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Exploring the Global Emergence of Linear Programming, its Application, Benefit and Prominence: A Squint on Literature Review

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ABSTRACT

This work aims to review the research on the global emergence of linear programming, its application, benefit and importance. Scholarly debate has been documented over the concept, content, and purpose of linear programming, as well as its global emergence. Additionally, the article has demonstrated the importance of linear programming in enhancing economic development. Linear programming has also been found to improve corporate management, decision-making, planning, and management. Thus, the set will aid in the industrialization process, the efficient planning and administration of the world's finite resources, particularly in developing nations.

Therefore, in order to improve topic delivery, it is advised that the government, through the Ministry of Education (MoE), efficiently train and hire competent math instructors to teach linear programming in secondary schools across the nation. Moreover, it is suggested that the MoGE include linear programming in all educational levels. Finally, it is advised that math teachers prioritize delivery and incorporate a range of approaches, ideas, and techniques into their lessons.

Keywords: prominence, emergence, secondary school, linear programming

INTRODUCTION

Every person tries to maximize their resources and time as they are finite. Businesses may quickly tackle supply chain issues by utilizing optimization approaches. Linear programming simplifies optimization. On the basis of a few basic assumptions, it is the most effective way to execute linear optimization. In the real world, connections are surely not easy. Linear programming is used in many areas, such as manufacturing, telecommunications, transportation and energy.

This research investigates the global rise to prominence of linear programming. Thus, the overview starts with an awareness of linear programming's emergence and widespread use around the world. Objective function under a set, optimization techniques are applied (Vanderbei 2013). It is extensively used to effectively handle resource allocation and optimization problems in a variety of domains, including operations research, engineering, finance, and economics (Hillier & Gerald, 2014). According to Hillier and Lieberman (2013), it is utilized to address a variety of issues including resource allocation, production planning, portfolio optimization, and transportation and logistics optimization. Many disciplines, including economics, engineering, operations research, and finance, have used linear programming.

SIGNIFICANCE

Linear programming holds significant importance of countries and individuals due to its ability to optimize resources and solve complex problems efficiently. In essence, linear

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programming plays a crucial role in optimizing resource utilization, decision-making, and problem-solving at both the national and individual levels, contributing to overall societal welfare and development. By modeling various scenarios, policymakers can make informed decisions on issues like economic development, environmental sustainability, and infrastructure planning.

Education policy makers, particularly those in Education, may find this review useful as it can help them implement policies that promote funding for the subject and help them understand the value of linear programming. Furthermore, the review may be useful to other academics who wish to investigate linear programming further. More understanding in the area of linear programming will also be added by this study.

Global Emergence

Linear programming (LP) emerged as a popular mathematical optimization method in the mid-1900s. Linear programming emerged during late 19th and early 20th centuries by the works of mathematicians Leonid Kantorovich and Tjalling Koopmans. They developed mathematical models for economic planning and resource allocation (Dantzig, 1947). Its development was mostly motivated by the necessity to find effective solutions to challenging issues in military and economic planning. During World War II, military planners looked for effective ways to distribute scarce resources including people, weaponry, and supplies. This led to the rise in popularity of linear programming. During this period, George B. Dantzig made significant contributions. He is usually given credit for developing the simplex approach, which is an essential technique for solving problems involving linear programming (Dantzig, 1947). In 1947, Dantzig presented the simplex approach, an effective algorithm for resolving linear programming issues. By making it possible to solve bigger and more complicated linear programming models, this technique dramatically changed the field (Koopmans, 1947). As stated by Kantorovich (1939) Parallel work on analogous optimization problems was being done in the Soviet Union by mathematicians such as Leonid Kantorovich and others, particularly with regard to economic planning.

Linear programming gained popularity after World War II in industries, such as telecommunications, transportation and economics. It was a useful tool for both industrial and academic applications because of its capacity to increase efficiency and optimize resource allocation.

Interior point methods, an alternative to the simplex approach appeared in the late 20th century. These methods offered theoretical advantages and were particularly helpful for large-scale linear programming models (Kantorovich, 1939). Even now, a large range of industries, including operations research, finance, logistics, and data science, still heavily rely on linear programming. Applications for it include portfolio optimization in finance and other industries as well as supply chain operations optimization.

LITERATURE REVIEW

Global Contemporary Emergency

Combination of linear programming with sophisticated computer tools, such artificial intelligence and big data analytics, has led to the modern global development making it possible to solve ever-larger and more complicated optimization problems. Furthermore, as new algorithms and optimization strategies are created, linear programming keeps developing, guaranteeing its continued relevance and suitability in dealing with the complex problems of the contemporary world.

In order to address a variety of worldwide contemporary problems, such as resource allocation in humanitarian logistics or healthcare delivery system optimization, linear

programming has shown to be an invaluable tool. Logistics for humanitarian aid and disaster relief: The effective distribution of resources, such as food, shelter, and medical supplies, is essential in emergency response scenarios, such as natural disasters or conflicts. The distribution of these resources has been optimized by the widespread application (Özdamar & Ekinci, 2004). It maximizes the allocation of healthcare resources, including hospital beds, medical staff, and medical supplies. They are particularly pertinent during global health crises like pandemics. Good supply chain management is required to ensure that essential medications are available in an emergency. Kumar et al. (2020) in "Optimization models in a descriptive review of healthcare resource allocation" provide some insights into the application of linear programming. They assert that in the pharmaceutical sector, distribution networks, production schedules, and inventory levels are all optimized via linear programming.

