Abstract – Apart from offering full-time jobs to deserving local residents, the Executive Development Centre (EDC) of Universiti Utara Malaysia provides part-time employment opportunities to their undergraduate students, particularly the students from the tourism and hospitality programme. The students are hired through short interview sessions. Based on various complaints, the EDC management realised that the outcomes from the interviews did not help in selecting the most appropriate candidates to fill in the vacancies. Therefore, this study aimed to propose an alternate procedure that combines two quantitative techniques (i.e. the simple scaling method and the 0-1 integer linear programming model) in ensuring the management will hire and assign the right positions to candidates with better justifications. This study has identified six students for the part-time jobs available in Semester 2, Session 2018/2019. Three 0-1 integer linear programming models with different objective functions were formulated and solved with the aid of LINGO Version 12. Each model derived a different set of results. Hence, the management could make their final decision by referring to the results from the model in accordance with the objective. The contributions of the study and future applications are discussed in the conclusion section.

Keywords: Simple Scaling Method, 0-1 Integer Linear Programming Model, EDC-hiring.

1. Introduction

The Executive Development Centre of Universiti Utara Malaysia (EDC-UUM) started its operations in September 2006 as a training and seminar venue cum hotel. Specifically, EDC-UUM was established to perform four objectives as follows (Nazri, Misiran, & Abdullah, 2015):

a) To act as Universiti Utara Malaysia (UUM)’s training hotel that is not limited to students and staff of UUM but also to other learning institutions, government institutions, and corporate bodies.

b) To generate income for UUM.
c) To provide a unique, friendly, pleasant service and atmosphere for UUM guests.
d) To create employment opportunities in the hotel industry to the potential members of the local community.

In addition to providing full-time employment to the members of the local community, EDC-UUM also provides opportunities to UUM undergraduate students, particularly students from the tourism and hospitality programme for part-time employment. For Semester 2, 2018/2019 academic year, the available part-time job openings at EDC-UUM are as shown in Table 1.

Table 1: The available part-time jobs for semester 2, 2018/2019 academic year.

| Job type            | Total workers needed |
|---------------------|----------------------|
| Waiters/Waitresses  | 2                    |
| Chambermaids        | 2                    |
| Kitchen Helpers     | 2                    |

Previously, students would fill in the application form by stating their most preferred and the least preferred job for the job placement. Then, they are interviewed by the EDC-UUM management team. However, the management decided to apply a new approach to replace the interview process due to their busy schedule and the ineffectiveness of interview process in deciding the appropriateness of the student-job matching (based on some complaints from students, the EDC-UUM’s patrons, and job supervisors). One of the suggested approaches is to obtain the opinion of the lecturers (i.e. the lecturers from the hotel and hospitality department at UUM) for the suitability of each student towards each job besides considering the students’ job preference.

The objective of this paper is to illustrate how quantitative techniques, particularly the simple scaling model in determining the weight for a job preference. Besides that, this study used the 0-1 integer linear programming (0-1 ILP) model in selecting the right candidate to solve the student-job matching problem at EDC-UUM.

2. LITERATURE REVIEW

The review focuses on two aspects, namely the techniques to determine the weights for students’ job-preference and job-suitability, as well as the 0-1 ILP model.

2.1 Techniques to Determine Students’ Job-Preference and Job-Suitability

There are various techniques to calculate the preference weight as discussed in the literature. Some of the techniques are analytic hierarchy process (AHP) (Saaty, 1980),
weighted scoring model (WSM) (Caroll, Far & Trainor, 2011), and scaling method (Neumann, Goldie & Weinstein, 2000).

The basic procedure to conduct AHP consists of the following steps (Saaty, 1994):
Step 1: Structuring a decision problem and listing of criteria.
Step 2: Setting the priority of the criteria by constructing a pairwise comparison (weighing) matrix.
Step 3: Checking for consistency in every pairwise comparison exercise.
Step 4: Obtaining an overall relative score for each criterion by calculating the matrix’s eigenvalue and the corresponding eigenvector.

