INTERNATIONAL JOURNAL OF LATEST TECHNOLOGY IN ENGINEERING,
MANAGEMENT & APPLIED SCIENCE (IJLTEMAS)

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VIII, August 2026

A Critical Review of the Application of the Simplex Method on Profit Maximization in Baker's Cottage

Enyi Patrick Enyi

Department of Accounting, Babcock University, Ilishan-Remo, Nigeria

DOI: https://doi.org/10.51583/IJLTEMAS.2026.150800094

Received: 30 August 2026; Accepted: 04 September 2026; Published: 18 September 2026

ABSTRACT

This review critically examines the application of the simplex method for profit maximization in Baker's Cottage as reported by Azman et al. (2022). The reviewed study formulated a linear programming model involving five bakery products and seven production resources and used Microsoft Excel Solver to identify a profit-maximizing product mix with a reported monthly profit of RM40,270.42. Although the study provides a useful practical demonstration of linear programming in production planning, this review identifies important analytical and interpretive limitations. In particular, the reported solution was presented as optimal without sufficient intermediate simplex information, such as a final simplex tableau or reduced-cost analysis, to permit independent verification. An independent simplex solution using ValuStats (VSP) 2.0 confirms the reported maximum profit and resource-slack values but reveals that the optimal allocation involves Chicken Floss, Spicy Floss and Frank Cheese rather than only Chicken Floss and Frank Cheese as emphasized in the original article. The review further demonstrates that water and sugar are the binding constraints, while flour, yeast, egg, milk and butter have substantial unused capacities. A supplementary case study illustrates how slack-variable values can provide additional information for resource-allocation and managerial decisions. The review concludes that simplex-based analysis should extend beyond the identification of an optimal objective value to include explicit optimality verification and meaningful interpretation of binding and non-binding constraints. Such an approach enhances the reproducibility, managerial relevance and decision-support value of linear programming applications.

Keywords: Linear programming; simplex method; profit maximization; Baker's Cottage; slack variables; resource allocation; Excel Solver; optimality.

INTRODUCTION

The article, *"Application of the Simplex Method on Profit Maximization in Baker's Cottage,"* by Azman, Mohamed, Mohamed and Musa, published in the *Indonesian Journal of Electrical Engineering and Computer Science* in 2022, applies linear programming and the simplex method to determine a profit-maximizing product mix for Baker's Cottage in Tampin, Negeri Sembilan, Malaysia. The study considers five bread products and seven production resources and uses Microsoft Excel Solver to obtain a solution. The authors report an objective-function value of RM40,270.42 per month, with approximately 332 units of Chicken Floss and 196 units of Frank Cheese as the recommended production mix.

The study is relevant because it demonstrates the practical application of linear programming to a real production problem involving scarce raw materials. However, a closer examination of the formulation, reported solution and interpretation reveals important methodological and analytical weaknesses. In particular, the paper's claim that the reported solution is optimal is insufficiently demonstrated, and the slack variables are not adequately interpreted as measures of unused resources and potential managerial opportunities.

Overview of the Study

The study formulates a profit-maximization problem involving five decision variables: Chicken Floss (x_1),

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VIII, August 2026

Spicy Floss (x_2), Frank Cheese (x_3), Mexico Bun (x_4) and Doughnut (x_5). The profit coefficients are 80, 80, 70, 50 and 30 cents, respectively. Seven resource constraints—flour, yeast, water, egg, milk, butter and sugar—are incorporated into the model.

The resulting objective function is:

[Maximize: $Z=80x_1+80x_2+70x_3+50x_4+30x_5$]

subject to the seven resource constraints and non-negativity restrictions.

The authors then introduce seven slack variables to convert the inequality constraints into equations and state that these variables represent the unused quantities of the available raw materials.

Using Excel Solver, the authors report $x_1=331.83$, $x_2=0$, $x_3=196.06$, $x_4=0$, and $x_5=0$, producing a reported profit of RM40,270.42 (Azman et al., 2022).

Strengths of the Article

The article has several notable strengths. First, it applies a well-established operations-research technique to an actual business problem rather than presenting a purely theoretical example. The use of real production and resource data gives the analysis practical relevance (Sogunro & Adekanye, 2009; Oladejo et al., 2020; Shakirullah et al., 2020).

