How to Cite:
Sahib, M. S. A., & Shiker, M. A. (2022). Employing the golden ratio to reach the BFS for T.P. *International Journal of Health Sciences*, *6*(S2), 14894–14901.
https://doi.org/10.53730/ijhs.v6nS2.8950

Employing the golden ratio to reach the BFS for T.P.

Mohammed S. Abdul Sahib
Department of Mathematics, College of Education for Pure Sciences, University of Babylon, Babil, Iraq
Email: mohammed.saheb.pure332@student.uobabylon.edu.iq

Mushtak A.K. Shiker
Department of Mathematics, College of Education for Pure Sciences, University of Babylon, Babil, Iraq
Corresponding author email: pure.mushtaq@uobabylon.edu.iq

***Abstract*---**Transportation problem is critical component of optimization field, as it aims to reduce the total cost of distribution from a set of sources to a set of destinations. Numerous transportation alternatives have been examined in the literature. Certain strategies, such as the northwest corner method (NWC), the low cost method (LCM), and the Vogel approximation method (VAM) were designed to identify the simplest possible solution, while others were designed to identify the optimal solution. The Golden Ratio is employed in this study to approximate the ideal solution. This technique employs the golden ratio to alleviate transportation concerns (1.61803). To begin with, the said ratio is raised to the second lowest cost and we determine the optimal cost of converting amounts from supply to supply peaks, where desired results have been obtained which are solutions that are close to the optimal solution.

***Keywords*---**transportation problem, new algorithm, initial solution, optimal solution.

Introduction

In operations research, the transportation issue is a subset of linear programming problems. In general, the transportation issue is concerned with the distribution of high- quality sources (sources) to numerous destinations (warehouses) [1]. The model's purpose is to find the delivery plan that minimizes overall shipping costs while meeting supply and demand constraints. The model assumes that the cost of shipping is proportional to the number of units sent along a certain route [2].

Manuscript submitted: 27 March 2022, Manuscript revised: 18 May 2022, Accepted for publication: 9 June 2022

In general, the transportation model may be applied to other areas of business, such as inventory management, scheduling of work, and staff assignment. Hitchcock created the fundamental transportation issue in 1941 with a constructive solution [1]. Later in 1949, Koopman differentiated the transportation problem in detail [2]. In 1951, Dantzig defined the transportation issues linear programming problem and technique for resolving healthcare concerns [3, 4]. Currently, transportation issues are frequently used in a variety of organizations and businesses, see [5- 18]. Typically, the three classical methods (NWC), (LCM), and (VAM) are utilized to tackle transportation difficulties. Vogel's approximation method (VAM) is more efficient technique for determining the simplest viable answer. The authors suggested many papers in optimization field [19- 40].

Golden Ratio

Two numbers are said to be in the golden ratio if their ratios add up to one. Algebraically stated, for values a and b with $a > b > 0$ then:

$$\frac{a+b}{b} = \frac{a}{b} = \varphi,$$

where φ represents the golden ratio, where, it is an irrational number that is the solution of the following quadratic equation:

$$x^2 - x - 1 = 0, \text{ with a value of } \quad x = \varphi = \frac{1+\sqrt{5}}{2} = 1.618033988 \ldots.$$

Transportation Problems

The classical transportation issue considers a collection of locations referred to as plants ($S_1, S_2, S_3, \ldots, S_m$) that have a commodity ready for shipping and another set of locations referred to as destinations ($D_1, D_2, D_3, \ldots, D_n$) that demand this commodity. The data set includes the availability of the commodity at each plant ($s_1, s_2, s_3, \ldots, s_m$), the demand for the commodity at each destination ($d_1, d_2, d_3, \ldots, d_n$), and C_{ij} is the cost of delivering the commodity per unit from each plant to each destination. The objective is to identify the amount of material x_{ij} to be carried from each facility to each destination in order to satisfy requirements while incurring the fewest possible shipping costs. The transportation issue is shown in a tableau (Table 1) and a network diagram (Figure 1).

