives on the given data set as well.

We have the data set consisting of consulting company parameters (the data set of 400 consultants at 5 hierarchy and skillset levels in 3 home locations), clients' projects parameters (the data set of 52 projects with its consultant demand and location) and the travel cost. Consulting company parameters include consultants' hierarchy levels, skillset levels, home locations, salary and the maximum number of bench headcount. Clients' projects parameters include projects' locations, daily rates, demands of consultants with their hierarchy and skillset levels in all projects.

To build the model, we need to clarify the parameters and data we have at first. Secondly, we perfect model settings and assumptions and turn them into constraints and objective functions to build our preliminary optimization model. Thirdly, we extend our model to a more general and realistic version, and we supplement our own assumptions and data if necessary. Finally, we implement our models on data sets to find and analyze the optimal solutions.

Static Model Description and Justification

To solve this complicated consultants' allocation problem, we first establish a static model.

This model uses seven sets: ***I*** for the ID of consultants, ***J*** for the projects, ***H*** for the hierarchy levels of consultants, ***R*** for the hierarchy levels required by roles in projects, ***S*** for consultants' skillset levels, ***L1*** for consultants' home locations and ***L2*** for the project locations.

This model has 12 parameters. We use ***Demand(j,r)*** to denote the number of consultants who are qualified in hierarchy level ***r*** to be roles in project ***j***, ***Skillset(i,s)*** to denote skillset levels of skill **s** for consultant ***i***, ***SkillDemand(j,s)*** to denote the skillset levels **s** required by project ***j***, ***Hierarchy(i,h)*** $\in \{0,1\}$ to denote the hierarchy level ***h*** of consultant ***I*** (it is 1 if consultant ***i*** is on level ***h***), ***HomeLocation(i,l1)*** $\in \{0,1\}$ to denote the consultant ***i***'s home location ***l1***, ***ProjectLocation(j,l2)***$\in \{0,1\}$ to denote the project ***j***'s location ***l2***, ***TravelCost(l1,l2)*** to denote the cost of travelling from ***l1*** to ***l2*** per day, ***DailyTravelCostBudget*** to denote the travel cost budget for whole company's consultants per day, ***BenchHeadcount(h)*** to denote the maximum number of people who are allowed to be on the bench with hierarchy level ***h***, ***ProjectLength*** to denote the length of projects(6months *20days), ***DailySalary(h)*** to denote the daily salary for consultants at hierarchy level **h**, ***DailyRate(j,r)*** to denote the daily rate earned by consultants in role which require hierarchy level **r** in project **j**.

We introduce three binary variables: ***Allocation(i,j,r)***$\in \{0,1\}$ with the meaning that it is 1 if a consultant with ID $i \in I$ is allocated to the role $\boldsymbol{r \in R}$ in project $\boldsymbol{j \in J}$, ***SKillAllocation(i,j,s)*** $\in \{0,1\}$ with the meaning that it is 1 if the difference obtained by subtracting SkillDemand(j,s) from Skillset(i,s) is greater than zero for all consultants **I** in all projects **j** with all skillset levels ***s***, and ***fill(j)*** $\in \{0,1\}$ with the meaning that it is 1 if the sum of ***Allocation(i,j,r)*** over all consultants **I** and all hierarchy levels ***r*** required by roles in projects is equal or greater than zero.

We introduce the daily travel cost of each consultant i with ***DailyTravelCost(i)***, which is computed by:

$$DailyTravelCost(i) = \sum_{j \in J, r \in R, l_1 \in L_1, l_2 \in L_2} \begin{matrix} Allocation(i,j,r) \times HomeLocation(i,L_1) \\ \times ProjectLocation(j,L_2) \times TravelCost(l_1,l_2) \end{matrix} \qquad for\ all\ i \in I$$

We obtain the following six constraints.

