DEVELOPMENT OF LINEAR PROGRAMMING MODEL FOR OPTIMIZATION OF PRODUCT MIX AND MAXIMIZATION OF PROFIT: CASE OF LEATHER INDUSTRY

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Abstract:

When the decisions are analytically supported they cannot be challenged and at the same time, the quality of decision increases. This paper is about proposing such a model which provides the analytical support to the decision for the selection of footwear articles to be produced. This paper aimed to suggest the analytically supported decision-making for deciding the number of pairs of different articles to be produced in a way that the cost and profit could be minimized and maximized respectively. This research was conducted at the ABC leather footwear company of Lahore Pakistan. The data was collected from the costing executive of the planning and costing department. Costing and profit analysis of the collected data was conducted in Microsoft Excel as per the company`s traditional method of calculations. The linear programming (LP) model was then formulated and implemented in Microsoft Excel by using solver add-in. Outputs of both the traditional method and LP model were compared. The comparison revealed that with 22% less production, 39% more profit could be earned if the selection of articles and their production quantity would be calculated accordingly. This model can be modified and used in fast-moving consumer goods (FMCGs) industries for making product mix strategies. A major limitation of the present developed model is that it is based on the scenario of the footwear industry so it cannot be used as general for other applications.

Keywords: linear programming; profit; maximization; modeling; mathematics.

1. Introduction

Operation research was introduced during World War 2 to manage the world war concerns quickly. In operations research, different techniques are used for simplification of industrial issues i.e. management of the queuing system by use of queuing theory (Kalwar, Khaskheli, Khan, Siddiqui, & Gopang, 2018; Kalwar, Mari, Memon, Tanwari, & Siddiqui, 2020; Kalwar, Marri, Khan, & Khaskheli, 2021; Kalwar, Memon, Khan, & Tanwari, 2021; Khan, Khaskheli, et al., 2021a, 2021b; Khaskheli, Marri, Nebhwani, Khan, & Ahmed, 2020), efficient allocation of resources by use of linear programming (Addy, 2014; Akpan & Iwok, 2016; Alvfors & Björelind, 2015; Aregawi, 2018; Gameiro, Rocco, & Caixeta Filho, 2016; Jain, Bhardwaj, Saxena, & Choubey, 2019; Jyothi, Rao, & Sivasundari, 2019; Maurya, Misra, Anderson, & Shukla, 2015; Tesfaye, Berhane, Zenebe, & Asmelash, 2016; Workie, Alemu A, & Asmelash, 2016; Woubante, 2017; Yoanita, 2016; Yu, 2015; Yue, 2013), and so on. Optimization and Operational research methods are thoroughly used to acquire better options and decisions to

industrial issues (Jyothi et al., 2019; Nawrocki, 2013).The industrial development strategy is identified by the reliable use of resources at every production stage. A quantitative decision-making method called linear programming can be made use of for the optimization dilemma of product mix (Aregawi, 2018). Linear programming is an analytical method created to aid managers to decide (Abuizam, 2012). In statistics, linear programming (LP) is a unique method used in operation research for the objective of optimization of linear features based on linear equal rights and inequality restraint. Linear programming determines the way to accomplish ideal outcomes, such as maximum revenue or minimum expense in a provided mathematical model, and offered some listing of requirements as a linear equation (Akpan & Iwok, 2016). It is a powerful tool used by operations supervisors and other supervisors to obtain optimum options to problems that include restrictions or constraints on their resources (Kriri, 2018). These problems are referred to as constricted optimization issues. Many applications of linear programming can be discovered in today's affordable industry environment. It is significantly crucial to make certain that a business's

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restricted resources are employed most efficiently (Abuizam, 2012). Linear programming can be defined as a mathematical technique for figuring out the best collection of an enterprise's minimal resources to accomplish the best possible goal. It is additionally a mathematical strategy employed in operational research or monitoring science to solve a specific types of problems such as product mix, allocation, transportation, and monitoring concerns that allows a choice or selections between alternate courses of action (Aregawi, 2018). Right here, the word programming implies developing a strategy that fixes an issue; it is not a reference to computer system programming.) Not long after that, LP entered into wide usage in industry, with the most fruitful utilization in the petroleum, petrochemical, and food industries (Maurya et al., 2015). Any linear programming model ought to have 3 requirements, particularly: objective feature, restrictions, and non-negativity needs. The function, being optimized is described as the unbiased feature and the restrictions usually are described as restraints (Aregawi, 2018; Gameiro et al., 2016). The objective function is simply a mathematical statement expressing the connection between the products the decision-maker wants to increase and the level of operation of the decision variables in the concern (Workie et al., 2016).