For a basic WSM, the decision criteria or factors are weighted in terms of their relative importance, and each decision alternative is graded in terms of how well it satisfies the factors according to the following formula (Taylor, 2013):

\[ S_i = \sum w_j g_{ij} \]  

(1)

Where

\( w_j \) = a weight between 0 and 1 (or any other suitable scale) assigned to factor \( j \), indicating its relative importance, where 1 is extremely important and 0 is not important at all.

\( g_{ij} \) = a grade between 0 and 100 (or any other suitable scale), indicating how well the decision alternative \( i \) satisfies factor \( j \), where 100 indicates extremely high satisfaction and 0 indicates virtually no satisfaction.

\( S_i \) = the total score for decision alternative \( i \) where a higher score is better.

Finally, the scaling method requires the decision-maker to express each criterion weight on a numerical scale. A higher value for a given criterion represents its relative importance over other criteria. The method is simple and advantageous when there are a small number of criteria that may give erroneous results if the number of criteria is large (Neumann, Goldie & Weinstein, 2000).

For the student-job’s preference evaluation, the result is in the form of the ranking scores of jobs based on the job-importance or job-preference. However, the ranking, as well as the scores, are different from method to method (Amine et al., 2014). Consequently, the result may differ according to the method, and it is relevant to establish practical and managerial implications for selecting one model or the other (Dehe & Bamford, 2015). Furthermore, no method can be considered perfect or applied to every type of problem (Ishizaka & Nemery, 2013).

### 2.2 The 0-1 Integer Linear Programming Model

The integer programming (IP) model is a mathematical optimisation model that restricts all the decision variables in the model to be integers. In many settings, the term refers to integer linear programming (ILP) in which the objective function and the constraints (other than the integer constraints) are linear. The model can be presented as follows (Taylor, 2013):

Maximise/Minimise \( \sum_{j=1}^{n} c_j x_j \)
Subject to:
\[
\sum_{j=1}^{n} a_{ij} x_j = \text{or} \geq b_i \quad (i = 1, 2, \ldots, m)
\]
\[
x_j \geq 0 \text{ and integer} \quad (j = 1, 2, \ldots, n)
\]

One of the special cases of ILP is the 0-1 integer linear programming (0-1 ILP) whereby all the decision variables are binary, and it is used for the student-job matching problem. It has been applied in various matching problems such as the assignment of projects to students in the education domain (Nazri & Ramli, 2003; Faudzi, Abd-Rahman, Abd Rahman, 2018), fleet assignment problem (Abara, 1989), traffic routing problem (Jaumard, Meyer & Thiongane, 2006), transportation backhaul matching problem (Ongtang & Sirivunnabood, 2014), and workforce shift scheduling (Ozder, Ozcan & Eren, 2019).

3. Methodology of the Study

The student-job matching problem was solved through four stages. Stage 1 involves the determination of the student-job's preference weight. This study used job preference because many studies have found that job preference, to a certain extent, could positively influence job performance (Hall, Morgan & Salzberg, 2014; Estimo & Aguilar, 2017).

This study used the scaling method to determine the student-job's preference weight because the technique is straightforward. Hence, the weight-evaluation can be executed quickly without using complex mathematical calculations.

3.1 Stage 1: Obtain each student-job's preference score

A total of fifteen students which comprises four males and eleven females had expressed their interest to work on a part-time basis at EDC-UUM. Each student has to state the level of preference towards each job type using a rating scale of 1 to 9, where 1 represents ‘least preferred’ and 9 represents ‘extremely preferred’. We provide an example (Table 2) of an evaluation done by Student 1 (Ming) on his preference value towards each job.

| Waiter/Waitress | Chambermaid | Kitchen Helper |
|-----------------|-------------|----------------|
| 5               | 5           | 5              |

Table 2: Job preference rating by Student 1 (Ming)

Instruction: Please rate the level of your preference towards each of the jobs listed using a scale of 1 to 9 where 1 = least preferred and 9 = extremely preferred.