1. A consultant *i* can only take part in one project:

$$\sum_{j \in J, r \in R} Allocation(i,j,r) \leq 1 \qquad for\ all\ i \in I$$

2. At least one of the skills of a consultant *i* assigned to the project *j* should satisfy the project demand:

$$SkillAllocation(i,j,s) = \begin{cases} 1 & Skillset(i,s) - SkillDemand(j,s) > 0 \\ 0 & otherwise \end{cases} \qquad for\ all\ i \in I, j \in J, s \in S$$

If $\sum_{s \in S} SkillAllocation(i,j,s) = 0$,

$$\sum_{r \in R} Allocation(i,j,r) = 0 \qquad for\ all\ i \in I, j \in J$$

3. Each consultant should be assigned to a role requiring same or lower hierarchy level but cannot be assigned to a role requiring a higher hierarchy level:

$$\sum_{h\in H}(Hierarchy(i,h)\times h) \geq \sum_{r\in R}(Allocation(i,j,r)\times r) \qquad for\ all\ i\in I, j\in J$$

4. The number of consultants assigned to role requiring specific level should be less than or equal to the project demand:

$$\sum_{i\in I} Allocation(i,j,r) \leq Demand(j,r) \qquad for\ all\ j\in J, r\in R$$

5. Daily travel cost of the whole company should be less than or equal to the budget:

$$\sum_{i\in I} DailyTravelCost(i) \leq DailyTravelCostBudget$$

6. Amount of people who are on the bench should not exceed the maximum bench headcount:

$$\sum_{i\in I}\left(Hierarchy(i,h)\times\left(1-\sum_{j\in J,r\in R} Allocation(i,j,r)\right)\right) \leq BenchHeadcount(h)$$

$$for\ all\ h\in H$$

About the objective function, we designed two different ones to achieve two different goals. Firstly, to find a consultants' allocation plan with maximum profit, we can use the first objective function, which is computed by total income minus the total cost. While total income is the sum of daily income earned by each consultant in client projects, and the total cost consists of each consultants' salary and their travel cost.

Objective 1 is given by:

$$\max\ (Profit)$$

$$TotalCost = \sum_{i\in I,h\in H} ProjectLength \times Hierarchy(i,h)\times\big(DailySalary(h)+DailyTravelCost(i)\big)$$

$$TotalIncome = \sum_{i\in I,j\in J,r\in R} ProjectLength \times Dailyrate(j,r)\times Allocation(i,j,r)$$

$$Profit = TotalIncome - TotalCost$$

The second objective function is designed to utilise satisfaction of client demands. We introduce the new binary variable ***Fill(j).*** And the vacancy represents the number of vacant roles on ongoing client projects (we regard a project as an ongoing project if there exists consultant assigned to the project).
Objective 2 is given by:

$$\min\ (Vacancy)$$

$$Fill(j) = \begin{cases} 1 & \sum_{i\in I,r\in R} Allocation(i,j,r) \geq 0 \\ 0 & Otherwise \end{cases} \qquad for\ all\ j\in J$$

For the projects accepted, compute the number of vacant roles:

$$Vacancy = \sum_{j\in J}\left(\sum_{r\in R} Demand(j,r)\times Fill(j) - \sum_{i\in I,r\in R} Allocation(i,j,r)\right)$$

Static Model Results

With the static model ready, then we implement this model on data set. According to the original data, there exists two scenarios on two parameters, the 'consultants' skillset levels' and the 'client demands' (client demands on consultants' hierarchy level for each project). We find the optimal solutions for different data sets in difference scenarios, meaning that our static model works for a variety of datasets. Below we state and analyse a representative solution, the solution basing on dataset including scenario 1 data in 'client demands' and the scenario 2 data only in 'consultants' skillset levels'. Because its scenario 2 data is simulated using real life logic and more aligned to each individual's hierarchy level, while scenario 1 data assume all staff members have maximum expertise for all skills which is too different from the real-world data.

Objective 1-max profit

Firstly, objective function one is used to find the company's maximum profit. In our optimal plan (shown in table 1 and 2), the company make a profit of 428181.24, and all 52 projects are ongoing while 205 vacant roles are left. About the allocation of consultants at different hierarchy levels, all consultants at the highest three levels(level 4, 5, 6) are assigned to projects, while 97% level 7 consultants are occupied. However, there is a high surplus on level 8 consultants, showing that all 20 level 8 consultants are left on the bench. We also analysed the match between consultants' hierarchy level and their job role in projects: 81.7% consultants are assigned to a role requiring same hierarchy level, however, we also see extreme cases, 6 consultants take up roles which are two or more levels below their hierarchy level. And for working location, a few number of consultants, only 9.3%, need to work on projects away from home.

