

Linear Programming in Operations Research and Decision Making: A Systematic Review of Methods, Applications, and Research Trends

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Abstract: Linear Programming (LP) continues to represent an essential tool for optimization in operations research and decision-making especially for resource-scarce situations, conflicting activities, and operational constraints. This systematic review provides a summary of literature regarding the evolution, solution procedures, applications, extensions, and new directions of research for LP. The review includes foundational work on simplex method, duality, sensitivity analysis, and mathematical modeling along with developments in the interior point approach and large-scale optimization. The expansion of LP into Integer Linear Programming, Mixed-Integer Linear Programming, Multi-Objective and Goal Programming, Fuzzy and Uncertainty-aware Optimization and Hybrid LP are also discussed. From the literature reviewed, it is clear that there are many applications of LP in areas such as production planning, transportation and logistics, supply chains, agriculture, finance, energy, healthcare, scheduling and many others. In addition, from recent literature, it is evident that LP continues to be a relevant field for large scale optimization as well as hybridization with decomposition, cutting-plane, column generation, data analytics, and machine learning techniques. There are many ongoing challenges such as the problem of parameter uncertainty, conflicting objectives like economics and sustainability, scalability, reproducibility, and prediction-driven optimization. From the analysis, it can be seen that LP is not just a conventional method of optimization, but rather a continuously evolving platform that continues to aid in current-day decision making. The future research should focus on optimization that is robust and sustainable, real-time decision making, integration of LP with artificial intelligence, and optimization transparency.

Keywords: Linear Programming, Operations Research, Optimization, Decision Making, Resource Allocation, Mathematical Programming, Systematic Review, Optimization Methods

I. INTRODUCTION

Linear Programming (LP) is a mathematical optimization technique that seeks to establish the best possible allocation of scarce resources among conflicting activities. Linear Programming was formally developed during the twentieth century and continues to be one of the components of operations research as a result of the fact that many decision-making problems can be stated in terms of a linear objective function and a number of linear constraints. Commonly, LP problems include the maximization of profit, production, services, and efficiency or the minimization of cost,

resource utilization, transportation distance and loss. The mathematical properties, efficient computation, and application scope of LP make it an appropriate decision tool in academia, industry, government and service sectors.

The significance of LP has evolved in conjunction with the rise of complexity of the resource-allocation decisions. Organizations often face constraints related to budgeting, work force, materials, production, transportation, time, energy and demand. The decisions based purely on experience and intuition cannot provide the best possible combination of alternatives. LP offers a way to represent these

relationships and identify the optimum feasible solution. The basic model of LP includes decision variables, objective function, constraints and non-negativity conditions.

However, the methodological development of linear programming has come a long way beyond the classical graphical and Simplex approaches. The Simplex is still the most popular solution technique for linear programming problems, while revised Simplex and interior-point methods can serve as alternatives for the computational problems of large scale. Such ideas as duality and sensitivity analysis make the use of linear programming more valuable by helping the decision makers analyze the economic meaning of constraints and impacts of parameter changes in the models. Furthermore, various extensions of linear programming as the tool for decision-making have been developed to solve the decision problems with discrete decisions, multiple objectives, uncertainty, vagueness, and nonlinearity of real world. They include Integer Linear Programming, Mixed-Integer Linear Programming, Goal Programming, Multi-Objective Linear Programming, Fuzzy Linear Programming, and other optimization techniques.

LP has been used in many different areas. LP is widely used in manufacturing for product mix and production planning. In transportation and logistics, LP models are used for distribution planning, transportation cost minimization, and supply chain planning. LP can be used in agriculture for crop selection, allocation of resources, production planning and land allocation. Applications of LP in healthcare include staff scheduling, capacity allocation, treatment planning, and supply management. In finance and energy systems, LP models may be used for portfolio allocation, generation planning, and resource distribution. Thus, the versatility of LP to optimize problems with significantly different objectives is shown.