Decision-making is just one of the significant features of managers; they are frequently confronted with decisions associated with the allocation and use of limited resources. Resources available for manufacturing, according to classical financial experts, are restricted and have multidimensional uses (Solaja, Abiodun, Abioro, Ekpudu, & Olasubulumi, 2019). The decision of many manufacturing supervisors is based upon the total input used in the manufacturing and outcome. This method of decision-making is always prejudiced, that is it causes a reduction in the accuracy of forecasting for the future, such as price fluctuation and scarcity of raw materials or offered resources (Akpan & Iwok, 2016). LP has been employed in the assessment and optimization of raw material resources, financing, machinery, tools, time, and manpower under particular restricting conditions to obtain one of the most profits (Yue, 2013). As a consequence of globalization and technological developments, the worldwide industry setting has turned out to be very affordable (Tesfaye et al., 2016). This condition triggers many businesses to want to go to the center of their areas. To ensure that every single company must be able to establish and boost performance to accomplish efficiency and performance (Anggoro, Rosida, Mentari, Novitasari, & Yulista, 2019). In Industries, the major restraints to increase (optimize or decrease) their purpose is inefficient management, use of resources (bad resource utilization management). The main factor for making use of linear programming methodology is to guarantee that limited resources are utilized to the maximum level without any waste which utilization is made as though the results are anticipated to be the most effective feasible. That is the use of an operational research method in the manufacturing time perspective helps the industry to improve its unbiased (Aregawi, 2018). Different products need different quantities of manufacturing resources having different expenses and profits at different stages of manufacturing. Therefore, the linear programming concern (LPP) method will be used to determine the product mix that will maximize the complete revenue at

a defined time. It is the very best method for identifying an optimum solution amongst choices to fulfill a defined purpose function limited by numerous constraints and restrictions. It is a planning procedure that allots resources, labor, raw material, equipment, and capital in the most effective possible means to ensure that expenses are lessened or revenues are taken full advantage of. The LPP then becomes a concern of allocating limited resources to products in a way such that revenues go to an optimum and/or costs are at a minimum (Woubante, 2017). A producing business's survival in a significantly competitive market closely depends upon its capability to create best quality products at least expensive feasible cost (Yu, 2015; Solaja et al., 2019). A business decision would adhere to the assumption of deliberate behavior with minimum cost to produce even more gross earnings. Revenue of the firm can only grow if monitoring decisions at the enterprise level lead to increased outcomes through cost minimization of needed resource inputs (Workie et al., 2016). The enterprise cost control is not only one of the most vital issues to be dealt with by the venture, however, also a crucial element to figuring out whether the venture can gain a competitive advantage in the intense market setting, which is also an inevitable need of the economic market competitors. The business cost control is an extra intricate concern, which is not just the decrease of the cost, but likewise, an affordable setup of the cost with the maximum benefit objectives, to achieve the most optimum results in all facets (Yu, 2015).

2. Literature Review

Akpan and Iwok (2018) made use of the idea of the Simplex algorithm; an aspect of linear programming i.e. raw material allocation to completing variables (large loaf, giant loaf, and small loaf) in the bakery for the objective of profit maximization. The evaluation was executed and the outcome revealed that small loaf (962 units), big loaf (38 units), and giant loaf (0 units) ought to be produced respectively to generate the profit of N20385. From the evaluation, it was observed that small loaf, followed by large loaf contribute fairly to the profit. Therefore, more small loaves and big loaves were needed to be produced for the maximization of profit (Akpan & Iwok, 2016).

Workie, Alemu, and Asmelash (2016) used linear programming applications in the textile industry. In the shared company, eight textile finished fabrics. The data gathered was mathematically modeled using a linear programming method which is a useful analysis process and a natural decision support tool, The calculations were made by using Microsoft Excel solver add-in. Since linear programming deals, numerous benefits to managers in the allocation of resources to their optimal use and in pointing out the economic situations of underemployed resources, the computational research of the approaches makes them provide faster choice on the type and amount of textile colored materials to be produced that yield more revenue than methods acquired from trial and error approaches to be enhanced by 72.63% and 65.91% (Workie et al., 2016).

Jyothi, Rao, and Sivasundari (2019) created a mathematical model for figuring out the very best feasible needed capacity, labor force, and lot size. Here, we undergo

the existing techniques of production planning in a single item flow-based mobile production unit generating vehicle electrical components. It is a linear programming model with 3 goals particularly, Manufacturing cost minimization, production quantity maximization, and maximization of ability application. It is to be addressed by considering each objective sequentially as a Lexicographic technique. The outcomes acquired from the model are compared with real observed values for validation (Jyothi et al., 2019).

Campo et al. (2018) recommended and implemented an aggregated production planning model to supply optimum methods in the tool term for a textile company, for which a linear programming model was suggested to decrease total costs related to work and stock levels. The model proposed considers features connected with textile con-grip, wastes in the process, the effectiveness of new staff members, and training requirements. The implementation and solution of the model were carried out in GAMS supported on Microsoft Excel for the calculation of optimal solution (Campo, Cano, Andrés, & Gómez-Montoya, 2018).