Objective 2-min vacancy

The second object is to utilise satisfaction of client demands with animism vacant roles on ongoing projects. Our optimal solution (shown in table 1 and 2) has a profit of 303455.52. And 82.8% consultants in company are assigned to 28 projects with all roles in these 28 projects are occupied. In this plan, over 90% of consultants at the highest three hierarchy levels are successfully assigned to a project, while no one level 8 consultant take a role. Analysing the consultants' hierarchy level and their role level, we find 78.5% consultants' role perfectly match their hierarchy level. However, 16 extreme cases exist, many level 4 consultants have to do level 6 work. We also see that most consultants, 61.9% of them do not work in their home location.

Objective	profit	Vacancy on ongoing project	Ongoing project
Objective 1-max profit	428181.24	205	52
Objective 2-min vacancy	303455.52	0	28

Table 1: Result of optimal allocation solutions for two objectives

Objective	All Levels	Level 4	Level 5	Level 6	Level 7	Level 8
Objective 1-max profit	94.3%	100%	100%	100%	97%	0%
Objective 2-min vacancy	82.8%	92.5%	92.5%	90.6%	75%	0%

Table 2: Utilisation rate of consultants at different hierarchy level

Generally consider above two optimal solutions, we can see that to maximise the clients' demands will significantly decrease company's profit and the number of ongoing project. More consultants will be assigned to a role which not perfectly matches their hierarchy level, and also more consultants (an about 50% increase) need to work away from their home base. There also exists some similar trend: all level 8 consultants in both plans are left on bench, while most (over 90%) high hierarchy level (level 4, 5,6) consultants are assigned to a role in project.

Profit-Vacancy Trade-off analysis

Thirdly, we consider both objectives simultaneously. The graph below shows the correlation between these two objectives, profit and vacancy. The last two points (red points) represents plans with very high profit but relatively more vacancy in roles. When our clients pay more attention to the profit and they accept few vacancies in some projects, these two plans are ideal. The third point (black point) is the plan with the highest profit when all roles in ongoing projects are occupied. This plan is provided to the client who believes no vacancy in ongoing projects is more important and allow a small decrease in profit.

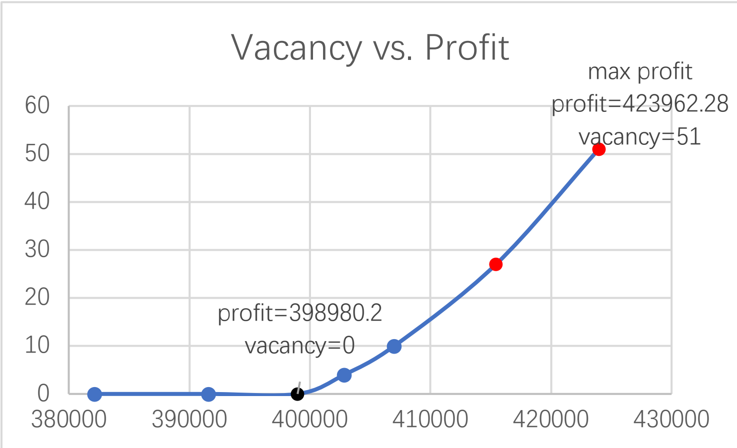

Figure 1: vacancy vs. profit

After analysing the two plans to different objectives, we have some ideas for further improvements of our model. We notice in second plan, 61.9% of consultants need to work away from home base, and 16 consultants at high hierarchy level need to do much lower-level work. We consider this situation in a real world, such long-term working far away from home location and doing low level work may lead to a decrease in employees' satisfaction with the company and work content, and the low satisfaction may also cause the dismission. So to make the model better simulate the workplace in real life, we need to consider more situations including the hiring, promotion and training of consultants, consultants leaving the company because of low satisfaction, projects with different length. Then we will build and introduce our dynamic model.

Problem Analysis

We have achieved a static version of the problem. But in practice, a dynamic version model is more realistic. Some different settings in our model as shown in table 1:

Static model	*Dynamic model*
Same length for all projects- 6 months *20 days	Different length for all projects- 3 to 6 months × 20 days
Consultants keep the same status (level and number) during one year.	Consultants get promoted.
	Consultants leave the company due to unhappiness. *
	New consultants are hired to meet the clients' demand better.