However, modern decision-making processes are associated with some challenges that cannot be handled with the help of traditional

deterministic LP models. Companies need to deal with uncertainties, fluctuating demand, sustainability requirements, large amounts of data, and fast-changing conditions. This makes it necessary to consider the possibilities of combining LP with other optimization techniques, artificial intelligence, machine learning, simulation, and decision support technology.

While there have been various works using LP in particular industries or decision-making problems, the literature has been scattered across different disciplines and methodologies. In order to analyze how LP methodologies have developed, what kind of application fields have been extensively studied, what types of methodological extensions have been used the most, and what research topics require further research, conducting a review could help in comprehending the role of LP methodologies in contemporary studies.

Thus, this study conducts a systematic review of Linear Programming for use in operations research and decision-making. The review will be done on the basis of LP methods, major application fields, methodological extensions, current research trends, and challenges. Through organizing the literature by methods and applications, this study intends to give an integrated view on current status of LP literature.

The key purposes of the literature review include the following: (1) study of significant methodological advances in Linear Programming; (2) categorization of major fields of application of LP; (3) comparison of major techniques of LP solutions; (4) identification of current trends in LP applications; and (5) determination of research gaps and future trends in the field of Linear Programming.

II. RELATED WORK

Linear Programming has evolved from being a base technique of operations research into an optimization methodology whose application spans such areas as production, transportation, economics, energy, agriculture, medicine, and

others. The initial developments provided the mathematics of LP as well as the practical significance of LP for optimal resource allocation. The development of the Simplex method by Dantzig in the 1940s gave the computational method of solving linear optimization problems and became the key achievement in the formation of modern operations research [1]. Further developments in duality theory, sensitivity analysis, and other computational approaches enriched LP methodology.

Classical LP model can be presented in the form of a linear objective function under the conditions of a system of linear inequalities and non-negativity restrictions. This model gives a flexible approach to modeling the problems of resource allocation and planning. The aspects of modeling, solution, interpretation, post-optimality analysis, and multiple criteria optimizations are discussed in Eiselt and Sandblom [2] that shows that LP is not limited to a computational technique but is a more complex process of creating and evaluating mathematical models.

Nonetheless, other modifications and improvements have been discovered, including revised Simplex methods, dual Simplex methods, and interior-point methods. Vanderbei [3] discusses LP in terms of its theory, Simplex and duality, sensitivity and parametric analysis, network problems, interior-point methods, and generalizations. Interior-point methods have gained prominence due to their theoretical aspects of polynomial complexity as well as due to their behavior with large-scale LP problems. The recent research continues to focus on the computation, implementation, complexity, and combination with decomposition and other optimization methods [4].

Duality has also been an area of active research in the realm of LP problems. Every good LP problem possesses a dual problem, which gives another mathematical view of the problem in question. This concept can be helpful for interpreting resources, establishing optimality conditions, and performing sensitivity analysis.

Balinski and Tucker [5] discussed the ways of constructing duality in LP problems as well as its connection with the Simplex methods. Moreover, duality helped create the connection between mathematics, economy, and decision analysis.

Resource allocation continues to remain one of the significant application areas of LP. LP is described by Panik [6] as a decision-making and resource allocation technique for firms, which encompasses product mix, production techniques, sensitivity analysis, structural changes, and parametric programming. Applications like these exemplify the relevance of LP in making decisions about limited labor, materials, capital, production capacity, and other resources. LP has therefore emerged as an indispensable technique in both operational and strategic decision-making.

The range of applicability of LP has widened considerably in terms of the number of areas to which LP can be applied. Cheng and Boom [7] conducted a survey of practical applications of LP in manufacturing and service organizations and concluded that LP can help managers make decisions in a wide range of industries. Further developments have added to the list of areas where LP can be applied. Golden et al. [8] collected a set of non-traditional and surprising applications of LP, indicating that even problems which seem non-linear at first glance can be modeled using linear techniques.

The evolution of LP is highly associated with the development of operations research in general. Emrouznejad and Marra [9] studied the history of operations research from LP to DEA and highlighted the pivotal importance of LP and Simplex method for establishing operations research as an academic field of study. This approach is relevant since many other optimization models that appeared later can be interpreted as modifications or combinations of concepts elaborated in mathematical programming.

