Helping a Small Development Organization
Manage Volunteers More Efficiently

Review 2 by Chinmay Bake for QMST 5332

Problem Description:

In this paper we get an overview of workforce operations of Small Development Organizations. These organizations have a heavy dependency on volunteers to carry out their activities including social missions. Also, to successfully retain their volunteers, it is very important for these organizations to manage and schedule its workforce efficiently. The researchers therefore have attempted to solve a scheduling/assignment problem for such organizations. The researchers highlight that there has been an extensive research on workforce scheduling problems in business . This research though specifically focusses on a volunteer driven organization and hence the topic of research has a unique domain.

This research is based on a small development organization based in South America. It consists of certain youth members as volunteers. The organization does have an existing scheduling approach, which the researchers compare against their newly developed approach. The researchers also prove that certain parameters like undesired assignments, labor shortages and scheduling costs would tend to perform better after adopting their scheduling approach. The organization has 20-25 volunteers on an average who work in 2 shifts, morning or afternoon, except for Fridays when they work in the afternoon only. The organization has certain set of rules for scheduling its volunteers. This includes the maximum number of shifts a volunteer could be assigned in a week and number of undesired assignments per volunteer. The factors affecting these constraints and the typical values which they usually take are made available to the researchers. The organization also had a mechanism to pay its volunteers with a per diem allowance to reimburse any travel expenses the volunteer had incurred. This process was independent of the shift the volunteer worked for and therefore the organization had an opportunity save its monetary resources by utilizing a same volunteer on both the shifts in a day. It was thus highlighted that this process resulted in inefficient managing of the volunteers.

Overview of the Model:

The objective function of the model must satisfy 3 objectives and it expects certain parameters to be reduced. They are as follows - undesired labor assignments, volunteer labor shortages and schedule costs. While calculating the undesired labor assignments, the model takes volunteer preferences into consideration. The process of calculating labor shortages and schedule costs is also elaborated. The developed model is a weighted model. It means that multiple objectives are ran simultaneously instead using multiple iterations. The objective function equation minimizes a weighted linear combination of all three objectives. The weights given to each objective are based on the preferences set by the organization and they are enumerated in a spreadsheet. The mathematical model also formulates a relationship between each objective. The weights are expressed in percentages.

The decision variables are associated with assignment of volunteers to different shifts. The researchers divide a set of binary integer variables into two sections. The binary variables represent a value of 1 if a volunteer is assigned to a certain shift and 0 if not. The integer variables represent a shortage of volunteers for each shift. There are two more sets for binary variables. In the first set, the variables take a value of 1 if a volunteer is assigned to at-most one shift a day, else 0. And in the last one, the variables take a value of 1 if the volunteer is assigned to both morning and afternoon shifts, else it takes a 0.

The constraints in general adhere the management policies of the organization and take the volunteer preferences into consideration. The first constraint checks for the workload requirements for each center against the number of volunteers assigned to each shift. The second constraint is the budget constraint. It checks that the schedule costs do not exceed the available budget. The third constraint takes the payment per diem criteria into consideration. Next, is the upper limit on the number of undesired assignments for each volunteer. Fifth constraint ensures that each volunteer would receive an adequate number of assignments. Finally, the last constraint ensures that the labor shortages are balance by having an upper limit on the number of shortages.

The optimization problem dealt in this research uses method Binary-Integer Programming for dealing with an Assignment/Scheduling problem. The objective function has multiple criterions

and hence is this is a Multi-Objective Optimization case. The research does not have any specific assumption before formulating the model.

Overview of the Solution Analysis:

The researchers utilize excel solver to solve this optimization problem. They design a Graphical User Interface for the spreadsheet model so that data entry and reporting process could be simplified for the organization. The researchers also integrate VBA macros so that users could easily initiate different functions in the model. The user interface takes objective weights as an input and the results are displayed in terms of objective values in Undesired assignments, Labor shortages and Total schedule costs. The model can be solved, and the detailed results can be viewed using buttons created using VBA macros. There are other buttons too, highlighting different functionalities which includes performing What-If analysis and updating volunteer information. This specific method for solving the model is preferred because the organization employees are familiar with the usage of spreadsheets.