Table 3: difference between two models

*: For the component of unhappiness, we consider the time a consultant spends away from their home base and time spent in roles below their hierarchy level.

Dynamic Model Description and Justification

In dynamic model, we newly introduce month duration as T={1,..,t}.

We use scenario 2 project demand data. Here are some supplements and modifications to the original data:

[1] $\boldsymbol{ProjectTimeperiod(j,t)}$matrix:

In dynamic model, we set 52 projects have different durations, depending on the total income of one project. Sort projects with income high to low, assume that the duration lengths are evenly distributed, high-income projects last for a short time (3 months), low-income projects last for a long time (6 months), dividing projects for 4 kinds of duration. The whole dynamic model is based on differentiated project length settings. Then we set a binary matrix to show the project duration, 1 indicates that the project is operating in these months, as shown in Table 1.

1	1	1	1	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	1	1	1	1
1	1	1	0	0	0	0	0	0	0	0	0
0	0	0	1	1	1	1	1	1	0	0	0

Table 4: The sample data in project duration matrix

[2] $\boldsymbol{UnhappinessMatrix(j,t)}$ and $\boldsymbol{HirePromotionMatrix(j,t)}$:

1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	1	1	1	1
1	1	1	1	1	1	1	1	1	1	1	1
0	0	0	1	1	1	1	1	1	1	1	1

Table 5: Sample data in promotion and hiring matrix

0	0	0	0	0	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1	1	1	1	1	1	1	1	1
0	0	0	0	0	0	0	0	0	1	1	1

Table 6: Sample data in travel and lower-level working matrix

$\boldsymbol{HirePromotionMatrix(j,t)}$ means once the consultant gets promoted or hired in a project, his status will be mapped to each month after this project.

$\boldsymbol{UnhappinessMatrix(j,t)}$ means once the consultant gets unhappiness from a project, the unhappiness will be sustained to each month after project j and be added up. The total unhappiness can be calculated by project length times unhappiness index. Take an example, if a level 4 consultant takes level 5 work for a 3-month project, after the project, the consultant gains 3-unit unhappiness. It works the same way on travel working. Unhappiness index is an accumulated index. We will explain later.

Then we will discuss constraints in detail:

1. In allocation, we should ensure that the involving projects (involved consultants≥1) meet the minimum level of satisfaction. Here, $satisfy\_degree$ is the lowest satisfaction of a project (Due to dynamic feature, we set it as low as 0.1 to avoid infeasible solution).

   $\boldsymbol{Extension}$: In order to offset/balance the situation of reduced project density and more staff abundance due to the dynamic setting of the project durations (in 12 months), the demand for each project was appropriately increased (1.2 was selected in our code as an example), and the situation of negative profit was adjusted.

$$\sum_{i\in I,r\in R} Allocation(i,j,r) \geq SatisfyDegree \times Extension \times \sum_{r\in R} Demand(j,r)\,, for\ all\ j \in J$$

2. Ensure that the involving projects (involved consultants≥1), allocation should less than or equals to the total demand amount.

$$\sum_{i\in I,r\in R} Allocation(i,j,r) \leq Extension \times \sum_{r\in R} Demand(j,r)\,, for\ all\ j \in J$$

3. Maximum number of people per role level in a project:

$$\sum_{i\in I} Allocation(i,j,r) \leq Extension \times Demand(j,r), for\ all\ j \in J, r \in R$$

4. Requirement of skill set:

   In our model, we only take the situation that all skills meet the demand to increase the feasibility, and this variable can be adjusted arbitrarily in actual use.

$$\sum_{r\in R} Allocation(i,j,r) \times SkillDemand(j,s) \leq Skillset(i,s), for\ all\ i \in I, j \in J, s \in S$$

5. Hierarchy. (We set the lower the value of r and h is, the lower the level is):

   $\boldsymbol{promotion\_index_{(i,j)}}$ is relaxation variable. We set that the hierarchy of the Consultant is allowed to be at most one level lower than the required role. When this index takes 1 it means consultant i gets promoted in project j.