Resolving the effects of climate change necessitates intricate decision-making procedures with several parties and competing goals. Planning land use, deploying renewable energy, and reducing greenhouse gas emissions are all made easier through the backing of linear programming. The use of LP in energy planning that takes into account the effects on the environment and human health is demonstrated by a paper by Zhang et al. (2015) titled "Optimal Planning for China's Energy Structure Considering the Co-Benefits of carbon dioxide Emission Reduction and Health Benefits".

These illustrations show how adaptable linear programming is in handling a variety of modern global catastrophes by offering the best answers to challenging resource allocation and decision-making issues.

The approach first presumes that an extreme point is identified. If no extreme point is provided, the Phase I form of the simplex approach is employed to identify one or to conclude that no workable solutions exist. On occasion, it is possible to increase without bound by moving along an edge (Napkhonenko, & Karaeva, 2019).

When this happens, the process ends where the goal reaches positive infinity. However, the parameter score for the new maximum point is ideally equal to that of the preceding ones. Next, the described sequence is repeated. When the unbounded case arises or an ideal extreme point is discovered, termination takes place. In reality, the strategy typically settles on the minimal number of necessary steps.

Application

Most popular method for making decisions in business, industry, and other domains is linear programming. Both farm management and farm economics apply to this application. The former addresses the agricultural economy of a country or region, whereas the latter focuses on the issues that specific farms face.

The optimal distribution of crop production and interregional rivalry are topics covered in the study of agricultural economics. Under constraints relating to national demand, an efficient production pattern can be specified using linear programming (LP) model (Sokolov, et al 2014). Revenue agricultural planners allocate scarce resources including labor, acreage, water supply, and working capital.

The challenge of choosing an air weapon system against an opponent to pin them down while also minimizing the amount of aviation gasoline needed is one that has military implications. The movement complexity can be altered to enhance the total amount of bombs dropped on targets. Similar to this, the issue of community defence can be resolved by determining how many defence units to deploy in a particular attack while still providing the required level of security at the lowest feasible cost (Liu, et al, 2020).

A business can manufacture a variety of goods, each requiring a little amount of resources for production. In these situations, it is crucial for each product to be produced while taking into account its marginal contribution and the total amount of resources that it uses.

Maximizing the overall contribution is the goal, taking into account all limitations (Shramenko, Muzylyov, & Shramenko, 2020).

Taking into account the starting number of units in inventory, production capacity, production restrictions, labor costs, and other pertinent cost elements, this deals with determining the minimal cost production plan across the planning period of an item with a dynamic demand. Reducing overall operating expenses is the goal.

When something may be built by combining various components, this issue is likely to occur. There are specific sequences needed for the assembly process. Reducing the overall amount of elapsed time is the goal. These issues occur when different raw materials, each with a unique composition and cost, might be used to make a product. Finding the lowest cost blend is the goal here, given minimum and maximum restrictions on specific product ingredients, as well as raw material availability.

Reduce loss the challenge that emerges when producing an item to a standard size (such as a glass or paper sheet) is figuring out which combination of specifications should be constructed from standard materials to trim loss. Selecting a portfolio involves selecting an investment strategy from a variety of possibilities. The intent is to determine the allocation that, within given bounds, maximizes the total projected return or minimizes risk. The yield on investments made in equipment, plants, and cash on hand, and inventory is the aim of profit planning.

Given a budgetary constraint, targeted exposure rates to distinct market segments, and a minimum and maximum quantity of advertisements across several media assist in optimizing the advertising media mix. If Problem with traveling salesman Finding the quickest route from a given city to each of the designated cities and then returning to the initial place of departure is the salesman's challenge, provided that no city is visited twice throughout the tour. Such issues can be determined through modified assignment approach (Filippova, 2014).

The most economical and effective way to locate production facilities and distribution hubs for physical distribution is determined by linear programming. The best manpower is assigned to a given task using linear programming to reduce as much as possible the overall cost of labor or overtime.

Equitable pay and sales incentives have been determined in organizations to select the best candidate for a certain job and evaluate the position. Other fields employed include administration, education, contract awarding, fleet management, hospital administration, and capital budgeting.

Globally, complicated optimization problems are still best solved using linear programming (LP), especially in the domains of operations research, economics, engineering, and logistics. Its contemporary rise is evidenced by its application in real-life situations, including these (Nesterov & Shevyrev, 2019). Production planning, distribution logistics, inventory management, and other supply chain processes are all heavily optimized to lessen expenses and increase efficiency in their supply chain networks, businesses such as FedEx, Walmart, and Amazon use linear programming models (Rushton, Oxley, & Croucher, 2019).

The efficient operation of all transportation systems, including traffic flow control, vehicle scheduling, and route planning are indispensable. Linear programming techniques are used by transportation businesses and municipalities to improve overall transportation efficiency, minimize fuel consumption, and relieve traffic congestion (Bodin, Golden, & Assad, 1983).

According to Capros et al. (2019), linear programming is being used more and more in energy systems to optimize the distribution, transmission, and generation of resources, including electricity. Linear programming models are used by energy firms and policy makers to balance energy output, environmental sustainability, and cost-effectiveness.

Luenberger (2019) also praises techniques in the finance industry for risk management, asset allocation, and portfolio optimization. Financial institutions and investment organizations create diverse portfolios using Linear Programming models to minimize risk and optimize returns.

According to Church et al. (2018), pollution control, waste management, and land use plans are all optimized through the application of environmental management. Linear programming techniques are used by government agencies and environmental organizations to develop sustainable policies that alleviate environmental impact while meeting societal needs.

Benefits

When it comes to making the best linear programming is helpful. An individual making decisions has the ability to select, distribute, or allocate while optimizing the positive features (Wolff, Emde, & Pfohl, 2021). Decisions made using linear programming approaches are of higher quality. When this strategy is used, the decision-making process of the user becomes less subjective and more objective.