Second, the authors clearly identify the decision variables, objective function and resource constraints. The model captures the fundamental production-planning problem faced by the bakery and demonstrates how scarce resources can be allocated among competing products.

Third, the study makes effective use of Excel Solver, which provides an accessible computational approach for practitioners and students. The article also reports the Solver output, including the objective value, product quantities and constraint status.

Finally, the study attempts to distinguish between binding and non-binding constraints. This is an important aspect of linear-programming analysis because a binding constraint represents a fully utilized resource, whereas a non-binding constraint indicates that some quantity of the resource remains unused.

Critical Assessment of the Reported Solution

The principal weakness of the article concerns its treatment of optimality. The authors repeatedly describe the Solver result as the “optimal solution” and conclude that production should focus on Chicken Floss and Frank Cheese. However, the paper does not provide sufficient evidence that the reported solution represents a fully verified simplex optimum.

In a simplex analysis, obtaining a feasible solution from a software package or through manual computation is not, by itself, a sufficient demonstration of optimality (Levin et al., 2005; Keyeke, 2006; Mohan, 2018; Anieting et al., 2013). An appropriate analysis should establish that no entering variable can further improve the objective function. This can be demonstrated through the final simplex tableau, reduced costs/opportunity costs, or an equivalent optimality test.

The article provides the Solver's final product quantities and constraint statuses but does not present the final simplex tableau or the relevant reduced-cost information. Consequently, the reader cannot independently verify from the article whether the reported solution satisfies the simplex optimality condition.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VIII, August 2026

This weakness is particularly important because the authors' conclusion depends entirely on the assertion that RM40,270.42 is the maximum attainable profit. The article states that the result is optimal but does not sufficiently demonstrate *why* no alternative feasible product combination can generate a higher objective value.

Inadequate Treatment of Slack Variables

A second and more significant weakness is the inadequate interpretation of the slack variables.

The authors explicitly introduce seven slack variables, $s_1 \ldots s_7$, to represent the unused quantities of the seven raw materials. The Solver output actually provides substantial information about these unused resources.

The reported slack values are:

Resource	Slack/Unused Quantity
Flour	35,915.49 g
Yeast	1,277.18 g
Water	0 g
Egg	282.82 g
Milk	25,307.04 g
Butter	6,635.49 g
Sugar	0 g

Source: Azman et al. (2022).

These values show that only **water and sugar are fully utilized**, while flour, yeast, egg, milk and butter remain partially unused. The article reports these values in its Solver constraint table but does not adequately interpret their economic or managerial significance.

This omission is important because the slack variables provide much more than mathematical information. They identify the resources that constrain production and those that are in excess supply. In the reported solution, water and sugar are binding constraints, while the remaining five resources have unused capacity.

The authors therefore miss an important opportunity to advise management. For example, increasing the availability of water or sugar could potentially permit an increase in profitable production, whereas acquiring additional flour, yeast, egg, milk or butter would not necessarily improve profit under the current optimal basis because those resources are not fully utilized.

The conclusion should therefore not simply state that the bakery should produce more Chicken Floss and Frank Cheese. It should explain **which resources limit that expansion and which resources are currently underutilized** (Tripathi & Kumar, 2023; Wolde & Larsson, 2024).

Managerial Interpretation of the Unused Slack

The slack values could have been used to provide a much stronger managerial interpretation.

A zero slack indicates a **binding resource constraint** (Pan, 2025). In this case, water and sugar are fully utilized. These resources therefore constitute the immediate limiting factors in the reported production plan.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VIII, August 2026

A positive slack indicates an **unused resource capacity** (Stafford, 1981). Flour has approximately 35.92 kg of unused capacity, milk approximately 25.31 kg, butter approximately 6.64 kg, yeast approximately 1.28 kg and eggs approximately 0.28 kg. These unused quantities indicate that the bakery possesses resources that are not fully employed under the reported product mix.

This finding raises an important question that the article does not address: **why are several resources substantially unused while water and sugar are exhausted?**

From a managerial perspective, this suggests that simply purchasing more of the non-binding resources would not necessarily increase profit. Rather, management should investigate the binding constraints and determine whether additional water and sugar, or a change in the production technology/product mix, could permit greater production of the profitable products. The article therefore leaves significant decision-support information contained in its own Solver output unexplored.