Gameiro, Rocco, and Filho (2016) proposed the linear programming mathematical model to a depictive dairy farm located in Brazil. The outcomes showed that optimization models are relevant devices to assist in the planning and management of farming manufacturing, in addition to aid in approximating possible gains from the use of integrated systems. Diversity was a required problem for economic viability. A complete expense decrease potential of regarding 30% was disclosed when a circumstance of reduced levels of diversity was contrasted to one of higher levels. Technical complementarities are verified to be crucial resources of economies. The possibility of recycling nitrogen, phosphorus, and potassium existing in animal waste could be boosted to 167%, while water reuse could be boosted by approximately 150%. In addition to economic gains, integrated systems bring benefits to the setting, specifically concerning the reuse of resources. The expense dilution of set manufacturing factors can aid economic climates of the extent to be attained. However, this does not seem to have been the primary source of these advantages. Still, the portion of land usage can raise to 30.7% when the most affordable and the highest diversity circumstances were compared. The labor coefficient could have a 4.3 percent rise. Diversity also leads to radical transaction expense reductions (Gameiro et al., 2016).

Solaja et al., (2019) used linear programming methods in this research study for a production planning trouble in a feed mill creating business. The linear programming model was formulated based on data obtained from the business operations journal. Data were processed with the help of Management Scientist Version 5.0. The research reveals better revenue through streamlining of the product array and removing the much less efficient products. This recommends the business may embrace the result of the linear programming strategies in production planning to improve monthly revenue. This research study has revealed that linear programming methods are effective devices that can be of help to managers in decision making and allocation of limited resources and suggest operations and revenue improvement. The outcome of this research study shows that the application

of heuristic strategy in production planning can does not ensure an ideal approach, yet help with wastage of resources on the production floor. Additionally, the application of linear programming methods is a powerful techniques production managers should certainly take on in production planning, this will certainly enhance improve the company's performance by boosting overall earnings. The research further reveals that it is not nearly enough for production companies to be after earnings maximization alone, but resources optimization; this will be beneficial to the firm as opposed to optimizing profit alone. The research wraps up that linear programming can be used in fixing any manufacturing planning issue. The research study suggests that choice makers need to not base their choice on experience and instinct but the analytical and technological technique. Likewise, supervisors need to find out to apply linear programming methods in production planning (Solaja et al., 2019).

Anggoro et al. (2019) performed research to give a production picture to maximize the earnings on the housing market of Bintang Bakery. The purpose of this research study is to enhance the advantages of the Bintang Bakery home market. Profit optimization estimations performed made use of Lindo tools. The outcomes of calculations by utilizing the simplex approach and Lindo help reveal that the production results applied by the Bintang Bakery residence sector are optimum. The optimum profit degree of Rp 19,750,000 by creating 3740 flavored pieces of bread, 1300 packaged bread rolls, and 520 loaves of bread packaging Celebrity Bakery sector experienced an earnings boost of Rp 250,000 by utilizing the simplex method (Anggoro et al., 2019).

Yu (2015) looked into the business cost control through the linear programming model and evaluates the constraint elements of the labor of venture production, raw materials, handling equipment, sales price, and other factors influencing the venture revenue, so regarding acquiring an enterprise cost control model based upon the linear programming. This model can determine logical production settings when it comes to minimal resources, and obtain optimum venture income. The production directing program and scheduling arrangement of the venture can be gotten with estimation results, so regarding offer technological and efficient advice for the venture production. This paper includes the sensitivity analysis in the linear programming model, to discover the security of the venture expense control model based on linear programming with the sensitivity evaluation, and confirm the rationality of the model, and show the direction for the enterprise expense control. The computation outcomes of the model can give a particular recommendation for the venture planning on the market economy atmosphere, which hasa solid recommendation and functional relevance in regards to the business cost control (Yu, 2015).

Tesfaye et al., (2016) accomplished a research study to design an efficient resource utilizing the system for the Ethiopian clothing market to enhance their resource application and profitability, taking among the garment manufacturing facilities engaged in the export market as a case study. Five kinds of items the business is presently producing, the number of resources employed to create each unit of the items, and the worth of revenue per unit

from the sale of each item have been gathered from the situation company. The regular monthly availability of resources utilized and the monthly production volume of the five items have also been gathered from the company. The data gathered was mathematically modeled making use of a linear programming technique, and fixed making use of a Microsoft Excel solver. The results of the research study illustrate that all of the organizational resources are badly underutilized. This research study proved that the resource utilization of the situation firm can be boosted from 46.41% of the existing resource application to 98.57%. This indicates that the brand-new approach gives a very considerable enhancement in business resource application. At the same time, with the brand-new approach, the total revenue monthly of the situation business can be enhanced from 365,699 birrs per month to 897,844 birrs each month (i.e., with an increment of 145.5%). Ultimately, it is ended that this amazing earnings increment of the business can enhance its international competition (Tesfaye et al., 2016).

Jain et al., (2019) optimized (maximized) the internet return of the Central Bank of India in the area of interest from loans such as Individual loans, Auto loans, Home mortgage, Agricultural loans, Industrial loans, Education and learning loans, and likewise optimize the net return of the investor by investing some amount in the investment policy of Central Bank of India such as Fixed Deposit, Saving Account, Public Provident fund, and various other financial investment Plans. The linear programming strategy is related to optimizing the revenue of the Bank and the investor (Jain et al., 2019). From the above discussion, it is wrapped up that the maximum web return of the Bank is Rs.16.155 Crore by allocating the quantity of Rs.7.5 Crore to Home mortgage, Rs.7.5 Crore to Agricultural loan, Rs.7.5 Crore to a Vehicle loan, Rs.67.5 Crore to Personal Loan, Rs.60 Crore to Education and learning loan and none of the quantity is for Industrial loan (Guaranteed and Unprotected) and the maximum revenue of investor is Rs.13,420 by investing the amount of Rs.40,000 to Conserving account, Rs.1,20,000 to the fixed deposit amount, Rs.40,000 to SCSS and none of the amount is for PPF (Jain et al., 2019).