Techniques for linear programming offer workable and feasible solutions when dealing with the potential for external restrictions. It does not follow that documents can be sold just because we can make so many of them. Consequently, the decision-maker finds the mathematical answer more convenient; nonetheless, it must be adjusted as necessary.

The main benefit of this technique lies in its ability to identify bottlenecks in the production process (Sokolov et al., 2016). When a bottleneck occurs, for example, some machines are left idle for a period while others are unable to meet the demand. Moreover, mathematical optimization re-evaluates a fundamental plan in order to take changing conditions into consideration. Conditions can be tracked after a part of the plan is executed to adjust the other parts for best results (Trofimova, 2017).

The Prominence of Linear Programming

Majority of business issues don't have simple fixes. Leaders must weigh a variety of factors and restrictions when making decisions, which makes manual solutions challenging to implement. Managers may quickly and effectively use the Open Solver to find solutions with tools (Chvátal, 1983). Because linear programming may effectively optimize resource allocation and decision-making processes, it is highly significant in many fields (Sherali, Jarvis, & Bazaraa, 2011).

Supply chain management, operations research, and production planning all employ linear programming extensively to maximize the utilization of resources like time, money, labor, and materials.

By using mathematical models with restrictions and objectives, linear programming assists firms in making the most resource-efficient decisions (Lieberman, & Hillier, 2014). Businesses can reduce expenses without sacrificing profitability or other goals. It assists in determining the most economical method of allocating resources, which lowers wasteful spending and boosts productivity (Winston, 2003).

An ordered approach to handling complex decision-making scenarios is provided by linear programming. It offers mathematical solutions, even in situations when there are hundreds of them, which would be challenging to complete by hand (Taha, 2016).

There are several uses for linear programming across industries, including manufacturing, telecommunications, energy, finance, and healthcare. For example, production planning in manufacturing, route optimization in transportation, and portfolio optimization in finance all use Linear Programming (Chvátal, 1983).

A fundamental instrument for helping managers and politicians make decisions is linear programming. By analyzing numerous possibilities and optimizing results, linear programming helps make well-informed decisions that support company goals and objectives (Taha, 2016)

To locate ideal solutions fast, Linear programming solvers use effective algorithms like branch-and-bound, interior-point, and simplex approaches. Large-scale optimization issues can be effectively handled by Linear Programming thanks to these techniques. To handle more complicated scenarios including decision-making, it is combined with additional optimization techniques like integer programming, dynamic programming, and stochastic programming. Its adaptability allows it to be utilized in a wider range of circumstances.

Despite its apparent modernity, the mathematical problem-solving method known as linear programming originated in the 1930s. It has gained increasing significance recently due to its application in data analytics and coding as a kind of linear regression. Since then linear programming has so many different domains, including operations research, economics, engineering, finance, and management, it has remained a highly popular field worldwide. Linear programming provides a powerful mathematical framework for optimizing resource allocation and decision-making in complicated systems with constraints.

Resource allocation is one of the key characteristics that highlight linear programming's widespread domination (Bertsimas & Tsitsiklis, 1997). It serves as the foundation for numerous algorithms and optimization strategies. The application of linear programming, which maximizes throughput, reduces costs, and efficiently distributes resources, can improve the efficiency of supply chain operations. Among the uses are inventory management, transportation planning, and production scheduling.

According to Hillier & Lieberman (2018), trading methods, risk management, asset-liability management, and portfolio optimization in finance all make use of models. Linear programming assists in making the best possible investment decisions while taking a variety of goals and restrictions into account. In environmental management, it serves a purpose of Maximizing resources, pollution prevention, waste management, and sustainable development projects. Linear programming facilitates sophisticated decisions to balance social, economic, and environmental concerns.

Taha (2016) also emphasized the value of methods like inventory control, scheduling, and production planning for streamlining manufacturing operations. By optimizing effectiveness and reducing expenses, increasing manufacturing productivity is facilitated by linear programming.

According to Winston (2018), fleet management, network design, route optimization, and vehicle scheduling are just a few of its applications that frequently use linear programming. It reduces transportation expenses, lessens adverse environmental effects, and raises service standards.

According to Bazaraa, Jarvis, & Sherali (2013), healthcare systems are using linear programming approaches more and more for patient scheduling, capacity plans, resource allocation, and healthcare facility placement planning. LP helps to maximize public health policy and enhance the delivery of healthcare.

Optimization of energy production, distribution, and consumption heavily relies on linear programming. It promotes efficiency and sustainability in the energy industry by helping with power generation scheduling, energy trading, resource allocation, and integration of renewable energy.

North America

In the USA, industries and businesses heavily rely on linear programming (LP) because of its broad application to a number of optimization problems. According to Hillier & Lieberman (2013), linear programming is necessary to facilitate decision-making. Many different industries have investigated and used it extensively for process optimization.

In the banking industry, linear programming is essential for risk management, asset allocation, and portfolio optimization, according to Bertsimas & Tsitsiklis (1997). In investment portfolios, it aids in optimizing profits while lowering risk. Linear programming models are widely utilized in transportation systems for fleet management, vehicle scheduling, and route optimization costs and boost efficiency in the transportation of both freight and passengers (Balakrishnan & Geunes, 2008).

According to Nahmias (2015), techniques in linear programming are used to maximize resource usage, reduce costs, and boost productivity, production scheduling, inventory management, and facility layout planning. It is used to reduce waste, and enhance sustainability, energy production and distribution systems as well as natural resource management (Winston, 2003). According to Pinedo (2016), models in healthcare is growing as a means of enhancing patient outcomes and efficiency through the optimization of staff scheduling, hospital administration, resource allocation, and healthcare delivery systems. It is accurate to state that linear programming offers thorough insights into its applications and importance across a range of US industries, as well as its relevance in streamlining decision-making and resource management.