Need for a Comparative Solution

A further limitation is the absence of an independent solution against which the Excel Solver result can be checked. Since the paper's central claim is that the identified product combination maximizes profit, an independent simplex solution would strengthen the validity and reproducibility of the analysis. This review presents a comparative solution in Table 1 to assess:

1. whether the reported product quantities are genuinely optimal;
2. whether the reported objective-function value is the maximum possible profit;
3. whether all constraints are correctly formulated;
4. whether the reported slack values are mathematically consistent with the solution;
5. whether alternative feasible product combinations yield a higher profit; and
6. whether the interpretation of the unused resources is appropriate.

Table 1: Final Simplex Solution Matrix (VSP 2.0 Software)

SV	X_1	X_2	X_3	X_4	X_5	S_1	S_2	S_3	S_4	S_5	S_6	S_7	SQTY
Flour	0	0	0	146.2	153.1	1	0	-2.54	0	0	0	-4.44	35915.49
Yeast	0	0	0	7.21	3.44	0	1	-0.08	0	0	0	-0.15	1277.18
Water	0	0	1	0.42	0.21	0	0	0.63	0	0	0	-0.007	196.06
Egg	0	0	0	-12.2	14.56	0	0	-1.92	1	0	0	-0.352	282.82
Milk	0	0	0	69.48	141.41	0	0	0.19	0	1	0	-3.380	25307.04
Butter	0	0	0	16.2	39.1	0	0	-2.54	0	0	1	-0.437	6635.49
Sugar	1	1	0	0.4	0.37	0	0	-0.018	0	0	0	0.021	331.83
Z <>	0	0	0	-11.5	-14.09	0	0	-0.545	0	0	0	-1.197	-40270.42

Source: Enyi (2026) derived with ValuStats (VSP) version 2.0

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VIII, August 2026

The contents of Table 1 have answered all six questions posed earlier. The results confirm the optimality of the Excel Solver's simplex solution reported in the article because all reduced costs values in the objective function (Z) row satisfy the adopted optimality criterion. Therefore, no alternative feasible solution can yield a higher profit. Table 1 also confirms that the reported slack values are mathematically consistent with the solution.

However, Table 1 reveals a significant piece of information that was completely absent from the authors' submissions. This concerns the fact that the simplex solution actually selected three products—Chicken Floss, Spicy Floss, and Frank Cheese—whereas the authors selected only the first and third products. The value of 1 under columns x_1 and x_2 indicates that Chicken Floss and Spicy Floss have identical coefficients in the Sugar constraint and under the reported solution structure should share the 331.83 units of products allocated to the Sugar row equally, since both have similar costs and revenue estimates. Frank Cheese, with a value of 1 under x_3 on the Water row, should have 196.06 units as its production quota.

This provides further confirmation that Water and Sugar are the only two binding resources among the seven production constraints. The mathematical proof of the accuracy of the optimal expected profit is provided below:

Chicken floss	(331.83/2) x 80	= 13,273.11
Spicy floss	(331.83/2) x 80	= 13,273.11
Frank Cheese	196.06 x 70	= 13,724.20
TOTAL		**40,270.42**

This comparison is particularly useful because the information on the slacks were completely absent from the authors' analyses and this presents insufficient intermediate simplex information to enable the reader to reproduce or independently verify the optimality claim. However, an important issue that remains unaddressed concerns the unutilised production capacity associated with the two unrecommended products, Mexico Bun and Doughnut, as well as the unused materials. The sunk costs incurred in developing the unutilised production capacity, together with the costs associated with the unused resources, will add to the firm's overall costs without generating any corresponding income.

Uses of Slack Variables

In the paper under review, all the Z-row values of the slack variables were either negative or zero. What happens when a Z-row value of a slack variable is positive? To answer this question, this paper review introduces the following real-life case study, drawn from the article entitled "The Sub-Optimal Effect of the Simplex Solution Method in Resource Allocation Using the Linear Programming Model" by Enyi Patrick Enyi, published in the American International Journal of Contemporary Research, Volume 2, Issue 8, August 2012. The case is stated as follows:

