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Optimal Staff Allocation using the Assignment Model. "A Cost Minimization Approach" (Assigning Lecturers to different Exams Venue in the Department of Statistics, Nasarawa State University, Keffi.

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Abstract- ***The study applied the Assignment Model of Operations Research to optimize the allocation of examination invigilation duties in the Department of Statistics and Data Analytics, Nasarawa State University, keffi. The objective was to minimize the walking distance of academic staff to examination halls. Nine eligible staff and eight halls were considered, with a dummy hall added to balance the problem. Distances in metres from staff offices to halls served as the cost matrix, and the problem was solved using Microsoft Excel Solver. The optimized allocation produced a total minimized distance of 580 metres, compared to a baseline of 920 metres under non-optimized allocation. This represents a significant reduction in walking distance, ensuring more efficient and fair deployment of staff. The study demonstrates the usefulness of the Assignment Model as a practical decision-making tool for resource allocation in university administration.***

Keywords: Assignment Model, Resource Allocation, Optimization, Cost Matrix, Dummy Variable, Distance.

I. INTRODUCTION

The Department of Statistics and Data Analytics, like many academic departments, faces challenges during examination period in allocating lecturers to various venue. Traditionally, such assignments are done manually, which can be time-consuming, prone to bias, and inefficient.

The assignment Model, a branch of linear programming offers a mathematical model for assigning a set of resources (lecturers) to a set of tasks (exam venues) in a way that minimizes total cost while meeting constraints. In this study, "cost" could represent time taken to move between venues, distance from offices, or workload preferences.

By implementing the assignment Model, the department can make data-driven decisions that reduce scheduling conflicts, balance workload, and minimize unnecessary expenses.

The Cost Minimization Principle within Operations Research underpins the approach of this study. It advocates for decisions that achieve the lowest possible expenditure of resources while still satisfying all constraints (Taha, 2017). In this context, cost is measured in terms of travel distance, time requirements, or workload implications. By applying this principle, the study ensures that lecturers are allocated to venues in a way that minimizes overall burden while maintaining equity.

Beyond these central theories, the study also draws on the Systems Theory, which views the allocation process as an integral component of the university's broader examination management system. Efficiency in lecturer allocation is seen as part of a chain reaction that contributes to the overall smooth conduct of examinations (Bertalanffy, 1968). Similarly, Decision Theory provides a foundation for the rational selection of alternatives, emphasizing that the best allocation is one that balances cost with fairness (Raiffa, 1968).

1.1 Statement of the Problem

During examinations, the Department of Statistics must allocate lecturers to invigilate in multiple exam venues. Manual allocation often results in unequal distribution of workload, inefficient scheduling that increases cost, scheduling conflicts, and delays caused by assigning lecturers to far-apart venues. To address these challenges, this study applied the Assignment Model of Operations Research, using a cost matrix of staff distances to venues and solving with Microsoft Excel Solver. This approach minimized total walking distance while ensuring fairness, efficiency, and elimination of conflicts in the allocation process.

II. LITERATURE REVIEW

Maslim Masrom et al (2025) studied the characteristics and significance of the assignment Model, followed by a detailed mathematical formulation that includes decision variables, objective functions, and constraints. The Hungarian Method is presented as a systematic approach to solving the assignment Model.

Sudradijat Supian et al (2018) studied the traveling time workers from the central post office Bandung in delivering the package to the destination location and was optimized using Hungarian method. The sampled data in this study are 10 workers who will be assigned to deliver mail package to 10 post office delivery centers in Bandung that is Cikutra, Padalarang, Ujung Berung, Dayeuh Kolot, Asia-Africa, Soreang, Situ Saeur, Cimahi, Cipedes and Cikeruh. The result of this research is optimal traveling time from 10 workers to 10 destination locations. The optimal traveling time required by the workers is 387 minutes to reach the destination. Based on this result, manager of the central post office Bandung can make optimal decisions to assign tasks to their workers.

Kuhn H.W(1955) demonstrated that numerical scores are available for the performance of each of n persons on each of n jobs, the "assignment Model" is the quest for an assignment of persons to jobs so that the sum of the n scores so obtained is as large as possible. It is shown that ideas latent in the work of two Hungarian mathematicians may be exploited to yield a new method of solving this problem.

Akpan N.P et al (2016) Matched highly skilled people to available position/job in a high-stake task that requires careful consideration by experienced resource managers. The assignment Model is a special type of the transportation problem; it is an important subject discussed in real world. In his research, two methods were used to solve the assignment Model (i.e Hungarian method, and the Alternate method of assignment) and the results were compared. The result from these comparison shows that both method gives the same optimal solution, but the Alternate method yielded the optimal solution in few steps which saves time.

Robert S. (2005) studied the assignment of heterogeneous workers to heterogeneous jobs. Owing to the anonymity of a large labour market, workers use mixed strategies when applying for jobs. This randomness generates coordination frictions. Two workers may apply for a particular job, whereas an identical job gets no applications. The model generates assortative matching, with a positive but imperfect correlation between matched workers' and firm's types. It predicts that a worker's wage is increasing in her job's productivity and a firm's profit is increasing in its employees' productivity.