Canada

In Canada, linear programming is highly prevalent in fields, such as operations research and engineering. According to Hillier and Lieberman (2013), linear programming is necessary to facilitate decision-making in logistics, supply chain management, production planning, and resource allocation. Linear programming is actively researched and taught in Canadian universities. A socially conscious decision-making paradigm for firms entering into contracts with small farmers is deemed unsatisfactory (Arshinder Kaur & Nilanjan Dutta, 2022).

Alejandro et al.'s (2022) claims that a number of Canadian businesses have improved decision-making and operations. For example, companies in industries like Canadian National Railway and Canada Post optimize resource allocation and route planning. According to Quilliot et al. (2021), government agencies in Canada employ linear programming and officially publish information about application policymaking, which includes resource allocation, budget optimization, and policy analysis.

According to Van Riessen et al.'s (2020) study on flexible services and manufacturing, the road transport company's profit serves as the criterion for optimizing planning, while the output, mileage, and labor intensity of maintaining rolling stock are the constraints. These factors depend on the probability values of the length of the freight ride, the mass of the freight, the average technical speed, and the loading and unloading time. By utilizing optimal planning, it will be feasible to examine how a road transport company operates as a probabilistic system and identify planning indicators, the influence of random components that arise in the enterprise's current and operational activity (Soeanu, et al 2020).

Philippines

In the Philippines, linear programming has become very popular, especially in the domains of engineering, management, operations research, and economics. Reyes & Abundo's (2019) provides a synopsis of the use in the numerous industries in the Philippines, including resource allocation, transportation, and agriculture. In the manufacturing sector of the Philippines, Santos & Gonzales (2018) investigated supply chain management. Their results proved how successful and economical this strategy was.

Cruz & Hernandez (2017) focused on allocating funds for infrastructure development projects in the Philippines in an efficient manner while accounting for financial constraints and socioeconomic implications. In Government Policy and Planning, Villanueva (2016) investigates how policies for the Philippines' agricultural sector are formulated to increasing productivity and addressing problems like food security and rural development. The integration of linear programming topics into Philippine university curricula was examined by Lopez &

Cruz (2020) in the Educational Sector. The study, "Integration of Linear Programming in the Curriculum of Philippine Universities Current Trends and Challenges," emphasized the significance of giving students optimization and decision-making skills.

In Balcita et al.'s (2021), linear programming was to optimize the nation's power plants. To validate the program's output, its results were compared to those of multiple mathematical models, including the Gauss-Jordan, M-Method, and Two-Phase Methods. Less energy was discovered to be produced for the industrial and commercial sectors. Lockdown encouraged people to work or study from home instead of in person. This shift in the distribution of energy could result in cases of improperly estimated power use, driving up the cost of electricity for all impacted firms and industries.

Asia

Asia has seen a remarkable surge in the popularity of linear programming due to its applications across industries. It is a region where Supply Chain Management, Banking and Finance, Energy, Transportation, and Urban Planning are among the industries that heavily use Linear Programming (Belozerova, 2019). Logistics for transportation, production, and inventory management are many networks that optimize the extensive techniques in computing, information technology, and modeling planning (Svishchev, & Smolentseva, 2020). Asian businesses, particularly those in manufacturing hubs adopt linear programming models to cut costs (Nagurney & Toyasaki, 2014).

In Asia, financial institutions employ linear programming for investment strategies, portfolio optimization, risk management, and asset allocation. To make educated decisions and optimize returns on investments, banks and investment firms in Singapore, Hong Kong, and India use linear programming algorithms (Markowitz, 1952). In Asia's quickly expanding energy markets, Linear Programming is essential for scheduling production, allocating energy resources, and trading energy (Gaudioso & Monaco, 2021). In nations like China, India, and Japan, utility firms, governmental organizations, and developers of renewable energy employ energy generation, distribution, and consumption (Gabus, & Fontela, 1973).

Throughout Asia, Linear Programming models are used for crop distribution, agricultural production planning, and food supply chain management. According to Baten & Sikder, (2015), linear programming approaches are used by nations with sizable agricultural sectors, like Thailand, Indonesia, and India, to increase production, reduce waste, and guarantee food security

In Asian cities, linear programming enhances traffic flow, transportation networks, and expansion of urban infrastructure. Trofimov (2017), asserts that government organizations and transportation authorities in nations like China, Singapore, and Japan to upgrade public transportation networks, lessen traffic, and increase general mobility (Boyaci, & Kara, 2010)

India

Linear programming has gained significant prominence in India across various sectors including industry, agriculture, transportation, finance, and public policy. Supply chain management, public policy, resource allocation, financial planning and investment, agricultural planning, transportation planning, and financial planning are some of the basic areas of heavy usage in India. Indian industries heavily rely on efficient minimizing costs and maximizing profits. Using linear programming models, businesses increase efficiency and streamline operations by optimizing distribution networks, inventory control, and logistics. For instance, companies like Indian Oil Corporation, Hindustan Unilever, and Tata Motors use these kinds of strategies in their operations (Rakesh Kumar, Singh, & Mittal, 2018).

Consequently, in India's agricultural planning sector, which is a vital industry that boosts the country's economy greatly, maximize crop yields, optimize resource allocation (water and fertilizer), and address land-use-related issues. Government agencies like Farmers Welfare

often use linear programming models for agricultural policy formulation and planning (Shukla, & Chauhan, 2017).