Table 3 shows the result of students’ evaluation.
Table 3: Student applicants and preference scores for each job

| Student | Waiter/Waitress | Chambermaid | Kitchen Helper |
|---------|----------------|-------------|----------------|
| 1 (Ming) | 5 | 5 | 5 |
| 2 (Han) | 7 | 6 | 8 |
| 3 (Mundzir) | 6 | 5 | 7 |
| 4 (Fitri) | 1 | 3 | 7 |
| 5 (Athirah) | 8 | 8 | 6 |
| 6 (SNajwani) | 8 | 8 | 6 |
| 7 (Haifa) | 4 | 2 | 3 |
| 8 (Nur) | 8 | 8 | 6 |
| 9 (Faizah) | 7 | 8 | 8 |
| 10 (Affah) | 7 | 3 | 8 |
| 11 (Nurhidayah) | 8 | 6 | 3 |
| 12 (Amirah) | 6 | 7 | 4 |
| 13 (Nabihah) | 5 | 8 | 4 |
| 14 (Izatu) | 4 | 9 | 5 |
| 15 (Fadhilah) | 4 | 7 | 5 |

Next, the student-job’s suitability score was obtained by asking the opinion of the lecturers on the suitability of each student in handling the three jobs. The suitability score was used as past studies revealed that job suitability could enhance job performance (Wade & Parent, 2002; Veldhoven, Dorenbosch, Breugelmens & De Voorde, 2017).

3.2 Stage 2: Obtain student-job’s suitability score from the perspective of the lecturer

For this purpose, this study applied the same scaling model. The lecturer was asked to evaluate the suitability level of each student in handling each job. The same scale of 1 to 9 was used with the modification as follows: 1 represents ‘least suitable’, and 9 represents ‘extremely suitable’. As an example, we show the evaluation done by the lecturer (Table 4) on the suitability of Student 1 (Ming) to perform each job.
Table 4: Job-suitability score of Student 1 (Ming) by the lecturer

**Instruction:** Please rate the level of your job-suitability for Student 1 (Ming) towards each of the jobs listed using a scale of 1 to 9 where 1 = least suitable and 9 = extremely suitable.

| Student | Waiter/Waitress | Chambermaid | Kitchen Helper |
|---------|-----------------|--------------|----------------|
| 1 (Ming)| 5               | 9            | 9              |

Table 5 shows the evaluation by the lecturer for all of the students.

Table 5: Student applicants and suitability score are given by lecturer cum trainer

| Student | Waiter/Waitress | Chambermaid | Kitchen Helper |
|---------|-----------------|--------------|----------------|
| 1 (Ming)| 5               | 9            | 9              |
| 2 (Han) | 8               | 8            | 9              |
| 3 (Mundzir)| 6           | 8            | 9              |
| 4 (Fitri)| 3               | 8            | 7              |
| 5 (Athirah)| 6             | 7            | 8              |
| 6 (Najwani)| 7             | 8            | 9              |
| 7 (Haifa)| 8               | 8            | 8              |
| 8 (Nur) | 7               | 8            | 9              |
| 9 (Faizah)| 7             | 8            | 8              |
| 10 (Affah)| 8              | 8            | 8              |
| 11 (Nurhidayah)| 6          | 8            | 8              |
| 12 (Amirah)| 7             | 8            | 9              |
| 13 (Nabihah)| 8             | 8            | 9              |
| 14 (Izatu)| 8               | 8            | 9              |
| 15 (Fadhilah)| 7            | 8            | 9              |

Next, the two scores are combined to give the total student-job's score.

**3.3 Stage 3: Obtain the student-job's combined-weight score**

For the combined score, the EDC-UUM management team agreed that the score should be based on the combination of 30 per cent of the student-job’s preference score and 70 per cent of the student-job's suitability score. In other words, the total combined score for each student can be calculated as follows:

\[
\text{Student total score} = 0.3(\text{student-job’s preference score}) \times 0.7(\text{student-job’s suitability score})
\]  

For example, the total combined score for Student 1 (Ming) for each job is shown in Table 6.