Table 1: Transportation Tableau

Destination / Plants	D_1	D_2	D_3		D_{n-1}	D_n	Supply quantity
S_1	x_{11}	x_{12}	x_{13}	…	$x_{1,m-1}$	$x_{1,n}$	s_1
S_2	x_{21}	x_{22}	x_{23}	…	$x_{2,m-1}$	$x_{2,n}$	s_2
S_3	x_{31}	x_{32}	x_{33}	…	$x_{3,m-1}$	$x_{3,n}$	s_3
.	.		.	.	.	.	.
.	.		.	.	.	.	.
.	.		.	.	.	.	.
	.						

.							
.							
S_{m-1}	$x_{m-1,1}$	$x_{m-1,2}$	$x_{m-1,3}$	…	$x_{m-1,n-1}$	$x_{m-1,n}$	s_{m-1}
S_m	$x_{n,1}$	$x_{n,2}$	$x_{n,3}$	…	$x_{m,n-1}$	$x_{m,n}$	s_m
Demand quantity	d_1	d_2	d_3	…	d_{n-1}	d_n	

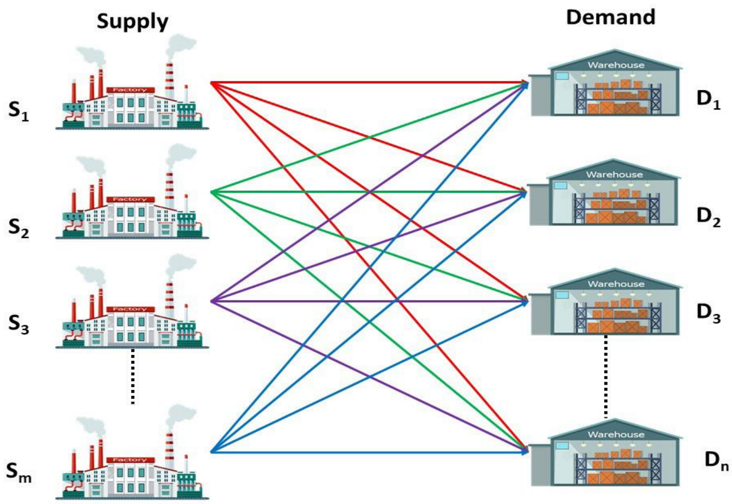

Figure 1: Network representation of general transportation problem

Note that the cost of the dummy destination is zero. To find the basic solution acceptable to the transport model, there are several different methods in terms of time and effort required to reach the initial solution. Three most commonly used methods to obtain an acceptable basic solution are:

1. Northwest-corner method: This is the easiest method to solve the transportation problems, since you do not take into account costs using any scientific logic in the distribution process (distribution of available quantities).
2. Least-cost method: This method is better than the previous one, considering the cost of transportation from the source to the center.
3. Vogel's approximation method: This method is the best one among the three classical methods to solve the transportation problems.
4. Transportation Model Problem
   The general type of transportation problems is illustrated as follows:

$$\text{Minimized (Z)} \quad \sum_{i=1}^{m} \sum_{j-1}^{n} C_{ij} X_{ij} \qquad (1)$$

$$\text{Subject to} \quad \sum_{j-1}^{n} X_{ij} = a_{ij} \qquad (2)$$

$$\sum_{j-1}^{n} X_{ij} = b_{ij} \qquad (3)$$

$$X_{ij} \geq 0 \qquad (4)$$

5. The New Proposed Algorithm

The new proposed technique is simple to implement and to find the basic solution to the balance and unbalance transportation problems, moreover, it can give an effective solution (optimal or near optimal).

The new algorithm (Golden ratio technique) can be explained as follows:

Step 1: The transportation table must be balanced.
Step 2: Use the mathematical formula $\{(1.61803)^{\wedge\ \text{(the second lowest cost)}}\}$ and calculate it for each of the rows and columns.
Step 3: Determine the highest value that result from step (2) in all rows and columns and choose the cell with the lowest cost to give the right amount available of supply to meet the needs (demand).
Step 4: If the result values are equal in more than one row or column, choose the cell with the lowest cost to allocate the request.
Step 5: The row that ran out of width or the column that was filled in the application does not enter into the following calculation.
Step 6: Repeat steps (2- 4) and calculate the total cost.