$$\sum_{r\in R} (Allocation(i,j,r) \times r) \leq \sum_{h\in H} (Hierarchy(i,h) \times h) + PromotionIndex(i,j), for\ all\ i \in I, j \in J$$

6. Bench headcount limits the number of idle consultants: （Due to the feature of dynamic model, we changed the value in $\boldsymbol{BenchHeadcount}$ into all as 100%, to ensure feasible solution, but in reality it can be turned and modified. $\boldsymbol{HireTimeperiod(i,t)}$ indicates the status of hiring.

$$\sum_{i\in I,j\in J,r\in R} Allocation(i,j,r) \times ProjectTimeperiod(j,t)$$
$$\geq \sum_{i\in I} (1 - BenchHeadcount) \times HireTimeperiod(i,t) \times Hierarchy(i,h)\,,\quad for\ all\ t \in T, h \in H$$

7. Each person can only have one project per month:

$$\sum_{j\in J,r\in R} \text{allocation}_{(i,j,r)} \times project\_timeperiod_{(j,t)} \leq 1, for\ all\ i \in I, t \in T$$

8. $\boldsymbol{TravelIndex(i,j)}$ **:** An intermediate variable, which indicates whether the consultant i has travel in assigned project j:

$$TravelIndex(i,j) \geq \sum_{r\in R} Allocation(i,j,r) \times \left(1 - \sum_{l1\in L1} HomeLocation(i,l1) \times ProjectLocation(j,l1)\right)$$

$$for\ all\ i \in I, j \in J$$

9. $\boldsymbol{LowerhierarchyIndex(i,j)}$: An intermediate variable, which indicates whether consultant i participated in lower-level work during the assigned project j (the person who was promoted did not consider this unhappy, because we assume that the person who was newly promoted within a year would not dislike the previous level of work).

$$LowerhierarchyIndex(i,j) \geq \sum_{r\in R} Allocation(i,j,r) \times \sum_{h\in H} (Hierarchy(i,h) \times h - r), for\ all\ i \in I, j \in J$$

10. $\boldsymbol{UnhappinessMatrix(j,t)}$ is used to map consultant i's unhappiness due to travel in project j to each month after project j and add them up.

$$TravelTimeperiod(i,t) = \sum_{j\in J} ProjectLength(j) \times TravelIndex(i,j) \times UnhappinessMatrix(j,t), for\ all\ i \in I, t \in T$$

11. $\boldsymbol{UnhappinessMatrix(j,t)}$ is used to map consultant i's unhappiness due to lower-level work in project j to each month after project j and add them up.

$$LowerhierarchyTimeperiod(i,t) = \sum_{j\in J} ProjectLength(j) \times LowerhierarchyIndex(i,j) \times UnhappinessMatrix(j,t)$$

$$for\ all\ i \in I, t \in T$$

12. $\boldsymbol{HirePromotionMatrix(j,t)}$ is used to map consultant i's promotion in project j to each month after project j. Data form is binary and it keeps value 1 if promotion happens.

$$PromotionTimeperiod(i,t) = min\left(\sum_{j\in J} PromotionIndex(i,j) \times HirePromotionMatrix(j,t), 1\right), for\ all\ i \in I, t \in T$$

13. $\boldsymbol{HirePromotionMatrix(j,t)}$ is used to map consultant i's new hiring situation in project j to each month after project j. Data form is binary and it keeps value 1 if new hiring happens. $\boldsymbol{HireIndex(i,j)}$ keeps 1 in former 400 consultants, only the last 100 candidates are in the state of 0,1, and 1 represents entry. We add 100 new consultants in the consultants table, which contains same amount of each level. Each level of consultants is evenly distributed in three home bases (Scotland, London and north England). Each candidate's skill values are 4 in 3 skills (technical, business and SME).

$$HireTimeperiod(i,t) = \min\left(\sum_{j\in J} HireIndex(i,j) \times HirePromotionMatrix(j,t), 1\right), for\ all\ i \in I, t \in T$$

14. Sum up the unhappiness: $\mathbf{unh1}$ and $\mathbf{unh2}$ are set as 1 when solving, but it can be changed as needed.

$$Unhappiness(i,t) = unh1 \times TravelTimeperiod(i,t) + unh2 \times LowerhierarchyTimeperiod(i,t), for\ all\ i \in I, t \in T$$

Finally, we can obtain the cost of separate aspects then add them all.