Addy (2014) maximized production scheduling by utilizing linear programming issues. The simplex algorithm was applied to identify ideal schedules for every of the 6 quick marketing copper products that can generate the overall monthly copper budget plan at sales. In a level of sensitivity evaluation, the influence of varying functional constraints on the linear programming model was checked out to verify the results of modifications on the results of the model. Interpretations of the arise from the evaluation created the basis for suggestions to boost supervisory decisions (Addy, 2014). This is demonstrated from the outcomes of the linear programming model application for the study, which indicates that the 65 loads target from the manufacturing of the six home electrical wiring cords can be viable within dominating restraints. Effective management of restrictions and emerging challenges in service operations can set the optimal solution as a minimum result. Hence the optimum values can be even more boosted. Results of the recommended model based on varied changes in the functional atmosphere were interpreted to recognize the proper referrals for rehabilitative and safety nets (Addy, 2014).

Woubante (2017) thought about the clothing commercial unit in Ethiopia as a case study. The month-to-month held resources, product volume, and amount of resources utilized to produce each system of item and earnings each for every product have been collected from the firm. The data gathered was made use of to estimate the parameters of the linear programming model. The model was resolved using LINGO 16.0 software. The findings of the research study show that the earnings of the company can be improved by 59.84%, that is, the complete earnings of Birr 465,456 each month can be enhanced to Birr 777,877.3 per month by using linear programming models if consumer orders need to be satisfied. The profit of the company can be boosted by 7.22% if the linear programming solution does not require thinking about consumer orders. The earnings of the business could be improved by 59.84% (from Birr 465,456 each month to Birr 777,877.3 monthly). Refuting consumer orders and embracing the LPP solution supplies only three types of products but the earnings of the firm can be boosted by 7.22% (from Birr 465,456 each month to Birr 499,058.5 each month) (Woubante, 2017).

Yoanita (2016) conducted a research study to evaluate the optimum product combination of soy sauces "Koki Dollar 629" created by UD. Sehati Tulungagung to maximize their profit. Via a quantitative approach, this study is conducted. The computational experiments in this research study include information and details of the system set you back, contribution margin, optimal resources capacity, particular product's absorption price, and various other restraints that belong to the manufacturing of soy sauces "Koki Dollar 629". And all of the information obtained is refined and examined with simplex method maximization with the aid of Production and Operations Management (POM) software version 3 for windows. This study finds that there are 4 out of 7 items are taken into consideration to be successful to create. It is likewise disclosed the variety to which UD. Sehati might enhance or lower the coefficient of the objective function and the right-hand side value of the restrictions without changing the optimal solution that has previously been achieved through the level of sensitivity analysis. For the various other three items which are caused the zero production, more evaluation, and consideration from the management of UD. Sehati is required to make them lucrative also. From the result analysis, the researcher makes some suggestions to UD. Sehati. The first is to take into consideration concerning extra manufacturing capacity consequently manufacturing quantity can be increased, then to minimize the expense of some products by trying to find different resources which are less costly, and the last is to expand the marketplace to get even more clients which cause the greater earnings of the business (Yoanita, 2016).

3. Problem Statement

Footwear is a rapidly growing industry across the globe (Arain, Khan, & Kalwar, 2020; Chaudhry, Kalwar, Khan, & Shaikh, 2021; Chaudhry, Khan, Kalwar, & Chaudhry, 2021; Kalwar & Khan, 2020a, 2020b; Kalwar, Marri, & Khan, 2021; Kalwar, Shaikh, Khan, & Malik, 2020; Khan, Kalwar, Malik, Malik, & Chaudhry, 2021). The footwear industry achieves its competitive advantage

because of its ability to improve the efficiency and effectiveness of its resources (Kalwar & Khan, 2020a). In Pakistan, footwear companies keep the raw material inventory for months (i.e. 1-6 months) for the upcoming production of articles. AT the end of the season, they produce the footwear articles from what is left from the old stock i.e. leather, shoe material, and sole. Similarly, the case company used to produce the leather uppers (from the leather stock of the previous season available at leather stores) for the remaining soles available in the warehouse. Produced finished goods were then sent to the company`s retail shop. In this way, the leftover raw material was used to be utilized. The planning and costing department was supposed to make the list of articles that could be produced to utilize the leftover raw material i.e. leather, shoe material, and sole. It was the psychic routine of strategic managers that maximum production of maximum articles yields the maximum profit; but if this situation is analyzed according to the linear programming, then there was need of mathematical model by the help of which, it could be decided on the articles and their quantity to be produced for the maximization of profit. In the present research, a linear programming model was designed for the maximization of profit.