SB Ltd. produces plain yoghurt (***p***) and orange milk drink (***m***) in cartons of 24 packs. The contribution for ***p*** is N400, while that of ***m*** is N500. Among the numerous production inputs, only labour and a special pasteurising material have limited supplies of 400 hours and 320 kg, respectively, per day. The only other constraint facing the company is the inability of the major distributor to stock more than 75 cartons of m per day owing to inadequate storage facilities. The workers spend 2 hours producing ***p*** and 4 hours producing ***m***, while the special material is used at rates of 2 kg and 1.6 kg, respectively, for ***p*** and ***m***. With this information, the following linear programming model was developed:

Maximize Z: 400p + 500m

Subject to:

INTERNATIONAL JOURNAL OF LATEST TECHNOLOGY IN ENGINEERING, MANAGEMENT & APPLIED SCIENCE (IJLTEMAS)

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VIII, August 2026

$2p + 4m \leq 400$ (Labour hours constraint)

$2p + 1.6m \leq 320$ (Special pasteurizing material constraint)

$m \leq 75$ (Distribution storage constraint)

$p, m \geq 0$

Because this is a problem with only two decision variables, it can easily be solved graphically. The graphical solution will be presented for comparison after the simplex solution presented in tables 2 to 6.

Table 2: Initial Simplex Tableau

SV	**P**	**M**	**S_1**	**S_2**	**S_3**	**SQTY**
X_1	2	4	1	0	0	400
X_2	2	1.6	0	1	0	320
X_3	0	1	0	0	1	75
Z	400	500	0	0	0	0

Source: Enyi (2026) derived with ValuStats (VSP) version 2.0

Table 3: Simplex Solution Tableau 1

SV	**P**	**M**	**S_1**	**S_2**	**S_3**	**SQTY**
X_1	2	0	1	0	-4	100
X_2	2	0	0	1	-1.6	200
X_3	0	1	0	0	1	75
Z	400	0	0	0	-500	-37500

Source: Enyi (2026) derived with ValuStats (VSP) version 2.0

Table 4: Simplex Solution Tableau 2

SV	**P**	**M**	**S_1**	**S_2**	**S_3**	**SQTY**
X_1	1	0	0.5	0	-2	50
X_2	0	0	-1	1	2.4	100
X_3	0	1	0	0	1	75
Z	0	0	-200	0	300	-57500

Source: Enyi (2026) derived with ValuStats (VSP) version 2.0

INTERNATIONAL JOURNAL OF LATEST TECHNOLOGY IN ENGINEERING,
MANAGEMENT & APPLIED SCIENCE (IJLTEMAS)
ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VIII, August 2026

Table 4 presents the final simplex solution matrix based on the rule that computation stops whenever the values in all the decision-variable columns are less than or equal to zero. By implication, this indicates that the optimal allocation has been reached. However, a critical observation of the Z-row values of the slack variables tend to suggest otherwise. Based on practice and previous studies, a negative slack value indicates that using additional resources represented by the corresponding constraint will lower costs further and increase profit, whereas allowing a positive slack to remain adds to costs and reduces overall profit by the same value. This implies that a negative slack represents a shadow gain, while a positive slack amounts to a shadow loss.

In Table 4, the Z-row value for slack S_1 is −200, meaning that the slack can reduce the cost per carton of the product by N200, while that of slack S_3 is 300, meaning that the slack adds N300 to the cost per carton of the product. To resolve this issue and maximise the optimality of the resource allocation, the solution quantity (SQTY) values would be divided by the corresponding elements in the column of the slack variable with the positive Z-row value (in this case, slack S_3), as shown in Table 5.

Table 5: Simplex Solution Tableau 3 (Slack Adjustment Computations)

SV	**S_3**	**SQTY**	**SQTY/S_3**
X_1	-2	50	N/A
X_2	2.4	100	41.67 ✓
X_3	1	75	75

Source: Enyi (2026) derived with ValuStats (VSP) version 2.0

Table 5 shows that row X_2 contains the division with the least value, hence it becomes the pivot row for the adjustment of the allocation (while other rows take their adjustment bearings from the new pivot row X_2 values) as in Table 6.