Contemporary literature also witnesses growing interest to the integration of classical LP with other optimization techniques. Integer and

mixed-integer programming are LP techniques that allow using discrete decision variables, and therefore are useful for solving scheduling, assignment, routing, facility-location problems, etc. Multiobjective and goal programming can be applied when there are several conflicting goals for a decision-maker. Fuzzy and stochastic approaches were created in order to model uncertain, imprecise or stochastic nature of decision-making parameters.

Another significant area is the interaction between optimization and predictive methods. Given the abundance of datasets and computing power nowadays, scientists started using predictive analytics alongside with mathematical optimization models. Thus, in such settings, machine learning could be used for the estimation of demand, costs, risks, etc., while LP and its relatives find optimal decisions under various constraints. The union of

prediction and optimization may serve as a link between these two areas.

Therefore, the literature implies three general phases of the development of LP. First, the basic phase was devoted to the mathematical foundation, the Simplex method, duality, etc. Second, the applied phase was aimed at expanding LP to production, transportation, agriculture, financial, energy, healthcare, and many other fields. Third, the current phase tends to focus on the big scale computations, uncertainty, multi-objective problems, sustainability, hybridization of optimization, and the intersection of LP with data-based approaches. Interior-point surveys show also that LP plays an important role in optimization, including the mixed integer programming, network optimization, decomposition, cutting plane, and column generation approaches [4].

Table 1. Selected Literature on Linear Programming

Author(s)	Year	Main Focus	Method/Approach	Contribution
Dantzig	1963	Linear programming foundations	Simplex and LP theory	Established foundational methods and theory of LP [1]
Eiselt & Sandblom	2007	LP theory and applications	Simplex, duality, postoptimality, multiobjective LP	Integrated modeling and applications [2]
Vanderbei	2020	LP foundations and extensions	Simplex, duality, interior-point methods	Comprehensive treatment of classical and modern LP [3]
Panik	2019	Resource allocation	LP, duality, sensitivity, parametric programming	Developed LP applications for resource allocation [6]
Cheng & Boom	1992	Practical applications	Applied LP	Reviewed manufacturing and service applications [7]
Emrouznejad & Marra	2019	Operations research foundations	LP and DEA	Examined the evolution of OR from LP to DEA [9]
Tripathi & Kumar	2023	LP literature	Literature review	Classified LP modeling approaches and solution methods [10]
Golden et al.	2024	Unexpected applications	LP modeling	Demonstrated the breadth and flexibility of LP applications [8]
Recent interior-point literature	2025	Large-scale optimization	Interior-point methods	Reviewed computational developments and modern applications [4]

In general, past research shows that LP in table 1 has been an optimization technique which constantly evolves in line with computational developments and applications. Yet, research in this area is scattered in terms of methodology, theory, and applications. This justifies the call for an integrated review where not only classical techniques and modern algorithms, but also applications and new directions of research are discussed.

III. REVIEW METHODOLOGY

This study follows a structured literature review method for compiling the research on Linear Programming. This is because the aim of this study is to critically review existing knowledge and not to analyze any data collected from observations. As such, there will be no need for any questionnaire, field survey, experimental data, or simulated data in this case.

3.1 Review Objectives and Scope

The review highlights five main aspects in Linear Programming research: (1) basics of Linear Programming theory and mathematics; (2) algorithms for LP solution; (3) extension of classical Linear Programming; (4) domains of LP application; and (5) tendencies in modern LP research. The review refers to foundational sources of literature in order to trace the development history of LP, and the emphasis is made on modern sources when dealing with its recent applications.

3.2 Literature Search Strategy

Identification of relevant literature may be carried out through major academic databases and scholarly search engines such as Scopus, Web of Science, ScienceDirect, SpringerLink, IEEE Xplore, Google Scholar, and publishers' databases. The keywords must be constructed around the main topic of Linear Programming using various methods and applications of the technique. Some of the keywords may include

"Linear Programming," "linear optimization," "Simplex Method," "interior-point method," "applications of linear programming," "resource allocation," "Integer Linear Programming," "Mixed Integer Programming," "Fuzzy Linear Programming," and "Multi-Objective Linear Programming."