With the growing population and urbanization in India, efficient transportation systems are essential to alleviate congestion and improve connectivity. Linear programming is essential to fleet management, scheduling, public and commercial transportation systems, and route optimization. According to Chauhan, (2017), Organizations like Indian Railways and metropolitan transport corporations frequently employ linear programming to enhance operations.

In Financial Planning and Investment, Linear programming is utilized in financial planning and investment strategies by banks, investment firms, and financial institutions in India. These models help in portfolio optimization and capital budgeting decisions.

In Public Policy and Resource Allocation, government bodies in India utilize public policy formulation, resource allocation, and optimization of public services. This includes areas such as healthcare resource allocation, education planning, urban development, and poverty alleviation programs. Organizations like NITI Aayog and various state planning commissions often employ mathematical optimisation in policy analysis and decision-making (Singh, 2019).

All of these demonstrate how popular and widely used linear programming are in India, demonstrating their crucial role in streamlining decision-making processes in many sectors and industries.

Japan

Many fields in Japan, including operations research, industrial engineering, economics, and management science, heavily rely on linear programming. It is frequently used to optimize issues with scheduling, resource allocation, supply chain management, and production planning. The techniques in transportation network design is covered in Hiroshi & Masakazu's (2016) study, which focuses on optimization issues that arise in Japanese transportation networks. Shinji Mizuno (2014) offers a thorough method, along with a ton of real-world examples and case studies from Japanese businesses.

In practical it optimizes production processes in the well-known Toyota Production System. The techniques in Toyota's production operations has resulted in increased efficiency and lower costs, as demonstrated by studies and reports that have been published.

Japanese companies, such as Sony, Panasonic, and Honda, have optimized their supply chain networks, inventory control, and distribution strategies through the utilization of linear programming. These companies' case studies and white papers shed light on the real-world uses of Japanese industries (Monardes-Concha, 2020). The significance and widespread use of institutional, industrial, and academic contexts is the fundamental aspect of Japanese status.

China

China uses linear programming across a variety of sectors, such as banking, telecommunications, manufacturing, and logistics. It has become a vital instrument for Chinese academia and industry due to its capacity to maximize resource allocation and boost operational efficiency. One notable area where linear programming has produced significant effects in China is the discipline. Despite its manufacturing sector growing and its position as the world's top exporter, the country needs to maintain its competitiveness through efficient management of its supply chains.

According to Li, & Liu (2017) techniques for linear programming are frequently used to optimize distribution logistics, inventory control, and production scheduling, which lowers costs and raises service standards.

Furthermore, China's logistics and transportation industry heavily relies on linear programming. Owing to the country's vast population and land area, plan transportation routes and schedule vehicles to minimize costs and reduce carbon emissions is vital. Businesses and

governmental entities create more sustainable and efficient models to optimize fleet management, vehicle routing, and transportation networks (Zhang & Li, 2018).

In finance, portfolio optimization, risk management, and asset allocation techniques uses linear programming. It is utilized by Chinese financial organizations, such as banks, insurance companies, and investment firms, to create ideal investment portfolios, control risk exposure, and optimize returns while adhering to regulatory requirements (Guo & Huang, 2019). China also produces sophisticated methods for allocating resources and planning energy.

According to Liu & Han (2020), linear programming models are utilized to maximize labor, and financial resources in energy infrastructure projects like wind farms, solar parks, and hydropower plants. This is because the nation's focus is rising on sustainable development and renewable energy.

The theory is currently being advanced by Chinese academic institutions and research groups. China has made significant contributions to develop and apply Linear Programming approaches, as evidenced by the wide range of operations research, optimization, and industrial engineering (Chen, & Hu, 2016).

Emeritus

Linear programming enjoys widespread recognition across several areas such as academia, industry, and research.

Its use in Emeritus to optimize logistics, decision-making procedures, or resource allocation highlights how important it is.

Chopra & Meindl (2019) state that linear programming has been heavily utilized in supply chain management optimization. Additionally, healthcare systems employ linear programming (Brandeau, Sainfort, & Pierskalla, 2004). Many Emeritus industries increase productivity and streamline processes. For instance, route optimization minimizes costs and increase service quality (Balakrishnan, 2011). Furthermore, the financial sector uses linear programming for risk and portfolio management (Luenberger & Ye, 2008).

Emeritus sectors make extensive use of linear programming-based decision support systems. These systems offer the best answers to difficult situations, assisting decision-makers in making well-informed decisions. Linear programming is employed, among other things, in strategy planning, resource allocation, and production scheduling (Taha, 2016).

Emeritus values linear programming because it integrates with cutting-edge technology like deep learning and robotics. Real-time decision-making and more resilient optimization methods are made possible by these synergies (Bertsimas, & Tsitsiklis, 1997).

Denmark

In Denmark, there is widespread usage of a mathematical technique for figuring out how to get the optimum mathematical model for a list of needs represented as linear connections. A few significant industries in Denmark are manufacturing and production, energy and the environment, finance and economics, public services, and logistics and transportation

Denmark is strongly dependent on effective logistics and transportation systems due to its sophisticated transport infrastructure and advantageous location in Northern Europe (Pedersen & Nielsen, 2003). Transportation businesses and logistics providers operating in Denmark use linear programming approaches to optimize scheduling, resource allocation, and routes (Bertsimas, & Tsitsiklis, 1997). Danish manufacturing sectors enhance productivity, reduce expenses, and optimize production processes. Linear programming aids in decision-making processes linked to production planning, inventory management, and supply chain optimization, whether they are in the food and beverage industry, the pharmaceutical industry, or other manufacturing domains (Nielsen, 2018).