Table 6: Simplex Solution Tableau 4 (Slack Adjustments)

SV	**P**	**M**	**S_1**	**S_2**	**S_3**	**SQTY**
X_1	1	0	-0.334	0.834	0	133.34
X_2	0	0	-0.417	0.417	1	41.67
X_3	0	1	0.417	-0.417	0	33.33
Z	0	0	-75	-125	0	-70000

Source: Enyi (2026) derived with ValuStats (VSP) version 2.0

This solution is checked as follows:

Pasteurized Yogurt (p) – cartons = 133.35 x 400 = 53,340

Orange Milk (m) – cartons = 33.32 x 500 = 16,660

TOTAL **70,000**

This new attainable contribution margin figure of N70,000 is the optimum, indicating that the most optimal resource allocation has been reached. This amount agrees with the graphical solution in figure 1.

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VIII, August 2026

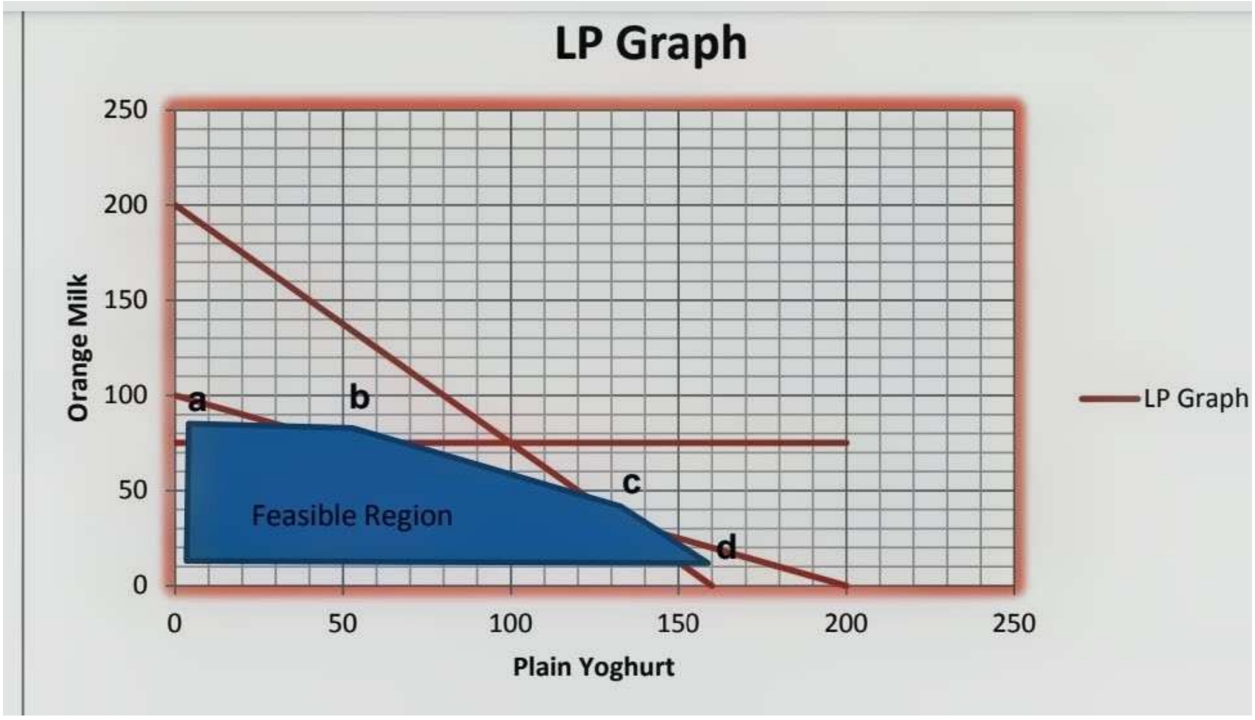

Figure 1: SB Ltd., LP chart

Source: Enyi (2012)

Graphical Interpretation

Barring the slight misalignment of the blue shaded area with the actual plotted lines, the graph can be interpreted as follows:

Point.	Orange Milk	Plain Yoghurt	Total
a	75 x 500	+ 0 x 400	37,500
b	75 x 500	+ 50 x 400	57,500
c	33.32 x 500	+ 133.35 x 400	70,000 ✓
d	0 x 500	+ 160 x 400	64,000

The results in Table 6 and Figure 1 provide clear evidence that, when the simplex algorithm is properly applied, the resulting set of information can be of great assistance to managers when correctly interpreted.