4. Research Gap

Linear programming has been used for production planning, scheduling, capacity design, marketing mix, and several other purposes in the different industrial sectors. From the reviewed literature, it was indicated that it has been used in industries i.e. bakery, textile Industry, manufacturing industry, feed mill, and bank. Table 1 shows the contribution of literature in the field of linear programming.

It has not yet been applied in the leather footwear industry for product mix as indicated by Table 1. In this regard, the present research was conducted in the leather footwear industry so that the value could be added to the literature.

5. Aims and Objectives

The purpose of the present research paper was to provide the mathematical model for the analytical support to decide the product mix.

- To maximize the profit of the overall product mix
- To minimize the total cost of the overall product mix

6. Research Methodology

Research methodology is the description of research methods that are used in the research. It also includes the descriptions of the data collection and analysis procedures which are given in the below-given headings.

6.1. Data Collection

This research was conducted at the ABC leather footwear company of Lahore Pakistan. The data was collected from the costing executive of the planning and costing department. The data included the costs i.e. leather material cost, shoe material cost, production cost (cutting, stitching, lasting, hand stitching, molding, and job work costs), overheads, tooling cost, factory overheads, and profit on each article.

6.2. Data Analysis

The whole collected data was put in the excel spreadsheet and firstly, the data was calculated as per the old method of calculations; the data also was organized in tables and line charts were plotted against it. At the same time, the linear programming (LP) model was formulated so that the method for calculation of the optimal quantity of articles to be produced could be conducted systematically for maximization of profit and minimization of cost. The collected data was converted into objective functions and constraints as per the developed model. The model was implemented in the MicrosoftExcel spreadsheet and was solved by the use of solver add-in and it was solved by Simplex method. The model was evaluated by putting the same data and its result was compared with the traditional system of calculations. Moreover, a comparison of both methods was conducted in tabular and graphical (line charts plotted in excel) way.

7. Existing System of Calculations

38 different footwear articles were planned to be produced with the different number of pairs, cost, and profit as shown in Table 2.

Table 1: Contribution table in the context of literature view.

Reference	Bakery	Textile Industry	Manufacturing Industry	Feed Mill	Bank
(Akpan & Iwok, 2016)	X				
(Workie et al., 2016)		X			
(Jyothi et al., 2019)			X		
(Gameiro et al., 2016)		X			
(Solaja et al., 2019)				X	
(Anggoro et al., 2019)	X				
(Nawrocki, 2013)			X		
(Tesfaye et al., 2016)		X			
(Jain et al., 2019)					X
(Woubante, 2017)		X			
(Yoanita, 2016)			X		
(Addy, 2014)			X		

Table 2: Costing data of the articles intended for production.

Article	Pairs	Profit/Pair (Rs)	Leather Cost/pair (Rs)	Material Cost/pair (Rs)	Labour Cost/pair (Rs)	Overheads/pair (Rs)	B pair cost/pair (Rs)	Tooling cost/pair (Rs)	Total Cost/ pair (Rs)
5335 PSE (CBY)	1110	784	550	335	208	250	20	136	1499
5335 PSE (RD)	1230	798	537	334	208	250	20	136	1485
2695 PSE (OF)	510	634	595	415	176	250	22	0	1458
4014 PSE (CBY)	410	447	819	610	172	250	28	0	1879
1032	1224	206	375	453	191	250	25	0	1294
1196	314	213	521	405	232	250	28	0	1436
1199	494	213	482	451	226	250	28	0	1437
1205	674	149	512	484	225	250	29	0	1500
1206	1406	67	573	504	225	250	31	0	1583
8023	378	274	482	414	203	250	27	0	1376
611003	926	246	627	270	230	250	28	0	1405
8104	916	442	233	382	172	250	21	0	1058
AT-8152	307	486	196	378	170	250	20	0	1014
AT-8153	2018	490	198	372	170	250	20	0	1010
AT-9101	1049	362	282	413	172	250	22	0	1139
AT-9102	680	398	253	405	172	250	22	0	1102
AT-9103	483	421	241	394	172	250	21	0	1078
AT-9152	1849	476	196	388	170	250	20	0	1024
AT-9153	720	490	181	389	170	250	20	0	1010
DM-7129	374	396	468	291	220	250	25	0	1254
DM-8101	254	433	491	276	176	250	24	0	1217
HZ-9101	402	368	137	528	195	250	22	0	1132
HZ-9102	2053	413	117	489	176	250	21	35	1088
HZ-9103	1106	392	134	507	195	250	22	0	1108
KL-8102	2067	183	320	561	160	250	26	0	1317
KL-8103	1104	175	375	515	160	250	26	0	1326
KL-8106	612	230	343	492	160	250	25	0	1270
KL-8152	984	221	365	485	154	250	25	0	1279
KL-9102	1048	101	471	491	160	250	27	0	1399
KL-9103	1104	160	420	484	160	250	26	0	1340
KL-9151	1808	287	308	478	154	250	24	0	1214
RF-8152	554	219	495	433	225	250	28	0	1431
RF-9101	494	194	415	533	230	250	29	0	1457
RF-9102	1596	269	369	518	217	250	27	0	1381
RF-9104	1041	253	394	508	218	250	27	0	1397
UM-9104	741	179	333	633	226	250	29	0	1471
US-9101	1224	279	292	441	214	250	24	0	1221
US-9103	2817	246	335	430	214	250	25	0	1254