Below some numerical examples to make the new technique clear and well understood.

Example 1:

	S1	S2	S3	S4	supply				
D1	7	3	8	2 100	100	4.23	4.23	4.23	4.23
D2	5 80	6 120	11	12	200	17.94	17.94	321.98	---
D3	10	4 50	7 190	6 60	300	17.94	17.94	17.94	17.94
demand	80	170	190	160	600				
	29.03	6.85	46.9	17.94					
	29.03	6.85	---	17.94					
	---	6.85	---	17.94					
	---	6.85	---	17.94					

Cost =(2*100) + (5*80) + (6*120) + (4*50) + (7*190) + (6*60) = 3210, where the cost of (VAM) = 3210

Example 2

	S1	S2	S3	S4	supply					
D1	3 100	4	6	0	**100**	4.23	---	---	---	---

D2	7	3 80	8	0	**80**	4.23	4.23	4.23	4.23	4.23
D3	6 10	4 30	5	0 50	**90**	6.85	6.85	6.85	6.85	6.85
D4	7	5	2 60	0 60	**120**	2.61	2.61	2.61	11.09	---
demand	**110**	**110**	**60**	**110**	390					
	17.9	6.85	11.09	1						
	29.03	6.85	11.09	1						
	---	6.85	11.09	1						
	---	6.85	---	1						
	---	6.85	---	1						

Cost = (3*100) + (3*80) + (6*10) + (4*30) + (0*60) + (2*50) + (0*60) = 840
The cost of (VAM) = 880

Note that the performance of the proposed method was equal to or (better than) Vogel approximation method in most cases, but there are some rare or few cases where the performance of the proposed method is undesirable where the result of (VAM) is little better, as in the following example.

Example 3

	S1	S2	S3	S4	supply				
D1	6	3 12	5 2	4 8	**22**	6.85	11.09	17.9	11.09
D2	3	9	2 14	7	**14**	4.23	4.23	4.23	2.61
D3	5 7	7	8 1	6	**8**	17.9	17.9	46.9	46.9
demand	**7**	**12**	**17**	**8**					
	11.09	29.03	11.09	17.9					
	11.09	-	11.09	17.9					
	11.09	-	11.09	-					
	-	-	11.09	-					

Cost = (3*12) + (5*2) + (4*8) + (2*14) + (5*7) + (8*1) = 149
Cost (VAM) = 148

Conclusion

Transportation models are the least cost method of moving a product created in several factories or from multiple factories to a variety of different warehouses. This is critical in logistics management. We improved the present administrative organization's solution approach via the using of the newly proposed allocation technique in order to produce a basic feasible solution to transportation challenges. Eventually, the suggested strategy will assist industry management in determining its own supply routes. Again, the same principle may apply to various approaches in which the penalty cost or cost cell difference must be determined. Furthermore, the researchers may be conducted to determine the performance of the same process using other methodologies.

The efficacy of the new presented approach is shown in the study of the outcome and evaluation section, where the suggested method's overall performance is evaluated. The new algorithm is more computationally efficient and takes less time to acquire a potential first fundamental solution to transportation problems, and its outcomes in most cases is better than (VAM) method and it's near the optimal solution. The more optimum solution requires fewer repetitions with a better beginning solution. Taking all of these into account, we assert that our suggested technique may be utilized to generate an initial basic solution to transportation problems and can be included into any operation research project.