One the challenges in the model was improving the results over the existing scheduling mechanism. The researchers observed that objective function values for labor shortages were not substantially better than the existing model. The researcher performed hypothesis testing, and with a 0.05 level of significance, they observed that there was no statistically significant difference between the two approaches.

Conclusions and Critical Review:

To evaluate the performance of the model, the researchers compared its performance with the existing manual scheduling approach which the organization was using. The researchers utilized 13 periods of volunteer preferences, and obtained schedules using both the approaches. Eventually they performed pair wise hypothesis testing to determine if there is a significant difference in the values obtained during each of these approaches.

The objective values for undesired assignments were observed to be reduced by a relative 23% with the actual observations reduced from 22% to 17%. The hypothesis test, at 0.05 level of

significance, indicated that this reduction was significant. Unfilled assignments were reduced from 16% to 15% with a relative decrease of 6% - since lesser weights were assigned to it while formulating the model. Finally, for the third objective, the average percentage of utilized budget was reduced from 94% to 82% which was subsequently concluded as statistically significant reduction.

All in all, the research managed to implement a generic decision support model for managing resources of a small development organization. The model achieved the objective of better satisfying volunteer preferences, so that eventually the organization's retention objective is also satisfied. Along with this, the model also managed to keep a tab on the unfilled assignments and decrease the total scheduling costs.

There could be a scope for the model to accommodate manual scheduling of certain volunteers without breaking existing functionality of the current model. There is a possibility that certain volunteers might request special accommodations. Also, graphical user interface can have functionality wherein the decision makers can visualize the outcomes of the excel solver sensitivity report. The decision makers at the organization might not be trained enough to interpret the sensitivity report, hence a functionality which could translate the sensitivity report values in layman terms could be very beneficial; especially if the organization intends to measure any change in their objective values as a result of any constraint related change.

Appendix:

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$$\text{Min } w_1\left(\frac{\sum_{i\in I}\sum_{j\in J}\sum_{k\in K}a_{ijk}x_{ijk}}{\sum_{j\in J}\sum_{k\in K}e_{jk}}\right)+w_2\left(\frac{\sum_{j\in J}\sum_{k\in K}y_{jk}}{\sum_{j\in J}\sum_{k\in K}e_{jk}}\right)$$
$$+w_3\left(\frac{(\sum_{i\in I}\sum_{j\in J}\sum_{k\in K}x_{ijk}-\sum_{i\in I}\sum_{l\in L}\sum_{k\in K}\beta_{ilk})}{f}\right)$$

where

$$w_1 > w_2 > w_3$$

$$\text{st} \quad \sum_{i\in I} x_{ijk} + y_{jk} \geq e_{jk}, \quad j \in J, \text{ and } k \in K$$

$$\sum_{i\in I}\sum_{j\in J}\sum_{k\in K} cx_{ijk} \leq f$$

$$x_{ijk} + x_{ij'k} = \alpha_{ilk} + 2\beta_{ilk}$$

$$i \in I,\ j \in M \cap L,\ j' \in A \cap L, l \in L, \text{ and } k \in K$$

$$\sum_{j\in J}\sum_{k\in K} a_{ijk}x_{ijk} \leq u_i, \quad i \in I$$

$$\underline{v}_i \leq \sum_{j\in J}\sum_{k\in K} x_{ijk} \leq \bar{v}_i, \quad i \in I$$

$$y_{jk} \leq p_{jk}, \quad j \in J \text{ and } k \in K$$

$$x_{ijk} \in \{0,1\} \quad i \in I,\ j \in J, \text{ and } k \in K$$

$$y_{jk} \geq 0 \text{ and integer}, \quad j \in J, \text{ and } k \in K \qquad (1$$

$$\alpha_{ilk} \text{ and } \beta_{ilk} \in \{0,1\}, \quad i \in I,\ l \in L, \text{ and } k \in K. \quad (1$$