Cost included the leather cost/pair, material cost/pair, labor cost/pair, overheads/pair, tooling cost/pair, and b pair cost/pair, and in last the total cost/ pair was calculated for each of the articles (see Table 2). The graph shown in Figure 1 represents the total costs (total leather cost, total material cost, total labor cost, total overheads, total b-pair cost, and total tooling cost).
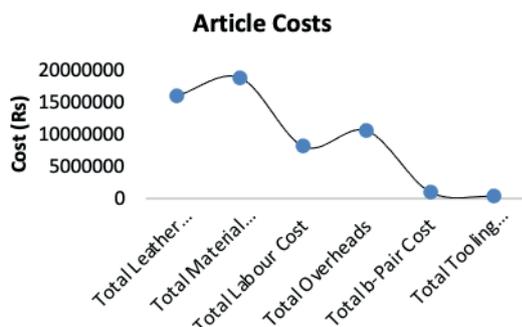
Article Costs

Figure 1: Representation of total costs involved in producing all planned articles as per the traditional way.

8. Mathematical Model

A linear programming model was developed at the case company so that in every closing season, managers can decide mathematically that how many pairs of which articles should be produced to gain maximum profit at the minimum total cost. A detailed, description of the model is given in the below-given headings.

8.1. Assumptions

1. The volume of raw material i.e. leather and shoe material was assumed to be limited

2. Factory overheads were assumed to be the same for every footwear article

3. Estimated labor cost (cutting, sewing by machine, hand sewing, lasting, job work, and molding) was considered

8.2. Important Notations

Indices and parameters are presented below.

8.2.1. Indices

i=index refers to the type of sole currently available in the inventory stock

g=index refers to the design of upper design to attached on the sole i

j=index refers to the leather items currently available in the inventory stock

k=index refers to the shoe material items currently available in the inventory stock

l=index refers to the size of the article of design g made on the sole i.

8.2.2. Parameters

max=maximum quantity currently available in the inventory stock

Q=quantity of specific items i.e. sole (number), leather material (s.ft), shoe material (number)

P=Profit

C=cost

Cut = cutting cost/pair

St=stitching cost/pair

HS=hand stitching cost/pair

MC=molding cost/pair

JW=job work cost/pair

LS=lasting cost/pair

T=estimated standard allowed minutes/pair (minutes)

PC=production cost/minute

FO=factory overheads/pair

SA=selling and admin/pair

ZTax = zakat tax/pair

Ltest = Leather testing cost/pair

Cutdies = Cost of cutting dies/pair

Last = cost of lasts/pair

Mold = cost molds/pair

BP=B-pair percentage of the production

SMC = shoe material cost

8.3. Model Formulation

The objective of conducting this research was to maximize the profit and minimize the cost. The objective function (Zmax) can be seen in (1).

Objective Function

$$Z_{max} = \sum_{i=1}^{I} \sum_{g=1}^{G} P_{ig}Q_{ig} \ \forall \left\{ \begin{array}{l} i = 1,2,3,...,I \\ g = 1,2,3,...G \end{array} \right\} \quad (1)$$

Subject to:

$$\sum_{i=1}^{I} \sum_{g=1}^{G} \sum_{j=1}^{J} C_{igj}Q_{igj} \leq \sum_{i=1}^{I} \sum_{j=1}^{J} C_{ij}max_{ij} \ \forall j = 1,2,3,...,J \quad (2)$$

$$\sum_{i=1}^{I} \sum_{g=1}^{G} \sum_{k=1}^{K} C_{igk}Q_{igk} \leq \sum_{i=1}^{I} \sum_{k=1}^{K} C_{ik}max_{ik} \ \forall k = 1,2,3,...,K \quad (3)$$

$$\sum_{i=1}^{I} \sum_{g=1}^{G} \left(Cut_{ig} + St_{ig} + HS_{ig} + MC_{ig} + JW_{ig} + LS_{ig} \right) \leq \sum_{i=1}^{I} \sum_{g=1}^{G} T_{ig}PC \quad (4)$$

$$\sum_{i=1}^{I} \sum_{g=1}^{G} \left(FO_{ig} + SA_{ig} + ZTax_i + Ltest_i \right) \leq \infty \quad (5)$$

$$\sum_{i=1}^{I} \sum_{g=1}^{G} \sum_{l=1}^{L} \left(cutdies_{igl} + Last_{igl} + Mold_{igl} \right) \leq \infty \ \forall l = 1,2,3,...,L \quad (6)$$

$$\sum_{i=1}^{I} \sum_{g=1}^{G} \sum_{k=1}^{K} C_{igk}Q_{igk}BP_{ig} \leq \sum_{i=1}^{I} \sum_{g=1}^{G} BP_{ig}SMC_{ig} \quad (7)$$

Non-Negativity Constraints:

PC, BP, FO, ZTax, max are constants;

C_{igj}, C_{igk}, C_{ik}, C_{ij}, Q_{igj}, Q_{igk}, Cut_{ig}, St_{ig}, HS_{ig}, MC_{ig}, JW_{ig},

LS_{ig}, FO_{ig}, SA_{ig}, $Ltest_i$, $cutdies_{igl}$, $Last_{igl}$, $Mold_{igl}$, BP_{ig},

SMC_{ig}, T_{ig}, P_{ig}, $Q_{ig} \geq 0$.