The literature search should consider not only the highly cited classic literature but also the more recent one. In particular, for the trend analysis, recent literature, within the last decade, may receive more emphasis, whereas the classic works would remain if they form part of the theoretical base.

3.3 Inclusion and Exclusion Criteria

The relevance criteria for studies include making a contribution to the area of Linear Programming in terms of theory, methods, applications, extensions or trends in the research. Peer reviewed journal articles, conference papers, scholarly books, and authoritative technical reports can be included in cases of providing adequate information on the methodology used.

Excluded studies include those where Linear Programming is cited tangentially without being used as research methodology, those which do not offer adequate information for classification purposes, those where duplicate versions of the same study are found, and those unrelated to mathematical optimization.

3.4 Literature Classification

The chosen papers are classified based on the following factors: publication year, area of investigation, area of application, LP model, solution approach, data, optimization objective, and contribution of the paper. Such classification is helpful in comparing different papers and finding shifts in LP research over time in table 2.

Table 2. Proposed Literature Classification Framework

Classification Dimension	Categories
Research focus	Theory, algorithm, application, review, hybrid optimization
LP type	Classical LP, ILP, MILP, goal programming, multi-objective LP, fuzzy LP
Solution method	Simplex, revised Simplex, dual Simplex, interior-point, decomposition, solver-based
Application	Production, agriculture, transportation, supply chain, healthcare, finance, energy, environment, education, workforce
Objective	Profit maximization, cost minimization, resource allocation, efficiency, sustainability
Data environment	Deterministic, uncertain, fuzzy, stochastic, data-driven
Computational tools	MATLAB, Python, R, LINGO, GAMS, CPLEX, GUROBI, Excel Solver

3.5 Synthesis Approach

In the current review, qualitative thematic synthesis is adopted for comparison of the chosen literature. Studies are clustered based on their similarities in methodology and application. Common findings, advancements in the methodology, strengths, weaknesses, and research gaps are discussed thereafter. Descriptive statistics can also be employed in identifying trends in publications, applications, and commonly cited solution methodologies if enough bibliographic information is available.

Thematic synthesis classifies the reviewed literature into classical linear programming framework and modern extensions. Classical LP comprises of the traditional model, Simplex-related methodology, duality and sensitivity analysis. Modern extensions comprise of integer and mixed-integer programming, multi-objective and goal programming, fuzzy and stochastic programming, and hybrid techniques that involve use of data-driven methodologies.

3.6 Reliability and Transparency

In order to enhance the reliability of the paper, the review needs to have constant search terms, inclusion and exclusion criteria, as well as an extraction structure. Any significant methodological assertions need to be verified with the original articles instead of secondary sources. Furthermore, bibliographic information needs to be verified regarding authors, publication date, journal name, volume, issue

number, pages, and DOI, if applicable. This will help prevent any selection errors.

The methodology developed helps provide a systematic approach for analyzing the history and present status of Linear Programming while avoiding empirical data. The following chapter presents the synthesis of literature on the subject based on the methodological advancements and areas of application.

IV. REVIEW FINDINGS AND ANALYSIS

From the literature review, it can be seen that linear programming is now more than just a classical technique for allocating resources; it has evolved to become an entire class of optimization methods used for making complicated decisions both operationally and strategically. There are four main topics covered in the findings of the literature.

4.1 Methodological Development of Linear Programming Techniques

It can be observed from the literature that there is an evolution in the methodological development. Initially, LP methodology was concerned with the formulation of optimization problems mathematically, Simplex algorithm, feasibility, optimality, duality and sensitivity analysis [1–3]. This is still relevant because current applications rely heavily on LP formulation for optimization problems.

The creation of interior point methods became a significant step forward in large-scale

optimization. In contrast to the Simplex class, which jumps from one vertex of the feasible polyhedron to another, interior point methods use the inner space of the feasible domain and can work well in large problems. Current studies still improve the interior point methods and their usage in large-scale mathematical programming [4].