References

1) F. L. Hitchcock, The distribution of a product from several sources to numerous localities. Journal of Mathematics and Physics, v. 20, p. 224-230, 1941.
2) T. C. Koopmans, Optimum utilization of transportation system, Econometrica, Supplement, v. 17, 1949.
3) G. B. Dantzig, Application of the simplex method to a transportation problem, John Wiley and Sons, New York, 1951.
4) A.T. Hamdy, An Introduction to Operation Research, Pearson Education, Inc., Prentice hall, 9th edition, New jersey, USA, 2011.
5) Z. A. H. Hassan and V. Balan, Reliability extrema of a complex circuit on bi-variate slice classes, Karbala International Journal of Modern Science, vol. 1, no. 1, pp. 1- 8, 2015.
6) Z. A. H. Hassan and M. A. K. Shiker, Using of Generalized Bayes' Theorem to Evaluate the Reliability of Aircraft Systems, J. of Engineering and Applied Sciences, 13: 10797-1080. 2018.
7) G. Abdullah and Z. A. H. Hassan, Using of particle swarm optimization (PSO) to addressed reliability allocation of complex network, J. Phys.: Conf. Ser. (1664) 012125, 2020.
8) Z. K. Abdullah G. and Hassan Z. A. H., (2020), Using of Genetic Algorithm to Evaluate Reliability Allocation and Optimization of Complex Network, IOP Conf. Ser.: Mater. Sci. Eng. (928) 042033.
9) Z. K. Hashim, M. A. K. Shiker, and M. S. M. Zabiba, An easy technique to reach the optimal solution to the assignment problems, "in press", ICCEPS – April, 2021.

10) Z. K. Hashim, S. S. Mahmood, and M. A. K. Shiker, Solving the assignment problems by using a new approach, "in press", 7th International Conference for Iraqi Al-Khwarizmi Society – Iraq, IOP conference, 2021.
11) Y. A. Hussein and M. A. K. Shiker, Using a new method named matrix method to find the optimal solution to transportation problems, "in press", ICCEPS – April, 2021.
12) H. J. Kadhim, M. A. K. Shiker and H. A. Hussein, New technique for finding the maximization to transportation problems J. Phys.: Conf. Ser. 1963, 012070, 2021.
13) H. A. Hussein and M. A. K. Shiker, A modification to Vogel's approximation method to solve transportation problems, J. Phys.: Conf. Ser. no. 1591, 012029, 2020.
14) H. A. Hussein and M. A. K. Shiker, Two new effective methods to find the optimal solution for the assignment problems, Journal of Advanced Research in Dynamical and Control Systems, vol.12, no. 7, pp. 49- 54, 2020.
15) H. A. Hussein, M. A. K. Shiker, and M. S. M. Zabiba, A new revised efficient of VAM to find the initial solution for the transportation problem, J. Phys.: Conf. Ser. no. 1591, 012032, 2020.
16) H. J. Kadhim, M. A. K. Shiker and H. A. Hussein, A New technique for finding the optimal solution to assignment problems with maximization objective function, J. Phys.: Conf. Ser. 1963 012104, 2021.
17) Z. A. H. Hassan and M. A. K. Shiker, Using of generalized baye's theorem to evaluate the reliability of aircraft systems, Journal of Engineering and Applied Sciences, no. 13, pp. 10797-10801, 2018.
18) Z. A. H. Hassan and E. K. Mutar, Geometry of reliability models of electrical system used inside spacecraft, Second Al-Sadiq International Conference on Multidisciplinary in IT and Communication Science and Applications (AIC-MITCSA), pp. 301-306, 2017.
19) L. H. Hashim et al., An application comparison of two negative binomial models on rainfall count data, J. Phys.: Conf. Ser. 1818, 012100, 2021.
20) L. H. Hashim et al., An application comparison of two Poisson models on zero count data, J. Phys.: Conf. Ser. 1818 012165, 2021.
21) H. A. Mueen and M. A. K. Shiker, A new projection technique with gradient property to solve optimization problems, J. Phys.: Conf. Ser. 1963, 012111, 2021.
22) H. A. Mueen and M. A. K. Shiker, Finding the real roots of polynomials by using Sturm's technique, "In press", 7th International Conference for Iraqi Al-Khwarizmi Society – Iraq, IOP conference, 2021.
23) H. A. Mueen and M. A. K. Shiker, Using a new modification of trust region spectral (TRS) approach to solve optimization problems, J. Phys.: Conf. Ser. 1963, 012090, 2021.
24) M. A. K. Shiker and Z. Sahib A modified trust-region method for solving unconstrained optimization, Journal of Engineering and Applied Sciences, vol. 13, no. 22, pp. 9667– 9671, 2018.
25) H. H. Dwail and M. A. K. Shiker, Using trust region method with BFGS technique for solving nonlinear systems of equations, J. Phys.: Conf. Ser. 1818, 012022, 2021.
26) M. M. Mahdi and M. A. K. Shiker, Solving systems of nonlinear monotone equations by using a new projection approach, J. Phys.: Conf. Ser. 1804, 012107, 2021.