Since there were six types of costs involved in the footwear products as set by the case company. The costs were leather material cost (see (2)), cost of shoe material (see (3)), labor cost (see (4)), overheads (see (5)), tooling cost (see (6)), and b-pair cost (see (7)). The right-hand sides of two constraints ((5) and (6)) are undefined.

8.4. Model Implementation

After the formulation of the model, the objective function and constraints ((8) to (14)) were designed from the data presented in table 1. Data processing, calculation, and retrieval have been made easier by the applications of Information technology (Kalwar & Khan, 2020b). There is numerous software (i.e. LINGO, TORA, POM, etc.) available in the market for the calculation of such problems. This problem of linear programming was solved in Microsoft excel by using the solver add-in as shown in Figure 2.
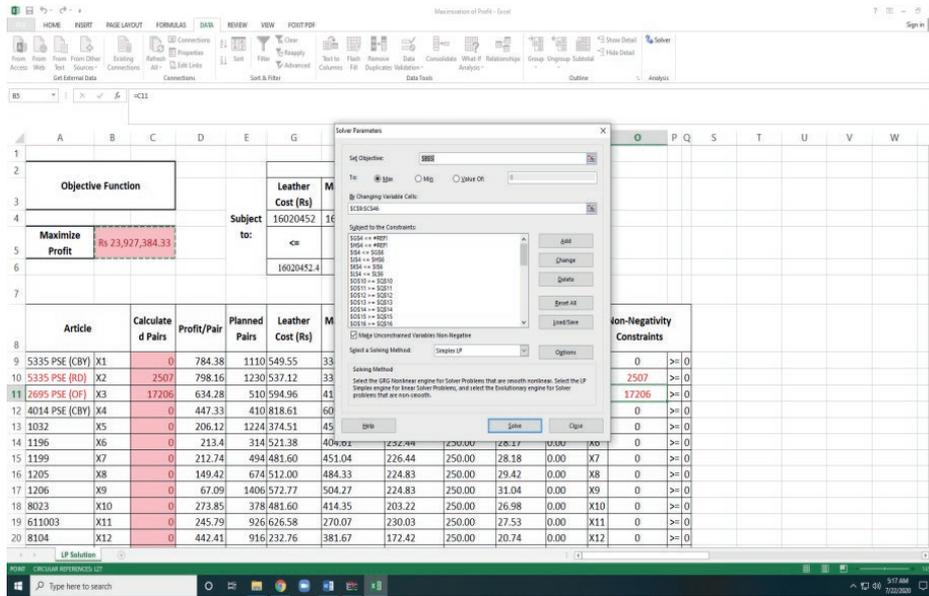
Figure 2: Model solution by the use of LP simplex method in solver add-in of the Microsoft excel

Objective Function

Z_{max} = 784x1 + 798x2 + 634x3 + 447x4 + 206x5 + 213x6 + (8)
213x7 + 149x8 + 67x9 + 274x10 + 246x11 + 442x12
+ 486x13 + 490x14 + 362x15 + 398x16 + 421x17
+ 476x18 + 490x19 + 396x20 + 433x21 + 368x22
+ 413x23 + 392x24 + 183x25 + 175x26 + 230x27
+ 221x28 + 101x29 + 160x30 + 287x31 + 219x32
+ 194x33 + 269x34 + 253x35 + 179x36 + 279x37
+ 246x38

Subject to:

550x1 + 537x2 + 595x3 + 819x4 + 375x5 + 521x6 + (9)
482x7 + 512x8 + 573x9 + 482x10 + 627x11 + 233x12 +
196x13 + 198x14 + 282x15 + 253x16 + 241x17 + 196x18
+ 181x19 + 468x20 + 491x21 + 137x22 + 117x23 +
134x24 + 320x25 + 375x26 + 343x27 + 365x28 + 471x29
+ 420x30 + 308x31 + 495x32 + 415x33 + 369x34 +
394x35 + 333x36 + 292x37 + 335x38 < 16020452

335x1 + 334x2 + 415x3 + 610x4 + 453x5 + 405x6 + (10)
451x7 + 484x8 + 504x9 + 414x10 + 270x11 + 382x12 +
378x13 + 372x14 + 413x15 + 405x16 + 394x17 + 388x18
+ 389x19 + 291x20 + 276x21 + 528x22 + 489x23 +
507x24 + 561x25 + 515x26 + 492x27 + 485x28 + 491x29
+ 484x30 + 478x31 + 433x32 + 533x33 + 518x34 +
508x35 + 633x36 + 441x37 + 430x38 < 16341998