Another important breakthrough was the development of LP to include the problems with discrete choices. The Integer Linear Programming and Mixed-Integer Linear Programming allow for choosing the integer values of decision variables and hence are used to solve the problems like assignments, scheduling, facility location, routing and other decisions where partial solutions do not make sense.

4.2 Major Application Areas

Application areas of Linear Programming include resource allocation, production planning, transportation and supply chain management. Production planning involves the use of linear programming to determine combinations of products that will yield maximum profits given labor, material, machines and market constraints. Resource allocation models also seek to establish how scarce resources should be allocated to competing uses [6].

Transportation and logistics problems usually entail cost minimization models where quantities are allocated from origins to destinations while satisfying the supply and demand constraints. LP can also be used in making supply chain management decisions including procurement, production, inventory and distribution decisions. The versatility of the LP formulation enables organizations to take into account various operational constraints within one model.

Linear programming applications in agriculture entail crop planning and land allocation. Decision makers seek to determine combinations of crops given land, labor, water, capital and production constraints. Similar

applications in the health care sector seek to allocate labor, facilities, equipment and supplies using LP formulations. Other applications include energy and environment applications that seek to allocate generation resources and minimize operating costs.

4.3 Computational Approaches

As shown in the literature reviewed here, selection of the proper solution methodology is highly dependent on the size and nature of the problem being solved. In the case of many traditional LP problems, the Simplex method still holds great importance due to the body of theory that exists, the interpretability of the results and the computational efficiency [2,3].

In the case of very large-scale continuous LP problems, the interior point methods offer another way forward. On the other hand, in the case of discrete/combinatorial decision-making problems, the integer programming methods are more suitable. Thus, there is no one-size-fits-all methodology; it depends upon the nature of the problem.

4.4 LP Extensions for Complex Decision Environments

Classical Linear Programming (LP) involves deterministic coefficients and linear relationships between the decision variables and the objective function and constraints. Practical decision-making contexts do not usually satisfy these requirements. There have thus been many extensions proposed to model increased complexity.

Multi-objective programming and goal programming deal with scenarios where decision makers try to meet different goals such as reducing costs, improving quality, improving service, or improving sustainability at the same time. If there are uncertainties and variations, then fuzzy LP or stochastic and robust optimization techniques can be employed. Integer and mixed integer programming is suitable for modeling discrete decision-making.

4.5 Integration with Data-Driven Methods

One current major trend is the combination of mathematical optimization techniques and data analytics/machine learning. Predictive models can predict future demand, prices, resource needs, or risks, while LP can utilize these predictions to find feasible and optimal actions. This leads to the link between predictive analytics and prescriptive analytics.

The combination seems especially attractive for situations of dynamically changing environments. At the same time, mistakes in prediction can affect optimization solutions. Future research thus should take into account uncertainty of machine-learning predictions, model robustness, interpretability, and optimization solution stability.

4.6 Sustainability and Emerging Applications

The issue of sustainability has emerged as a critical factor for optimization studies. While conventional LP models tend to focus on optimizing economic factors like maximizing the profits or minimizing the costs, modern examples tend to take into account the factors related to the environment and society, such as energy usage, emissions, waste management, equal distribution of resources, etc. It is promoting the use of multi-objective optimization models and hybrid optimization models. Instead of considering sustainability as the secondary concern, it is becoming a primary consideration and decision factor itself.