1. Salary cost:

   $\boldsymbol{DaysPerMonth}$ is the number of working days in each month.

$$\text{CostSalary} = \sum_{i\in I, t\in T, h\in H} DaysPerMonth \times Hierarchy(i,h) \times (DailySalary(h) \times \big(HireTimeperiod(i,t) - PromotionTimeperiod(i,t)\big) + DailyPromotedSalary(h) \times PromotionTimeperiod(i,t))$$

2. Travel cost:

   $\boldsymbol{travel\_budget}$: Set travel costs budget per day as 300.

$$CostTravel = \sum_{i\in I, j\in J, t\in T, r\in R, l1\in L1, l2\in L2} DaysPerMonth \times TravelCost(l1,l2) \times HomeLocation(i,l1) \times ProjectLocation(j,l2) \times Allocation(i,j,r) \times ProjectTimeperiod(j,t) \leq \sum_{t\in T} DaysPerMonth \times TravelBudget$$

3. New hiring cost:

$$CostHire = \sum_{i \in I, h \in H} DaysPerMonth \times Hierarchy(i,h) \times DailySalary(i,h) \times min\,(\sum_{j \in J} NewhireIndex(i,j)\,, 1)$$

4. Promotion training cost:

$$CostTraining = \sum_{i \in I, h \in H} 2 \times DaysPerMonth \times Hierarchy(i,h) \times DailiSalary(i,h) \times min\,(\sum_{j \in J} PromotionIndex(i,j)\,, 1)$$

We need to claim that in our dynamic model, we set maximizing the company's profit as objective, then the objective function: $\boldsymbol{ProjectIncome(j,r)}$ is the income of different level corresponding in each project.

$$TotalProfit = \sum_{i \in I, j \in J, r \in R} DaysPerMonth \times Allocation(i,j,r) \times ProjectLength(j) \times ProjectIncome(j,r) - (CostHire + CostTraining + CostSalary)$$

Dynamic Model Results

In our plan, the profit result is 227174.58, the total cost is 1059740 and the total income from 52 projects is 1286914.58.

[1] For the allocation, determine the consultants in each level with different number of assigned projects to measure utilization ,as shown in table 4, and the proportion of lower-level work in each hierarchy level as shown in table 5.

Level	Total amount	Utilization	0 project	1 project	2 projects	3 projects	4 projects
Level 4	40	80%	8	18	12	4	0
Level 5	80	98.75%	1	49	23	7	0
Level 6	160	96.88%	5	48	59	43	5
Level 7	100	62%	38	39	19	4	0
Level 8	20	30%	14	3	2	0	0

Table 7: Quantity relationship between consultants and projects and utilization

	Level 4	Level 5	Level 6	Level 7	Level 8
Proportion of working in lower- level role	63.5%	66.7%	6.6%	12.4%	0%

Table 8: The proportion of lower-level work in each hierarchy level

Level 8 is the lowest level we know, so level 8 consultants cannot take lower-level work. Level 5 and level 6 are most utilized, and level 6 consultants have the smallest number of lower-level work. Level 8 consultants' utilization is significantly lower than other levels, this may be caused by low demand of level 8 in projects.

[2] For the promotion, we have the result as 1 consultant gets promoted. The No.25 consultant gets promoted at the tenth month to fit in No.40 project (month 10-12), from level 8 to level 7.

[3] For the new hiring, we have one new consultant in No.40 project (month 10-12), whom hierarchy level is 6 and home locates at North England.

[4] For the unhappiness, we consider a total result then analysis each component separately. Model result as shown in table 6.

	Total unhappiness	The unhappiness that comes with lower-level work	The unhappiness that comes with traveling work
Consultant Amount	168	117	88
Unhappiness mean value	5.16	4.86	3.41
Proportion of unhappiness ≥5	22.75%	14%	3%

Table 9: The total unhappy consultants and unhappiness situation in different components

For low level work, only 3 projects don't need our staffs work in roles below their hierarchy level.

The most extreme case is found at No.370 consultant, who works in project No.4 (month 2-5), No.19 (month 6-8) and No.33 (month 9-11). This man lives in North England but No.19 project locates in Ireland. He has 13 points unhappiness.