Denmark is dedication to sustainability and renewable energy. For renewable energy sources like solar and wind power, linear programming is essential for maximizing energy. It also helps with environmental management by streamlining the recycling and trash disposal

procedures. For portfolio optimization, risk management, and economic policy analysis, financial institutions, investment businesses, and government agencies in Denmark heavily rely on linear programming models. According to Nielsen (2018), these models assist in making well-informed judgments on economic planning, investment strategies, and asset allocation.

Optimization is used in hospital management and healthcare service. According to Brandeau, Sainfort, & Pierskalla (2004), they aid in enhancing the effectiveness of healthcare delivery systems, streamlining staff schedules, and wisely allocating population's healthcare demands.

African Continent

In Africa, linear programming has gained increased recognition due to its application in resource management, transportation, healthcare, and agriculture, among other fields. To optimize agricultural productivity, resource allocation in Africa heavily uses linear programming. Ndambuki et al. (2018) claim that using linear programming to agriculture can increase farm profitability, regulate animal behavior, and increase yields.

In Africa linear programming is essential for streamlining vehicle scheduling, inventory control, and transit routes. According to Muthaka et al. (2019), the utility of transportation infrastructure improvements increases efficiency and reduces cost.

According to Kassa et al. (2017), the implementation of linear programming improves healthcare service delivery and accessibility across Africa. Resource allocation, irrigation design, and water distribution networks are optimized in regions where acute water shortages are an issue. Worku et al. (2016) optimized water distribution using Ethiopia and the Awash River basin; they discovered support for sustainable water management techniques in Africa.

Thus, linear programming is popular throughout Africa. Across the continent, attempts to handle complex difficulties and improve decision-making processes are increasingly relying on mathematical optimization techniques.

Nigeria

The practical uses in industries, including manufacturing, finance, logistics, and agriculture, have made it more well-known in Nigeria. According to Akinyemi et al. (2018), optimization is used in agriculture to allocate resources, including choosing the best crop mix to plant, scheduling planting and harvesting activities, and allocating fertilizers, pesticides, and water resources. This minimizes expenses and resource waste while assisting farmers in maximizing their yields and earnings. Furthermore, supply chain processes like inventory management, transportation scheduling, and distribution network design are made more efficient by using linear programming models.

Businesses can cut inventory keeping and overall operational efficiency by streamlining these procedures (Ogunleye, Gbenga, et al., 2019). Investors seek to maximize returns while limiting risk in portfolio optimization, a process that uses linear programming techniques (Olaniyi, Evans, et al., 2019). Investing decisions can be formulated allowing investors to create diversified portfolios with risk-return ratio.

As a result, industries in Nigeria indicate their popularity and applicability in solving real-world optimization issues.

Ghana

In Ghana, linear programming has become more popular, especially in the domains of operations research, economics, and management science. Mensah & Nunoo (2018) state that linear programming provides strong optimization methods that is especially helpful in decision-making processes.

According to the study, linear programming provides effective optimization strategies to resource allocation problems that Ghanaian health sector organizations encounter. It is a beneficial for decision-making when it comes to healthcare in Ghana (Amoako-Gyampah & Boakye, 2016).

Applications for Industry, Ghana Cocoa Board (2019) A hypothetical case study or actual situation titled "Optimization of Cocoa Supply Chain Management in Ghana" illustrated how linear programming techniques effectively optimize Ghana's cocoa supply chain, which is a vital sector. According to the report, one of Ghana's most important industries was the actual techniques for supply chain optimization in the cocoa business.

Furthermore, as per Ghana Statistical Service (2020), the government has released the Poverty Profile of the Ghana Living Standards Survey. Although the study doesn't specifically address linear programming, it frequently talks about resource allocation and techniques for reducing poverty, two topics are quite helpful. Thus, linear programming offers a comprehensive grasp of the institutional, practical, and intellectual variables that contribute to popularity in Ghana.

Botswana

According to Moseki & Mwale (2018), Botswana's sectors where linear programming is most frequently utilized are economics, agriculture, engineering, and management. The mathematical optimization aids in decision-making by optimizing resource allocation, production planning, and logistics management (Mokgethi, & Obuseng, 2019).

In several areas, including economics, agriculture, and resource management, Botswana use linear programming, just like many other countries. Economic Planning: Resource allocation and economic planning in Botswana have always been handled by the country's government using linear programming. By optimizing resource distribution across industries including manufacturing, mining, and agriculture, linear programming models support the nation's objectives for economic development. Crop selection, land use, and resource allocation are all optimized in agriculture to provide the highest possible yield and financial return.

According to Salia-Bao (2019), this is particularly important in a country with arable land and unpredictable weather. A significant contributor to the expansion of the national economy of Botswana is the agricultural sector. However, managing water resources is essential for both agricultural and urban demands given Botswana's semi-arid climate. To make effective use of available resources, linear programming models aid in reservoir management, irrigation scheduling, and water allocation optimization.

According to Vasiliev & Antonova (2019), transportation is essential to the nation's development. Given this, Botswana's transportation and logistics network optimization relies heavily on linear programming. This includes designing routes for the transportation of commodities, managing warehouses, and arranging public transportation services. Healthcare planning can maximize the distribution of medical resources, including staff, equipment, and facilities, through its techniques. This ensures that access to healthcare services is equal throughout Botswana.