27) M. M. Mahdi and M. A. K. Shiker, A New Class of Three-Term Double Projection Approach for Solving Nonlinear Monotone Equations J. Phys.: Conf. Ser. 1664, 012147, 2020.
28) H. H. Dwail and M. A. K. Shiker Using a trust region method with nonmonotone technique to solve unrestricted optimization problem, J. Phys.: Conf. Ser. 1664, 012128, 2020.
29) M. M. Mahdi and M. A. K. Shiker, A new projection technique for developing a Liu-Storey method to solve nonlinear systems of monotone equations, J. Phys.: Conf. Ser. 1591, 012030, 2020.
30) K. H. Hashim and M. A. K. Shiker, Using a new line search method with gradient direction to solve nonlinear systems of equations, J. Phys.: Conf. Ser. 1804, 012106, 2021.
31) H. H. Dwail and M. A. K. Shiker, Reducing the time that TRM requires to solve systems of nonlinear equations, IOP Conf. Ser.: Mater. Sci. Eng. 928, 042043, 2020.
32) H. A. Wasi and M. A. K. Shiker, A modified of FR method to solve unconstrained optimization, J. Phys.: Conf. Ser. 1804, 012023, 2021.
33) M. M. Mahdi and M. A. K. Shiker, Three terms of derivative free projection technique for solving nonlinear monotone equations, J. Phys.: Conf. Ser. no. 1591, 012031, 2020.
34) H. H. Dwail et al., A new modified TR algorithm with adaptive radius to solve a nonlinear system of equations, J. Phys.: Conf. Ser. 1804, 012108, 2021.
35) N. K. Dreeb, et al., Using a New Projection Approach to Find the Optimal Solution for Nonlinear Systems of Monotone Equation, J. Phys.: Conf. Ser. 1818, 012101, 2021.
36) K. H. Hashim et al., Solving the Nonlinear Monotone Equations by Using a New Line Search Technique, J. Phys.: Conf. Ser. 1818, 012099, 2021.
37) H. A. Wasi and M. A. K. Shiker, Nonlinear conjugate gradient method with modified Armijo condition to solve unconstrained optimization, J. Phys.: Conf. Ser. 1818, 012021, 2021.
38) H. A. Wasi and M. A. K. Shiker, A new hybrid CGM for unconstrained optimization problems, J. Phys.: Conf. Ser. no. 1664, 012077, 2020.
39) H. A. Wasi and M. A. K. Shiker, Proposed CG method to solve unconstrained optimization problems, J. Phys.: Conf. Ser. 1804, 012024, 2021.
40) M. M. Mahdi and M. A. K. Shiker, Three-term of new conjugate gradient projection approach under Wolfe condition to solve unconstrained optimization Problems, Journal of Advanced Research in Dynamical and Control Systems, 12: 7, p 788- 795, 2020.
41) Rinartha, K., & Suryasa, W. (2017). Comparative study for better result on query suggestion of article searching with MySQL pattern matching and Jaccard similarity. In *2017 5th International Conference on Cyber and IT Service Management (CITSM)* (pp. 1-4). IEEE.
42) Rinartha, K., Suryasa, W., & Kartika, L. G. S. (2018). Comparative Analysis of String Similarity on Dynamic Query Suggestions. In *2018 Electrical Power, Electronics, Communications, Controls and Informatics Seminar (EECCIS)* (pp. 399-404). IEEE.