[5] For the cost: The travel cost in every month as shown in Figure 1. Consider the data comprehensively, there are 4 projects need our staff to travel working which is caused by these 4 projects locate in Ireland, but our staffs' home is all at 3 home locations. The proportion of projects in Ireland in the example data set is not high, but it has a great influence on the unhappiness and travel cost in our plan. Salary keeps unchanged in first 9 months and increased after new hiring as shown in Figure 2. New hiring costs 192 and promotion training costs 200.

Figure 2: Travel cost in every month

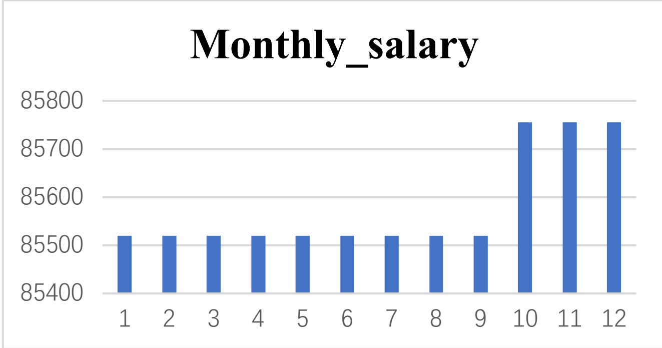

Figure 3: Salary cost in every month

Conclusions and Recommendations

Our static model is a simplified version and produces optimal consultants' allocation plans for all projects with same length. Compared to the static model, the result from dynamic model gets less profit and more cost. But dynamic model has evolved to be more realistic. As the project duration is extended to two times to original (the loss caused by changing from all project last 6 months to projects last from 3 to 6 months will be partially offset by extension), the salary cost will be doubled. Though the allocation is more in dynamic, which is 643. A confluence of different factors eventually led to a decline in total profits.

We have considered to set an unhappiness threshold to judge whether the consultant leave or not. However, the cost-free leaving caused by unhappiness will prompt the model to force consultants to be intentionally assigned to inappropriate projects and positions in the last part of the year in order to maximize profit (the reason maybe saving the salary cost from last few months). So, we scrapped this mechanism and instead investigated the characteristics of the values of unhappiness.

Our recommendations are as below:

1. If the company further increases the proportion of projects in Ireland, we will suggest that the company establish its headquarters in Ireland and hire Irish consultants to reduce long-term costs.
2. The company should notice the extreme cases like No.370 consultant and some level 6 consultants who work the whole year for 4 projects without any rest, and take some adjustments for these situations.
3. Promote some level 7 consultants to level 6. A high percentage of level 7 consultants do not have a project to work on in one year. But level 6 consultants' utilization near to 100% and some of staffs works for 4 projects. Training and promotion of level 7 or even level 8 consultants is necessary in order to alleviate the current project demand pressure and increase long-term profitability of the company.
4. We recommend to add a nonrecurring expense to prevent the company from taking advantage of cost-free leaving to force out consultants. By increasing this cost, the optimization process is optimized with a minimum of unhappiness, ensuring the rights and interests of consultants.
5. In our dynamic model, we set a satisfy_degree when considering whether to start the project. This constant can be adjusted by company due to different project urgency and importance. In reality, if the number of assigned consultants in a project is below the project satisfaction level but above the minimum requirement, a "project extended" is considered, that is, a delay of one month or more, depending on the number of available consultants.
6. **(further studies for special event happens)** Our model can also work even when a scenario of global crisis or other major event happen. For example, the Global Recession from 2007-2009 impacts the company's financial situation and it need to reduce its headcount. To solve this, we can modify our model by changing <u>**BenchHeadcount(h)**</u> in constraints. And we deduce this will reduce the profit. In addition, when the COVID-19 pandemic happens, the business needs to drastically reduce the amount of travel. To modify our model, we can significantly reduce the company's travel cost budget or add a constraint to make consultants only work in home location. And we argue that in maximum profit plan (first plan), the profit will be slightly affected as only 9.3% consultants need to travel and work. While in minimum vacancy plan (second plan), the profit will significantly increase if we reduce the travel. Because 61.9% consultants need to travel for work, the reduction on travel will lead to a big decrease in travel cost, and profit will be significantly influenced.