Consultants' allocation challenge

Presented by

Sopra Steria

and

The School of Mathematics of the University of Edinburgh

1. Introduction

This paper defines a real-life 'resource management' problem which is similar to the 'crew scheduling' type of models in the airline industry, for example. Such models can be used to define a data-driven optimised strategy of a consultancy business. Assume this is an imaginary company looking to solve the optimisation problem based on real world rules and assumptions to examine how these techniques can be used to identify optimum profitability and other objectives.

Each consulting firm works with many different clients (accounts), for example banks, to provide expert services on projects within a specific timeframe. At the beginning of each project, a variety of transaction parameters are agreed between the consultancy and the client, including fixed and conditional terms, daily rates (payments), locations, required expertise and so on.

Some costs (such as salaries/wages) are defined at fixed rates, while other costs (such as travel expenses) are variable and depend directly on operations. When the total income exceeds the company's total cost, it will make a profit.

Due to confidentiality restrictions, all provided data is defined and simulated using real life logic but does not represent real data. It is up to the students to examine the feasibility of the optimisation model and offer suggestions for data amendments if they find sensible to do so.

2. Objective(s):

- ✓ Main objective: Maximise the company's profit (= Total income – all salaries and all travel costs and any other costs).
- ✓ Secondary objective (to be reviewed separately): utilise satisfaction of client demands (minimum vacant roles on client projects).

3. Problem Parameters:

Assume a fixed model initially, i.e. all projects start and end at the same time. There is a room for further work by introducing a timeline. The last section proposes an extension of the model using 12-month time interval and two types of project lengths (3 months and 6 months) - see more details at the end of this document.

3.1. Consultants' parameters:

- **Total headcount:** 400 consultants across 3 home locations and 5 hierarchy levels.
- **Hierarchy levels:** 4 (highest) - 8 (lowest) (levels 1-3 are directors and other executive roles). For a reference and clarity:
  - Level 4 is Senior Consulting Manager;
  - Level 5 is Consulting Manager;
  - Level 6 is Senior Consultant
  - Level 7 is Consultant
  - Level 8 is Junior Consultant
- **Skillset levels** (more information on what the different type of skills are will be found in the 'Client demands' section):
  - 0 (low/no experience)

- 1 (basic knowledge)
- 2 (intermediate knowledge)
- 3 (advanced knowledge)
- 4 (expert).

- **Home (Contractual) locations:** we have many offices in the UK and the rest of the world. However, assume for simplicity there are 3 main home locations: London, North England and Scotland. Every consultant lives in one of these 3 areas and this is their home location. If they need to work on a project in a different location, the company pays for travel costs (trip, hotels etc).

- **Salary** - we provide simulated data which represents daily wages. Assume same salary for all consultants at each level (in reality people's salaries are individual but in common intervals corresponding to the market's standards). Note that the figures are made-up (but still following market distributions). In other words, if someone's monthly salary in the real world is £2,000 after tax, this would mean £100 a day assuming 20 working days for simplicity. The simulated wages provided for this project vary between 5 and 20 a day in order to keep the data confidential. This applies for all other monetary parameters in the project. The units used here can be assumed to represent an imaginary currency with unknown conversion rate.

3.2. Clients' Projects parameters:

- **Total volume: 52.** Total demand for consultants on these 5 projects is set to 582 - in order to ensure there is a high probability of the allocation problem to achieve feasibility, the demand for consultants from our clients is set to be higher than the existing staff members. This can be explored further by applying sensitivity analysis once a working main model is achieved.

- **Locations:** In addition to the 3 defined base/home locations of our consultants, the company also works with clients in Republic of Ireland. Therefore, there are 4 project locations.