Povh J (2008) considered two classical problems from location theory which may serve as theoretical models for several logistic problems where one wants to assign elements of a set A to elements of a set B such that some linear or quadratic function attains its minimum. It turns out that linear objective function yields a linear assignment Model, which can be solved easily by several primal-dual methods like Hungarian method, Shortest augmenting path method etc. On the other hand, taking quadratic objective function into account makes the problem much harder. The resulting quadratic assignment Model is a very useful model but also very tough problem from theoretical and practical point of view. We list several well-known applications of these models and the most effective methods to solve the problem. However, it is still a challenging task to solve this problem to optimality when the size of underlying sets A and B is greater than 25 and currently impossible task when the size is greater than 35.

Quazzafi et al (2019) worked on the existing Hungarian method used for solving unbalanced assignment Models which is based on the assumptions to assign some jobs to dummy or pseudo machines, those jobs assigned to dummy machines are left without execution. In real world situations one may be interested to execute all the jobs on actual machines. This purpose can be served by assigning multiple jobs to a single machine. The present paper proposes a Modified Hungarian Method for solving unbalanced assignment Models which gives the optimal policy of assignment of jobs to machines. A stepwise algorithm of proposed method is presented, and the developed algorithm is also coded in Java SE 11. A numerical example is taken to demonstrate the performance and efficiency of the proposed method. The obtained result is then compared with several existing methods to show the superiority of our algorithm.

Bogomolnia A et al (2021) explained that a random assignment is ordinally efficient if it is not stochastically dominated with respect to individual preferences over sure objects. Ordinal efficiency implies (is implied by) ex post (ex ante) efficiency. A simple algorithm characterizes ordinally efficient assignments: our solution, probabilistic serial (PS), is a central element within their set. Random priority (RP) orders agents from the uniform distribution, then lets them choose successively their best remaining object. RP is ex post, but not always ordinally, efficient. PS is envy-free, RP is not; RP is strategy-proof, PS is not. Ordinal efficiency, Strategyproofness, and equal treatment of equals are incompatible.

III. TECHNIQUES FOR DATA ANALYSIS

The Assignment Model is an optimization technique within Operations Research that deals with the problem of assigning a set of resources to a set of tasks on a one-to-one basis in the most efficient way possible. The central aim is to minimize total cost (such as time, distance, or workload) or maximize total benefit (such as efficiency or productivity).

The problem is generally represented in the form of a cost matrix, where rows represent the resources (e.g., lecturers) and columns represent the tasks (e.g., examination venues). Each cell of the matrix contains the cost of assigning a particular resource to a particular task. The goal of the assignment Model is to identify the combination of assignments that produces the minimum possible total cost, subject to the condition that each resource is assigned to only one task, and each task is assigned to only one resource.

The Assignment Model is mathematically expressed as follows:

Let:

$$x_{ij} = \begin{cases} 1, if\ lecturer\ i\ is\ assigned\ to\ venue\ j \\ 0, otherwise \end{cases}$$

Where:

C_{ij} = $cost\ of\ assigning\ i\ is\ assigned\ to\ venue\ j\ (e.g\ walking\ time\ or\ distance)$

n = number of lecturer or venues (whichever is larger; dummy rows/columns are added if unbalanced)

Objective Function:

$$Minimize\ Z = \sum_{i=1}^{n}\sum_{j=1}^{n} C_{ij}.X_{ij} \qquad 3.1$$

Subject to:

1. Each lecturer is assigned to exactly one venue

$$\sum_{j=i}^{n} X_{ij} = 1\ \forall\ i \qquad 3.2$$

2. Each venue receives exactly one lecturer (or required slots if expanded)

$$\sum_{i=1}^{n} X_{ij} = 1\ \forall\ j \qquad 3.3$$

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3. Binary decision variables

$$X_{ij} \in \{0,1\} \quad 3.4$$

To solve this problem, the Hungarian Algorithm is typically applied. This algorithm works by systematically reducing the cost matrix (subtracting row and column minima), covering zeros optimally, and identifying the assignment configuration that satisfies the constraints while minimizing total cost. Its efficiency and guaranteed optimality make it one of the most widely used methods for solving assignment Models.

In the context of this study, the assignment Model ensures that lecturers are allocated to examination venues in such a way that the total operational cost (measured by distance, time, or workload) is minimized, while maintaining fairness in workload distribution. The Excel Solver Add-in was employed to implement this formulation and obtain the optimal allocation

IV. ANALYSIS AND RESULTS

This part presents the data used for the analysis, explains the construction of the cost matrix, outlines the implementation of the assignment solution, reports the optimal allocation of lecturers to examination halls, and provides an interpretation of the results. The primary objective is to minimize the total walking distance (in metres) travelled by invigilators while ensuring that all departmental halls are adequately covered during the examination session.