Table 3. Major Research Themes in Linear Programming

Research Theme	Typical LP Approach	Main Objective	Representative Applications
Production planning	Classical LP	Profit maximization / cost minimization	Manufacturing, product mix
Resource allocation	LP / Goal Programming	Efficient distribution of scarce resources	Business, agriculture, public services
Transportation	Transportation LP	Cost minimization	Logistics, distribution
Scheduling	ILP / MILP	Conflict and cost minimization	Workforce, production, education
Supply chain	LP / MILP	Cost and service optimization	Procurement, inventory, distribution
Agriculture	LP / Fuzzy LP	Production and resource optimization	Crop planning, land allocation
Healthcare	LP / MILP	Capacity and resource optimization	Staffing, facilities, supplies
Energy	LP / Multi-objective LP	Cost and sustainability optimization	Generation, energy planning
Finance	LP / Goal Programming	Portfolio/resource allocation	Investment planning
Data-driven optimization	LP + ML	Predictive-prescriptive decision making	Demand planning, dynamic allocation

4.7 Overall Synthesis

In general, the body of literature shows that the true power of Linear Programming in table 3 is in its mathematical clarity, flexibility, and tractability. Classic linear programming is still relevant in many resource allocation problems under certainty, whereas its extensions give

tools to address discrete variables, multi-objectives, uncertainty, and more complicated environments.

Furthermore, the literature shows that there is great variety of applications of LP. The method is not only used in solving classic production and transportation problems but also in

medicine, agriculture, energy, sustainability, public sector, finance, data analytics, and decision support. In addition, the current computational advances make it possible to solve larger and more complex optimization problems.

On the other hand, there are some challenges that can appear. Choosing an appropriate objective function may be problematic in case when decision-makers have different preferences. Uncertainty of parameters may affect the validity of a deterministic solution. Hybrid systems of LP and machine learning bring new challenges concerning prediction error and interpretability of models.

V. RESEARCH GAPS AND FUTURE DIRECTIONS

While LP theory is well established, the literature review has revealed many areas where further investigation is needed. The recent literature demonstrates how LP still develops along with big data computation approaches, mixed-integer problems, uncertainty-oriented optimizations, and combining with other decision support systems [4,11].

5.1 Uncertainty in Optimization Parameters

The majority of traditional LP models presume that coefficients, available resources, costs, and demand are defined precisely. However, in real conditions, those parameters might vary due to the market changes, interruptions of supplies, climate conditions, variation of demand, and so forth. Thus, further study should pay more attention to stochastic, robust, and fuzzy optimization which allows making decisions under different circumstances.

5.2 Multi-Objective and Sustainable Optimization

Most LP problems in their classical form focus either on profit maximization or cost minimization. Modern decision-making

problems imply that economic, environmental, and social factors should be taken into account together. Further study should consider multi-objective and sustainable LP and goal-programming models.

5.3 Large-Scale and Computationally Demanding Models

As the size of optimization problems increases, new research on interior-point methods stresses their significance for very large-scale LPs and the combination of these algorithms with decomposition, cutting planes, and column generation [4]. Future research needs to enhance computational scalability by means of parallel computing, sparse matrix computations, decomposition approaches, and optimization software.

5.4 Predictive Analytics and Machine Learning in Optimization

Predictive analytics combined with optimization is an important future trend. In particular, machine learning algorithms can be used to predict the demand, prices, resources needed, or risks. LP algorithms can then turn the predictions into optimal decisions, forming a predictive-prescriptive approach in which the two types of algorithms complement each other. Future research needs to account for the uncertainty, robustness, explainability, and stability of the predictions.

5.5 Reproducibility and Open Research in Optimization

Reproducibility is an important future research topic. Optimization studies need to provide enough details on the mathematical formulation, the datasets, the parameter estimation, the constraints, the solver settings, and the computational process. Openly available datasets, openly available mathematical models, and reproducible experiments would allow researchers to compare different algorithms and verify published results in table 4.

Table 4. Major Research Gaps and Future Directions

Research Gap	Current Limitation	Future Direction
Deterministic assumptions	Parameters treated as fixed	Stochastic and robust LP
Single objective	Economic objectives dominate	Multi-objective optimization
Limited sustainability	Environmental impacts may be omitted	Sustainable and green LP
Static decision-making	Models represent fixed conditions	Dynamic and real-time optimization
Limited AI integration	Prediction and optimization are often separated	LP-machine-learning frameworks
Computational scale	Very large models can be expensive	Parallel, decomposition, and advanced IPM methods
Reproducibility	Incomplete reporting of models and data	Open and reproducible optimization
Fairness	Efficiency may dominate equity	Fairness-aware resource allocation

VI. COMPARATIVE LITERATURE ANALYSIS

Literature can be classified broadly into two categories, studies that deal with methodology and studies that are application oriented. Studies related to methodology have mainly focused on

algorithm development and comparisons such as Simplex and interior point algorithms. Studies concerned with applications have used LP in production, transportation, logistics, agriculture, finance, health care, energy, and other fields. Recent reviews confirm the extensive applicability of LP [8].