- **Client demands:** Each client requests several consultants from each hierarchy level. To be precise, our hierarchy follows the internal classification specified above and the clients are not familiar with it but their demands are usually based on equivalent factors so we assume for simplicity that they would also request consultants using our internal hierarchy. Also, each client's project requires a specific skillset, looking at 3 different categories: Technical Skills, Business Skills and SME skills. For reference, these mean as follow:
  - Technical skills - specific modelling and programming languages expertise, e.g. SAS, Python, Big data etc.
  - Business skills - project management, stakeholders management etc.
  - SME (Subject Matter Expertise) is a term which is used to reference expertise in specific industry fields, such as credit risk, retail banking, healthcare etc.
- **Length** - assume a static model, i.e. same length for all projects - 6 months x 20 days (for the purposes of calculating total profit for the duration of a project). As mentioned above, expanding this to a dynamic timeline is a good area of development once a working main model is achieved.

3.3. Costs and Income:

- **Travel costs** - this depends on the locations and not on the consultant's hierarchy level. There is an upper bound (maximum budget) of what the company can spend on travel. The distance between different geographical points costs different amounts, e.g. it is assumed to be cheaper to go from Scotland to North England compared to the Scotland-Ireland route.
- **Daily rates** (I.e. income - the money the clients pay for our consultants' services) - this is defined individually for each project and hierarchy level of consultants involved in the project. The prices are usually negotiated between the respective client and our account manager for that client. We are assuming for simplicity 20 days a month, i.e. 120 days for each 6 months. This normally accounts for people being on holiday or sick (outside of this project's scope)

3.4. Business rules/assumptions:

- Each consultant can be assigned to one project role at a time and stays assigned to that project until its end.
- Each consultant can be assigned to a project which is not in their home location. However, the respective travel costs need to be considered and they are different for the different routes (defined in the data).
- Each consultant can be assigned to a role requiring same or lower hierarchy level but cannot be assigned to a role requiring a higher hierarchy level (e.g. a senior consultant (level 6) can work on a role where the client requested a level 7 consultant but cannot be assigned to a level 5 role). Suggestion: create a cumulative demand matrix where each project is presented as a column and the rows look like this:

Level-based demand:	Project 1	Project 2	Project 3	...	Project 52
Lv 8	0	0	0	...	0
Lv 7	0	0	4	...	0
Lv 6	6	7	6	...	3
Lv 5	0	2	0	...	0
Lv 4	0	0	0	...	0

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Cumulative demand:	Project 1	Project 2	Project 3	...	Project 52
Lv 8	0	0	0	...	0
Lv 7 + Lv 8	0+0=0	0+0=0	0+4=4	...	0+0=0
Lv 6 + Lv 7 + Lv 8	0+6=6	0+7=7	4+6=10	...	0+3=3
Lv 5 + Lv 6 + Lv 7 + Lv 8	6+0=6	7+2=9	10+0=10	...	3+0=3
Lv 4 + Lv 5 + Lv 6 + Lv 7 + Lv 8	6+0=6	9+0=9	10+0=10	...	3+0=3

/and try to satisfy all 5 as simultaneous constraints/

- Consultants who do not get assigned to a role stay 'on the bench' and are available immediately for new roles. They still receive their salary regardless of whether they work on a project or not, because all consultants are employed on a full-time contract basis.
- We assume for simplicity that every consultant remains on the same personal salary (in the real life people can get seasonal amendments of their salaries).
- Maximum bench headcount - we set an upper limit for people who are on the bench, otherwise the company's financial position may become unstable, if too many people sit on the bench at the same time.

4. Main points for analysis:

- Does any of the input data lead to feasibility of the optimisation model? If not, which data inputs should be amended?

- Does the company make profit? Are all constraints exhausted? Is there any slack and if yes, what would it mean for the business, i.e. opportunities for improvement?
- Comment on the allocation of consultants at different hierarchy levels - which level is most utilised, is there any level where you see high surplus?
- Comment on how many consultants are allocated to projects at their level and how many - on a lower level. Are there any extreme cases, e.g. level 4 (senior consulting manager) working on a much lower level for the client?
- What proportion of the staff members work on a project away from home?
- Present summary statistics and appropriate charts/graphs, showing meaningful conclusions and findings from the model's solution.
- If the objective is not to maximise profit but to maximise the clients' demands (see the second proposed objective in section 2), how would this be modelled efficiently? This would require a constraint involving a minimum profit threshold (consider different lower bounds which are greater or equal to 0, i.e. Ensure the company does not make a loss). How different would the allocation solution look like?