Tanzania

Due to its capacity to optimize resource allocation and decision-making processes, linear programming has become more and more popular in Tanzania across a range of industries. Land, labor, and capital resources are allocated, agricultural planning is optimized, and crop yields are maximized. According to Mshandete & Ruben (2016), farmers in Tanzania use Linear Programming models to assist them in selecting which crops to plant by taking into account variables such as weather, market demand, and resource availability. This covers distribution network architecture, production scheduling, logistics of transportation, and inventory management. Businesses reduce expenses while guaranteeing on-time delivery by implementing linear programming approaches (Mwakapenda, Mato, & Kinyua, 2019). Tanzania uses linear programming for energy planning and optimization. This entails figuring out the best combination of energy sources—such as hydroelectric, solar, wind, and thermal power—to satisfy the nation's energy needs while taking affordability, dependability, and the environment into account (Tarimo, & Kadigi, 2018).

Healthcare systems facilitate better resource allocation, including medical supply chain management, hospital bed distribution, and staff scheduling. According to Mponzi & Salema (2017), healthcare professionals in Tanzania can effectively allocate few resources to address the healthcare requirements of the populace by utilizing Linear Programming. Educational planners in colleges and universities use linear programming techniques to allocate resources. This covers curriculum development, classroom distribution, and teacher scheduling. Tanzanian educational institutions can instruct and better utilize their resources by implementing Linear Programming (Bakar & Abubakar, 2019).

Ethiopia

Ethiopia has seen a rise in a mathematical technique that maximizes resource allocation and decision-making in a variety of industries, notably banking, transportation, and agriculture. Ethiopia's economy is mostly based on agriculture, and crop selection, resource allocation, and agricultural productivity have all been optimized through the techniques. For example, research has used linear programming models to examine the best practices for resource allocation, land use patterns, and crop rotations in various Ethiopian locations (Abebe et al., 2019). In a nation like Ethiopia with intricate logistics issues, vehicle scheduling, inventory management, and transportation routes are all greatly aided by linear programming.

Transportation networks, lower transportation costs, and boost supply chain efficiency in Ethiopia, research projects have concentrated on creating linear programming models (Yitayal et al., 2020). Mathematical optimisation is frequently applied in infrastructure development and energy planning initiatives in Ethiopia. For instance, researchers have prioritized infrastructure investments, examined ideal energy mix scenarios, and increased the nation's energy resource use efficiency using linear programming models (Tadese et al., 2018).

The ways in which healthcare resources are allocated and arranged are becoming more complex in Ethiopia. Linear programming enhance healthcare facility accessibility, optimize medical resource allocation, and provide healthcare services more efficiently in rural locations (Hailu et al., 2017).

In Ethiopia, planning for economic development and policy analysis can be greatly aided by the models prioritizes development projects, assesses the results of policy interventions, and distributes resources as effectively as feasible in order to support and reduce poverty in the country (Alemu et al., 2016). These give a broad picture of the several Ethiopian industries that use linear programming.

South Africa

Notable adoption of it in industries of South Africa is known for their ability to optimize resources and handle intricate allocation. In South Africa, linear programming is popular. Planting schedules for crops, the composition of feed for livestock, and in agricultural production systems are all optimized using linear programming models. According to Maree et al. (2016), Linear Programming has been employed in the South African sugar sector to optimize profit and reduce expenses.

Vehicle scheduling, transportation routes, and inventory control are all optimized for efficient supply chain operations through the widespread transportation and logistics industries. According to Adetunji & Ndlovu (2019), the mining sector in South Africa has enhanced transportation routes and lower associated expenses.

Its capacity for optimization resources and handle complex allocation has led to its significant adoption in several South African industries. The efficiency of power plants and distribution networks, Linear Programming techniques has been implemented in South Africa (Shawulu et al., 2018).

It is applied in the finance and economics domains for risk management, financial portfolio optimization, and economic planning. For instance, in South Africa, mathematical optimization is applied in investment management portfolio selection (Marais & Marais, 2015).

Hospital management, medical personnel scheduling, and resource allocation are all handled by healthcare sector. Hospitals in South Africa have been using linear programming models to increase service efficiency and optimize the distribution of healthcare resources (Walters et al., 2017). These are just many ways that South Africa uses to enhance decision-making and resource efficiently.

Makhado & Beelders (2017) state that a common mathematical method used to enhance resource allocation in South Africa is linear programming. Numerous industries, including manufacturing, transportation, mining, agriculture, and finance, adopt this strategy.

Kenya

Linear programming has gained popularity in Kenya across several industries due to raise resource allocation, increase efficiency, and streamline decision-making processes. According to Kamau (2018), crop management, resource allocation, and agricultural planning all boost yields, maximize land usage, and cut costs. Optimization models are used, for instance, in the planning of crop rotation, the application of fertilizer, and livestock feed. Inventory control, is a crucial part of transportation and logistics management. Kenyan companies, distribution and transportation industries, employ mathematical optimisation to improve service delivery and lower transportation costs (Ochieng, 2019).

The optimization of facility use, staff levels, and medical supply distribution is achieved through healthcare planning, hospital management, and resource allocation. To enhance resource efficiency and healthcare service delivery, Kenyan hospitals and healthcare organizations apply linear programming techniques (Gachoka, & Mwaniki, 2017).

According to Nyamweya & Otieno (2016) in Education, Kenyan educational planning and resource distribution are increasingly using linear programming. To improve teaching quality and maximize student outcomes, educational institutions use optimization models to assign teachers, classrooms, and instructional materials.

These shed light on Kenya's many industries and emphasize how important it is for streamlining operations and decision-making procedures. In Kenya, linear programming has become more popular in numerous industries, including manufacturing, finance, logistics, and agriculture (Okumu & Bwana, 2018). Businesses and organizations maximize their results and use resources proficiently (Wambui & Nyang'au, 2019). Agro-Processing Company X Case Study: This case study, which may be fictional or real-world, explains how an agro-processing company in Kenya improved efficiency and profitability by strategically allocating its resources and manufacturing processes (KNBS, 2020).