Table 6: Total combined score for Student 1 (Ming)

| Job          | Waiter/Waitress | Chambermaid | Kitchen Helper |
|--------------|-----------------|-------------|----------------|
| Total score  | 0.3(5) + 0.7(5) = 5 | 0.3(5) + 0.7(9) = 7.8 | 0.3(5) + 0.7(9) = 7.8 |
Table 7 shows the result for the total combined score for all the students.

| Student   | Waiter/Waitress | Chambermaid | Kitchen Helper |
|-----------|-----------------|-------------|---------------|
| 1 (Ming)  | 5               | 7.8         | 7.8           |
| 2 (Han)   | 7.7             | 7.4         | 8.7           |
| 3 (Mundzir)| 6               | 7.1         | 8.4           |
| 4 (Fitri) | 2.4             | 6.5         | 7             |
| 5 (Athirah)| 6.6             | 7.3         | 7.4           |
| 6 (Najwani)| 7.3             | 8           | 8.1           |
| 7 (Haifa) | 6.8             | 6.2         | 6.5           |
| 8 (Nur)   | 7.3             | 8           | 8.1           |
| 9 (Faizah)| 7               | 8           | 8             |
| 10 (Afifah)| 7.7             | 6.5         | 8             |
| 11 (Nurhidayah)| 6.6         | 7.4       | 6.5           |
| 12 (Amirah)| 6.7             | 7.7         | 7.5           |
| 13 (Nabihah)| 7.1             | 8           | 7.5           |
| 14 (Izatu)| 6.8             | 8.3         | 7.8           |
| 15 (Fadhilah)| 6.1             | 7.7         | 7.8           |

After obtaining all the necessary student-preference and student-suitability weights, the final stage for the student-job matching process is to apply a suitable mathematical optimisation model.

### 3.4 Stage 4: Apply the 0-1 Integer Linear Programming Model

Specifically, the decision variables to be solved for the student’s job-matching problem in EDC-UUM are as follows:

$$X_{ij} = \begin{cases} 1 & \text{if student } i \text{ is assigned to job } j \\ 0 & \text{otherwise} \end{cases}$$

where \( i = 1, 2, 3, \ldots, 15 \) and \( j = \text{waiter/waitress (W), chambermaid (H), kitchen helper (K)} \). Three different 0-1 ILP models were developed and solved. The three models share the same constraints but with different objective functions as stated below:

Model A: To maximise student-job’s total preference score where
\[ \text{Total preference-score} = 5X_{1W} + 9X_{1H} + 9X_{1K} + 8X_{2W} + 8X_{2H} + 9X_{2K} + \ldots + 8X_{14W} + 8X_{14H} + 9X_{14K} + 7X_{15W} + 8X_{15H} + 9X_{15K} \]

Model B: To maximise student-job’s suitability score from the perspective of the lecturer

\[ \text{Total suitability-score} = 5X_{1W} + 9X_{1H} + 9X_{1K} + 8X_{2W} + 8X_{2H} + 9X_{2K} + \ldots + 8X_{14W} + 8X_{14H} + 9X_{14K} + 7X_{15W} + 8X_{15H} + 9X_{15K} \]

Model C: To maximise student-job’s combined score where

\[ \text{Total combined-score} = 5X_{1W} + 7.8X_{1H} + 7.8X_{1K} + 7.7X_{2W} + 7.4X_{2H} + 8.7X_{2K} + \ldots + 6.8X_{14W} + 8.3X_{14H} + 7.8X_{14K} + 6.1X_{15W} + 7.7X_{15H} + 7.8X_{15K} \]

The constraints are:

Set 1: Each job’s requirement must be fulfilled.
- For waiter/waitress: \( X_{1W} + X_{2W} + \ldots + X_{14W} + X_{15W} = 2 \)
- For chamber maid: \( X_{1H} + X_{2H} + \ldots + X_{14H} + X_{15H} = 2 \)
- For kitchen helper: \( X_{1K} + X_{2K} + \ldots + X_{14K} + X_{15K} = 2 \)

Set 2: Each student can only be assigned to the maximum number of only one job.
- For student 1: \( X_{1W} + X_{1H} + X_{1K} \leq 1 \)
- For student 2: \( X_{2W} + X_{2H} + X_{2K} \leq 1 \)
- For student 3: \( X_{3W} + X_{3H} + X_{3K} \leq 1 \)
- ... ...
- For student 14: \( X_{14W} + X_{14H} + X_{14K} \leq 1 \)
- For student 15: \( X_{15W} + X_{15H} + X_{15K} \leq 1 \)

4. Findings and Discussion

The three 0-1 ILP models were run using LINGO Version 12 and the optimal results are given in Table 8, Table 9, and Table 10.

Table 8: Model A’s result based on the student’s job-preference score

| Job-Type       | Waiter/Waitress | Chambermaid | Kitchen Helper |
|----------------|-----------------|-------------|----------------|
| Students (Score) | Athirah (8) | Nabihah (8) | Han (8) |
|                | Nurhidayah (8) | Izatu (9)   | Faizah (8) |

Table 9: Model B’s result based on the student’s job-suitability score

| Job-Type       | Waiter/Waitress | Chambermaid | Kitchen Helper |
|----------------|-----------------|-------------|----------------|
| Students (Score) | Han (8) | Ming (9) | Mundzir (9) |
|                | Haifa (8) | Fitri (8)  | Najwani (9) |

Table 10: Model C’s result based on the student’s combined score

| Job-Type       | Waiter/Waitress | Chambermaid | Kitchen Helper |
|----------------|-----------------|-------------|----------------|
| Students (Score) | Asifah (7.7) | Izatu (8.3) | Han (8.7) |
|                | Najwani (7.3) | Nur (8)     | Mundzir (8.4) |
This study obtained three different optimal results. Two observations are worth reporting, although the results depend on the models’ objective functions. First, Han is featured in all of the three solutions although he or she was not necessarily assigned to the same job (i.e. kitchen helper for model A and model C, and waiter for model B). Tan provided a very high preference score for kitchen helper and was given a high job-suitability score for all the jobs by the lecturer. Hence, Tan received a high combined score for both waiter and kitchen helper. Second, model B provided many different optimal solutions because the lecturer gave high job-suitability ratings for most of the students.

5. Conclusion

This study presented an efficient procedure integrating two quantitative techniques, namely the simple scaling method and the 0-1 ILP models to provide suggestions to the EDC management before hiring the most eligible students for the six part-time jobs (i.e. waiter/waitress, chambermaid, and kitchen helper) available in Semester 2, Session 2018/2019. Generally, the application of the procedure has four stages. First, each student-job's preference score is obtained using a 1-9 rating scale. The student-job's suitability score from the perspective of the lecturer is then collected using a similar rating scale. Subsequently, student-job's combined-weight score is computed. Finally, three 0-1 ILP models with different objective functions are developed and solved using LINGO Version 12. Each model has a different set of results; thus, the management could make their final decision by referring to the results derived from the model that is in line with their objective.

The contribution of the study is two-fold. First, unlike the conventional interview method, the proposed quantitative procedure can help the management to manage the hiring process more systematically and decide the best-possible candidates based on strong evidence or justifications. As a result, the issue of dissatisfaction over the EDC hiring approach can be completely eliminated in the future. Second, this study provided some useful hints to the management in terms of the most suitable students for the six part-time vacancies available in Semester 2, Session 2018/2019.

Future studies may adapt the proposed procedure to deal with similar student selection matters such as appointing committee members for university associations or clubs, identifying the deserving participants for free in-house workshops offered by the university, and hiring eligible final year undergraduate students for internal internship programs.

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