The Department of Statistics had eight halls available for invigilation: LT I, LT II, NS I, NS II, NS III, EDU I, EDU II, and EDU III. Since there were nine available personnel and only eight halls, the problem was unbalanced. To convert it into a square assignment Model, a dummy hall column was introduced. Assignment to the dummy hall represents that a lecturer is not scheduled for invigilation during that session (idle).

The list of available staff members considered for allocation, together with the examination halls, is presented in Appendix A. The measured distances from each staff office to each hall, which form the basis of the cost matrix for this study, are provided.

4.1 Solution of the Assignment Model Using Excel Solver

The assignment model was implemented in Microsoft Excel. The decision variable matrix X_ij (binary) was created with one row per staff and one column per hall (including the Dummy). The objective function was specified as the SUMPRODUCT of the cost matrix and the decision matrix, which represents the total walking distance to be minimized. Constraints were set so that each staff is assigned to exactly one column (row-sum = 1) and each hall column is assigned exactly one staff (column-sum = 1). Binary restrictions were enforced for all decision variables.

Excel Solver was run with the objective to minimize the SUMPRODUCT cell, subject to the stated constraints. Solver reported that an optimal feasible solution had been found.

4.2 Solver Output and Reduction Summary

During the Solver process, the initial assignment (baseline manual or arbitrary assignment) had a higher total distance. Solver iteratively improved the assignment until no further reduction in total distance was possible. The key reduction steps observed were as follows:

- Initial total distance (baseline/manual arrangement): 920 metres.
- Final minimized total distance (Solver optimal solution): 580 metres.

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Table 4.1 reports the Solver decision matrix (1 = assigned, 0 = not assigned) and confirms that each hall (including dummy) is assigned exactly one staff. The final row and column sums are all equal to one, demonstrating feasibility.

Staff/Hall	LT I	LTII	NS I	NS II	NS III	EDU I	EDU II	EDU III	Dummy	
Dr. M. B	0	0	0	0	0	0	0	0	1	1
Dr. M.O	0	1	0	0	0	0	0	0	0	1
Dr. S.E	0	0	0	0	1	0	0	0	0	1
Dr. I. S	0	0	1	0	0	0	0	0	0	1
Dr. M.A	1	0	0	0	0	0	0	0	0	1
Dr. M.I	0	0	0	0	0	1	0	0	0	1
Mr. R.Y	0	0	0	0	0	0	0	1	0	1
Mr. N.I	0	0	0	0	0	0	1	0	0	1
Mr. M.M	0	0	0	1	0	0	0	0	0	1
	1	1	1	1	1	1	1	1	1	
Objective Function	136.25									

4.3 Optimal Result from Excel Solver

The final allocation (staff → assigned hall) and the distance associated with each assignment are summarized in Table 4.2:

Table 4.2: Optimal allocation and distances

s/n	Names of Lecturer	Assigned Halls	Distance (m)
1.	Dr. Maijama's Bilkisu	Dummy	0
2.	Dr. M.O Adenomon	LT II	60
3.	Dr. S.E Chaku	NS III	80
4.	Dr. Alh Isamai'l Suleiman	NS I	70
5.	Dr. M.A Awal	LT I	55
6.	Dr. M.I Umar	EDU 1	70
7.	Mr. R.Y Saidu	EDU III	65
8.	Mr. N.I Audi	EDU II	75
9.	Mr. M.M Yahaya	NS II	70
	Total		545

4.4 Summary of Results and Interpretation

This study employed the assignment model to allocate academic staff of the Department of Statistics to available examination halls with the objective of minimizing the total walking distance. A cost matrix of distances was constructed and solved using Excel Solver.

The baseline (non-optimized) allocation resulted in a total walking distance of 920 metres. However, the optimized solution obtained from Solver produced a significantly lower total distance of 545 metres, representing a saving of 375 metres (approximately 41% reduction).

The optimal allocation ensured that:

1. Each examination hall received exactly one invigilator.
2. One staff member was optimally assigned to the dummy hall (i.e., left without allocation) to achieve a balanced distribution.
3. The assignment Model provided an objective and systematic approach to staff–hall allocation compared to the arbitrary/manual baseline.

Overall, the application of the assignment model through Excel Solver minimized the total invigilation distance, enhanced fairness in hall distribution, and demonstrated the practical usefulness of Operations

Research techniques in academic staff scheduling and administrative decision-making.

V. CONCLUSION

The study concludes that the Assignment Model is both practical and effective for optimizing resource allocation in an academic administrative setting. By applying Excel Solver, the Department was able to generate an allocation plan that minimized total walking distance while ensuring that all examination halls were covered.

The findings confirm that Operations Research techniques—though simple to implement—can significantly enhance institutional efficiency. Specifically, the model provided:

1. An objective basis for decision-making.
2. An optimal allocation that minimized total staff movement.
3. A transparent framework that can be easily communicated, repeated, and audited.

Consequently, reliance on arbitrary or ad-hoc allocation methods exposes institutions to unnecessary inefficiencies which can be avoided through structured optimization.

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