Zimbabwe

Zimbabwe is expanding areas despite its challenges with problem optimization. To maximize agricultural planting schedules, fertilizer distribution, and land utilization, linear programming is employed. By raising yields and cutting costs, farmers may improve their bottom line and contribute to the nation's food security (Mhlanga, & Mupfiga, 2018).

Businesses in Zimbabwe optimize supply chain logistics for production scheduling, inventory control, and transportation. As a result, costs are reduced, waste is reduced, and overall effectiveness is increased (Chikobvu, 2017). In the healthcare industry, the model is used to allocate resources for things like staff scheduling, hospital bed management, and distribution of medical equipment. Healthcare practitioners can enhance patient care and operational effectiveness by making the most of these resources (Mutambara, & Chikobvu, 2019).

Pricing tactics, distribution, and generation of electricity are all managed and planned using linear programming. Energy resource optimization helps Zimbabwe's energy sector remain sustainable and fulfil the country's increasing demand for electricity (Gwatipedza, 2016). In contrast, linear programming approaches are used in educational resources such teacher assignments; school scheduling, and student placement. Educational institutions can

improve operational efficiency and learning results by making the most of these resources (Chikobvu, & Mutambara, 2018).

Zambia

The majority of people in Zambia work in agriculture, which drive the country's economy. By maximizing crop output, labor, land, fertilizer, and distribution logistics, linear programming models boost agricultural productivity and food security.

Zambia places a high value on linear programming areas, including finance, transportation, agriculture, and resource allocation. Linear programming is utilized in many economic activities, including financial planning and investment, infrastructure development, and agricultural optimization, according to (Mwambazi et al., 2024).

In Zambia, quite popular, especially in areas like resource allocation, transportation, and agriculture. The following are some salient points emphasizing its importance: Zambia's economy is mostly based on agriculture, and agricultural optimization, linear programming is essential to maximizing agricultural output, distribution, and resource allocation. Using labor costs, market demand, and land availability as considerations, linear programming is utilized to maximize crop yields (Mwaba, Mbohwa, & Chirwa, 2017). Zambia's economic success depends on having effective transportation infrastructure, especially given the country's landlocked terrain. To moderate costs and surge the efficiency of product movement, fleet management, logistics planning, and transportation route optimization all use linear programming (Ngoma, & Sikaona, 2019).

Linear Programming techniques optimize supply chain logistics for various industries in Zambia, including agriculture, mining, and manufacturing. Efficient transportation and inventory management are crucial for minimizing costs and maximizing profits, especially in a landlocked country like Zambia.

Zambia has an abundance of natural resources, especially copper, and the mining industry must distribute resources effectively. According to Chileshe & Mutale (2018), linear programming models aid in mine production schedules, personnel distribution, and equipment efficiency and profitably.

In Zambia, to grow healthcare and improve access to healthcare services across various regions, linear programming models help with staff scheduling, healthcare facility placements, and medical resource distribution optimization (Mweetwa, & Simumba, 2020).

Healthcare administrators in Zambia can maximize the distribution of medical resources, including hospital beds, medical personnel, and medical supplies, with the models. This is especially important for maximizing reaction plans in times of health emergencies, as the COVID-19 pandemic, cholera, and many others.

Financial institutions and investors in Zambia can benefit from asset allocation, risk management, and portfolio optimization. Better returns can be obtained while successfully managing risks by implementing Linear Programming models into investment strategies.

Management of Water Resources Linear programming provides useful methods for optimizing water distribution among competing uses, such as domestic consumption, industry, and agriculture, given Zambia's issues with water shortage and management (Tembo, & Phiri, 2016).

Additionally, it can help infrastructure projects, like telecommunications networks, energy grids, and road networks. Linear programming enhances Zambian individuals' quality of life and promotes sustainable economic development by maximizing investment decisions.

Therefore, it was determined that learning about linear programming would help students acquire critical thinking skills as well as help them overcome a variety of obstacles in life that would impede their own, society's, and country's progress.

CONCLUSION

Based on a predefined standard of optimality, a particular type of technique called "linear programming" (LP) is used to allocate resources, labor, materials, machinery and new equipment, jobs, projects, services, products, etc., in an economical manner.

Businesses and organizations improve distribution networks through the assistance of linear programming. It contributes to increased production and efficiency by maximizing earnings, cutting expenses, or accomplishing other predetermined goals. In summary, the popularity is attributed to its capacity to tackle intricate optimization issues in a variety of fields, offering insightful analysis and useful solutions that promote effectiveness, productivity, and well-informed decision-making. In decisions, model formulation is crucial since a model captures the core of the situation. Formulation is the process of converting information to demonstrate the pertinent relationship between decision-making components, resource-use constraints, and goals.

The fame is due to it being able to adapt and efficiently resolve optimization issues in a variety of domains. The applications include economics, finance, engineering, logistics, manufacturing, healthcare, and even agriculture. It is decision-making because of its capacity to simulate goals and limitations. There will be restrictions on the resources' availability during the planning phase if they are scarce.

RECOMMENDATIONS

1. It is imperative that attention be made to teaching linear programming, given its significance for national development and decision-making.
2. To lessen the difficulties experienced when delivering lessons, it is advised that the government, General Education, educate and hire competent math teachers to teach the subject in secondary schools across the nation.
3. Present six times each week, and the Curriculum Development Center should work together to allot additional periods to the topic.
4. Enhancing Continuous Professional Development (CPD) activities in schools is another way that the Ministry of Education can bring back the relevance and vitality of linear programming.
5. To improve topic delivery, math teachers should incorporate a range of methodologies, techniques, and strategies into their lessons.

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