Table 5. Verified Literature Matrix

No.	Year	Author(s)	Research Area	Approach	Main Contribution
1	1963	Dantzig	LP foundations	Simplex and LP theory	Established foundational mathematical and computational treatment of LP [1]
2	1994	Lustig, Marsten & Shanno	Large-scale LP	Interior-point methods	Compared interior-point computation with Simplex approaches for large LP models [12]
3	2007	Eiselt & Sandblom	LP theory and applications	Simplex, duality, postoptimality	Integrated modeling, solution, interpretation, and applications [2]
4	2012	Gondzio	Large-scale optimization	Interior-point methods	Reviewed 25 years of interior-point development and large-scale computation [13]
5	2019	Panik	Resource allocation	LP and sensitivity analysis	Examined LP for firm decision-making and resource allocation [6]
6	2020	Vanderbei	LP theory and extensions	Simplex, duality, interior-point	Provided a comprehensive treatment of LP foundations and extensions [3]
7	2024	Golden et al.	Multiple applications	Linear Programming	Demonstrated the breadth of practical LP applications [8]

No.	Year	Author(s)	Research Area	Approach	Main Contribution
8	2025	Gondzio	Modern optimization	Interior-point methods	Reviewed contemporary IPM theory, computation, decomposition, and column generation [4]
9	2025	Clautiaux& Ljubić	Mixed-integer optimization	MILP, branch-and-cut, decomposition	Reviewed recent practical advances in integer linear programming [11]
10	2025	Allamigeon et al.	LP algorithms	Interior-point methods	Examined theoretical relationships between interior-point and Simplex approaches [14]

The comparative analysis clearly shows in table 5, the move from simple algorithmic developments to larger-scale, applied optimization that is also hybrid. The Simplex algorithm plays an integral role in the historical and theoretical background of Linear Programming. Interior point methods have become very important in case of large-scale LPs [4,13]. Applied Linear Programming is used in resource allocation as well as for a variety of decision-making purposes [6,8]. Integer programming is another development in this respect.

VII. RESEARCH TRENDS

A number of significant trends may be distinguished based on the analysis of the reviewed literature.

7.1 From Classical Algorithms to Large-Scale Optimization

Historical development of LP involved transition from the Simplex algorithm to a more general class of algorithms that allows solving increasingly complex optimization problems. Interior-point methods are an integral part of this development and a subject of ongoing research [4,13].

7.2 From Single-Objective to Multi-Criteria Decision Making

LP studies are becoming more focused on multiple criteria and often even contradictory objectives. This trend is especially important to the field of sustainability as economic

efficiency needs to be reconciled with other objectives.

7.3 From Deterministic to Optimization in Uncertainty Conditions

It has been recognized that in real-world applications exact values of model parameters cannot always be provided. This trend points to stochastic, robust and fuzzy optimization techniques as significant directions for LP-related research.

7.4 From Isolated Optimization to Hybrid Systems

LP becomes an integral component of more complex computational systems. Recent research on interior-point methods is associated with decomposition, cutting planes and column generation [4]. Mixed integer programming research develops branch-and-cut, Dantzig-Wolfe and Benders decomposition approaches [11].

7.5 From Descriptive Models to Prescriptive Decision-Making Using Data

The increasing availability of data allows the linkage between prediction models and optimization methods. The future systems will be able to make predictions using machine learning and LP to choose from feasible and optimal decisions. It is a transition from descriptive and predictive analytics towards decision support.