CONCLUSION

The reviewed article makes a useful contribution by demonstrating the application of linear programming and Excel Solver to bakery production planning. Its formulation of the product-mix problem is straightforward, its use of actual resource data enhances practical relevance, and the reported solution provides a potentially useful basis for production planning.

Nevertheless, the analytical treatment is incomplete. Most importantly, the paper was unable to adequately demonstrate the optimality of its reported solution beyond presenting the Excel Solver output. The absence of a final simplex tableau, reduced-cost analysis or another explicit optimality verification limits the reader's ability to independently establish that the reported profit of RM40,270.42 is truly maximal.

More importantly, although the authors introduced seven slack variables and reported their values, they do not adequately interpret the unused resources. The Solver results show that flour, yeast, egg, milk and butter have positive slack, while water and sugar are the binding constraints. These findings have direct managerial implications that should have been discussed.

Consequently, the study would be considerably stronger if it combined the computational output with a rigorous optimality test, an independent comparative solution, and a detailed interpretation of both binding and non-binding constraints. Such an approach would transform the analysis from a simple demonstration of Excel Solver into a more complete decision-support application of the simplex method.

Overall, the article provides a useful practical illustration of linear programming; however, its claim of optimality and its interpretation of resource utilization require further analytical verification. The comparative solution presented in this review provides an important basis for assessing the validity of the reported results and demonstrating the additional managerial information that can be derived from a simplex solution. This perspective is further exemplified by the analysis of a case study, which provides deeper insight into the importance, interpretation, and application of slack-variable values in simplex-based linear programming solutions for resource allocation.

Use of Generative AI

No Generative AI was used in the preparation of this review paper manuscript except for grammar and language checking.

REFERENCES

1. Anieting, A. E., Ezugwu, V. O., & Ologun, S. (2013). Application of linear programming technique in the determination of optimum production capacity. IOSR Journal of Mathematics, 5(6), 60–65. https://doi.org/10.9790/5728-0566265�
2. Azman, N. Z. M., Mohamed, N. A., Mohamed, N. F., & Musa, M. (2022). Application of the simplex method on profit maximization in Baker's Cottage. Indonesian Journal of Electrical Engineering and Computer Science, 27(2), 1034–1042. https://doi.org/10.11591/ijeecs.v27.i2.pp1034-1042�
3. Enyi, P. E. (2012). The sub-optimal effect of the simplex solution method in resource allocation using the linear programming model. American International Journal of Contemporary Research, 2(8), 185–193.
4. Keyeke, G. C. (2006). Operations research. QAT Publishers.
5. Levin, R. I., Kirkpatrick, C. A., & Rubin, D. S. (2005). Quantitative approaches to management. McGraw-Hill.
6. Mohan, L. (2018). Application of linear programming for optimal use of raw materials in bakery. Research Review International Journal of Multidisciplinary, 3(11), 1168–1172.
7. Oladejo, N. K., Abolarinwa, A., & Salawu, S. O. (2020). Linear programming and its application techniques in optimizing portfolio selection of a firm. Journal of Applied Mathematics, 2020, Article 8817909. https://doi.org/10.1155/2020/8817909�
8. Pan, P.-Q. (2025). Face method: Toward the new generation of linear programming. Springer. https://doi.org/10.1007/978-3-031-93594-7�
9. Shakirullah, F. M., Ahammad, M. U., & Uddin, M. F. (2020). Profit optimization of an apparel industry in Bangladesh by linear programming model. American Journal of Applied Mathematics, 8(4), 182–189. https://doi.org/10.11648/j.ajam.20200804.13�
10. Sogunro, A., & Adekanye, F. (2009). Linear programming for business, banking and finance. F & A Publishers.
11. Stafford, L. W. T. (1981). Business mathematics (2nd ed.). Macdonald and Evans.
12. Tripathi, S. K., & Kumar, R. (2023). A short literature on linear programming problem. EAI Endorsed Transactions on Energy Web, 10. https://doi.org/10.4108/ew.4516�

ISSN 2278-2540 | DOI: 10.51583/IJLTEMAS | Volume XV, Issue VIII, August 2026

13. Wolde, B. C., & Larsson, T. (2024). A steepest feasible direction method for linear programming: Derivation and embedding in the simplex method. Operations Research and Decisions, 34(2), 163–182. https://doi.org/10.37190/ord2402010