5. Additional questions/suggestions:

- Can you combine both objectives in one? Would this make a substantial difference or not?
- Consider introducing a penalty cost for unsatisfied client demand (penalty should be proportionally based on hierarchy level) and find out if this has any material impact on the total profit?
- **Training and hierarchy promotions** - consultants can be sent to a training course (assume the price/cost is equal to 2 months/40 days of the individual's salary) and then get promoted to the next hierarchy level (i.e. from 8 to 7, from 7 to 6, 6 to 5 and 5 to 4. Note that level 4 cannot get promoted as part of this model). Assume no time constraint is included in this process and the training + promotion happens immediately, only the cost is relevant. Would such an investment change the model results - both the optimal allocation and the profit?
- **Sensitivity analysis:**
    - If there is a remaining slack in the travel budget, what if it is decreased? Similarly, if the optimisation results show that the budget is used up, what happens if it is increased? Where are the critical points?
    - Based on whether there is surplus or insufficiency of consultants in a specific level, explore an optimal strategy for training people up and promote them to the next hierarchy level (only one promotion is in scope, this is a lengthy process in the real world). **Hint:** explore a scenario where the client demands for each problem follow the second (revised) dataset on the spreadsheet where more Lev 8 and Lev 4 are required, replacing some of the Level 6 demand (see the notes in the spreadsheet – tab 'Projects - consultants demand').
    - Based on the same margins from the previous point, consider hiring new people on levels that are insufficient, assuming the hiring cost (fix it to be equal to their daily salary for 20 working days/1 month) and salary vs more income from potentially extra satisfied client demand. **Idea**: run sensitivity analysis for each level because the allocation solution may re-shuffle the existing consultants, especially those that are allocated to a lower-level role.

- Explore a scenario of a global crisis or any other major event impacting the economy (such as the Global Recession from 2007-2009 or the COVID-19 pandemic). Assume the business needs to reduce its headcount, therefore needs to make redundant 20% of the staff at each level (with unchanged client demands). Pick the 20% randomly. What is the total impact on the profit?
- Explore a scenario where the business is able to relocate some of the consultants at a once-off fixed cost. What would this fixed cost have to be for this options change your solution? Can you examine the trade-off between the flight costs and the cost of relocating consultants?

6. Extended model concept (add a time dimension):

Consider two types of project lengths - 3 and 6 months (randomly split all projects by half), starting at the same time and simulate the optimisation model for 12 months. There is an opportunity at time 0, 3, 6 and 9 months to hire new people, or train up existing consultants so they can get promoted to the next level (i.e. from 8 to 7, from 7 to 6 etc) with all respective hiring or training costs.

Assume that once a 3-month projects ends, an equivalent project starts immediately (i.e. all parameters are the same as the first project). Same for the 6-month projects. However, there is an additional condition - if someone is allocated to a 6-month project, they cannot leave at the end of the third month to join another project that is just starting. In other words, there is a limited opportunity for rotation at months 3 and 9 but everyone can rotate at month 6.

As part of the 12-month simulation, consider consultants' happiness, or better said - potential unhappiness. It can lead to resignations (people leaving the company) and extra cost is required to hire a new consultant to replace them with the same profile (assume equal to their daily salary for 20 working days/1 month). Although in the real world it takes some time to find a suitable replacement on the professional market, recruitment is assumed to be immediate here once a consultant resigns.

Note that the unhappiness should be calculated based on two variables - if they spent time on a project away from their base location or if they work on a lower hierarchy level role (i.e. level 5 consultant works on a level 7 project role). If any of these is valid for a specific consultant, randomly simulate if they are to leave using the following leaving probability table and any appropriate simulation algorithm:

Lv8	Lv7	Lv6	Lv5	Lv4
2.50%	2.00%	1.50%	1.00%	0.50%

(it is assumed that people at lower hierarchy levels are more likely to change jobs easier).