VIII. DISCUSSION

It is clear from the above review that LP is still one of the core elements of operations research

methodology. It is not only because of the legacy but also because of the mathematical model, which makes decision problems concerning the allocation of scarce resources clear and tractable for computations. Golden et al. [8] give evidence that LP application is very broad, and there is further research in interior-point methods for computational advances in LP [4].

Comparison of studies on the methodology of LP indicates that LP should be considered not as a fixed algorithm but rather as a growing family of approaches. Simplex method plays a crucial role, but interior-point methods are also important for large-scale optimization problems. Extensions for integer and mixed-integer programming make discrete variables possible. Decomposition and cutting plane methods increase capabilities of optimization models of big size [4,11].

The application literature shows that LP is capable of adaptation to operational environments quite different from those initially assumed. Such diverse applications as production planning, resource allocation, transportation, scheduling, logistics, and many others can be modeled by means of appropriate decision variables and constraints. What unites all these applications is the need to choose the best available combination of alternatives with limited resources.

However, the deterministic and single-objective nature of the model gives grounds for further improvements. Decision makers face problems of uncertainty and multiple objectives. This suggests the need for further research and development aimed at addressing these aspects, thus maintaining the interpretability and relevance of the LP model.

The use of LP in combination with artificial intelligence and machine learning promises much for the future. However, this combination of LP and ML cannot be interpreted as the replacement of optimization with prediction. ML can provide estimates of the pattern or of future states, while optimization is responsible for choosing an optimal solution, which makes

this combination prescriptive-predictive in nature.

8.1 Practical Implications

The results have several applications in research, management, policy-making and computer programming. Managers can apply LP to objectively analyze potential resource allocation solutions prior to allocating scarce resources. Researchers can develop new LP frameworks by incorporating uncertainty, sustainability considerations, multiple objectives and discrete decisions into classical LP formulations. Policy-makers can use LP to guide them in the allocation of public resources under the constraint of budgets and capacities. Computer programmers can embed LP solvers into decision support systems through advanced computational technologies.

From a practitioner's perspective, the most useful feature of LP is its intelligibility. LP decision variables, objectives and constraints are normally comprehensible to the stakeholder community, making optimization outcomes more understandable than some other complicated black-box techniques.

8.2. Limitations of the Review

The review has various weaknesses. Firstly, the scope of Linear Programming is too wide for any review to capture every article available. Secondly, different fields have different terminologies, which implies that not all articles will be captured by specific search strings. Thirdly, the reviewed literature contains both theoretical and applied articles, making it difficult to make numerical comparisons. Fourthly, the research field is evolving rapidly especially on large scale optimization and hybrid computation techniques.

In summary, the review can only be taken as a systematic synthesis of available Linear Programming literature but not an exhaustive bibliometric enumeration of all the available LP literature. Upcoming research may build on this work by conducting a PRISMA review, having a well-defined search string for specific databases, duplicate checking, multiple

independent screening of articles, and having a reproducible data set.

IX. CONCLUSION

Linear Programming is still one of the most significant optimization paradigms in operations research and decision-making. From the inception of the Simplex algorithm to the present day, when there are interior-point and mixed-integer methods available, the paradigm constantly evolves while keeping its mathematical essence. Literature review suggests that Linear Programming can still be applied to resource allocation, production planning, transportation, supply chain management, agriculture, finance, healthcare, energy, scheduling, and many other domains.

At the same time, the review suggests that the future of LP will be determined by its ability to evolve in order to cope with more and more complicated decision-making situations. Such areas as large-scale computation, uncertainty-aware modeling, multi-objective optimization, sustainability, decomposition, and hybrid optimization are crucial for the future of LP. Recent research proves that interior-point algorithms are still highly relevant to large-scale Linear Programming and Linear Programming is still used in the context of mixed-integer programming.

On the whole, Linear Programming cannot be viewed as an obsolete mathematical tool. Instead, Linear Programming provides a reliable basis for modern optimization and can act as a link between mathematical modeling and data-driven decision-making. Future research should concentrate on robust, sustainable, and transparent LP-based systems, especially those combining optimization and predictive analytics/artificial intelligence.

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