208x1 + 208x2 + 176x3 + 172x4 + 191x5 + 232x6 + (11)
226x7 + 225x8 + 225x9 + 203x10 + 230x11 + 172x12 +
170x13 + 170x14 + 172x15 + 172x16 + 172x17 + 170x18
+ 170x19 + 220x20 + 176x21 + 195x22 + 176x23 +
195x24 + 160x25 + 160x26 + 160x27 + 154x28 + 160x29
+ 160x30 + 154x31 + 225x32 + 230x33 + 217x34 +
218x35 + 226x36 + 214x37 + 214x38 < 7720631

250x1 + 250x2 + 250x3 + 250x4 + 250x5 + 250x6 + (12)
250x7 + 250x8 + 250x9 + 250x10 + 250x11 + 250x12 +
250x13 + 250x14 + 250x15 + 250x16 + 250x17 + 250x18
+ 250x19 + 250x20 + 250x21 + 250x22 + 250x23 +
250x24 + 250x25 + 250x26 + 250x27 + 250x28 + 250x29
+ 250x30 + 250x31 + 250x32 + 250x33 + 250x34 +
250x35 + 250x36 + 250x37 + 250x38 < 10545000

20x1 + 20x2 + 22x3 + 28x4 + 25x5 + 28x6 + 28x7 + (13)
29x8 + 31x9 + 27x10 + 28x11 + 21x12 + 20x13 + 20x14
+ 22x15 + 22x16 + 21x17 + 20x18 + 20x19 + 25x20 +
24x21 + 22x22 + 21x23 + 22x24 + 26x25 + 26x26 + 25x27
+ 25x28 + 27x29 + 26x30 + 24x31 + 28x32 + 29x33 +
27x34 + 27x35 + 29x36 + 24x37 + 25x38 < 1034708

136x1 + 136x2 + 0x3 + 0x4 + 0x5 + 0x6 + 0x7 + 0x8 + (14)
0x9 + 0x10 + 0x11 + 0x12 + 0x13 + 0x14 + 0x15 + 0x16
+ 0x17 + 0x18 + 0x19 + 0x20 + 0x21 + 0x22 + 35x23 +
0x24 + 0x25 + 0x26 + 0x27 + 0x28 + 0x29 + 0x30 + 0x31
+ 0x32 + 0x33 + 0x34 + 0x35 + 0x36 + 0x37 + 0x38 <
339660

Non-negativity constraints:

x1 > 0, x2 > 0, x3 > 0, x4 > 0, x5 > 0, x6 > 0, x7 > 0, x8 > 0,
x9 > 0, x10 > 0, x11 > 0, x12 > 0, x13 > 0, x14 > 0, x15 >
0, x16 > 0, x17 > 0, x18 > 0, x19 > 0, x20 > 0, x21 > 0, x22
> 0, x23 > 0, x24 > 0, x25 > 0, x26 > 0, x27 > 0, x28 > 0,
x29 > 0, x30 > 0, x31 > 0, x32 > 0, x33 > 0, x34 > 0, x35
> 0, x36 > 0, x37 > 0, x38 > 0.

8.4.1. Optimal Solution

Z_{max} = Rs.23, 927,384

When, x1 = 0, x2 = 2507, x3 = 17206, x4 = 0, x5 = 0, x6 =
0, x7 = 0, x8 = 0, x9 = 0, x10 = 0, x11 = 0, x12 = 0, x13 =
0, x14 = 2,2459, x15 = 0, x16 = 0, x17 = 0, x18 = 0, x19 =
9, x20 = 0, x21 = 0, x22 = 0, x23 = 0, x24 = 0, x25 = 0, x26

= 0, x27 = 0, x28 = 0, x29 = 0, x30 = 0, x31 = 0, x32 = 0, x33 = 0, x34 = 0, x35 = 0, x36 = 0, x37 = 0, x38 = 0 pairs.

After solving the maximization problem, the profit was calculated to be Rs.23,927,384.33 if the calculated pairs of articles i.e. x2 = 2507, x3 = 17206, x14 = 2,2459, x19 = 9 will be produced.

9. Comparison of Results of Traditional Method and Model Output

The comparison of cost and profit as calculated by the traditional method and model was conducted. It was indicated by the comparison that with 11% (4099 pairs) greater production, 92% (Rs.11492112) more profit can be earned if the selection of articles and so their production quantity would be conducted by the model as can be seen in Table 3 and Figure 3.

Furthermore, it was also indicated by the output of the model that total leather cost, total material cost, total labor cost, total overheads, total b-pair cost, and total tooling cost would increase by 0%(Rs.0), 13%(Rs.2403825), 4%(Rs.357626), 0%(Rs.0), 0%(Rs.1) and 0%(Rs.0). At the same time, the total cost of produced pairs would increase by 11% (see Table 3 and Figure 3). The total cost of production would increase by only 5% (Rs. 2761450).

10. Discussion

The positive or negative outcome that a firm experience depends mostly on the ability to make the appropriate decision (Workie et al., 2016). Operation research is a phenomenon in which numerous techniques are available which are used for increasing the quality of decisions. It supports the decision-making process analytically by queuing theory, linear programming, and many other techniques. The present research is based on the use of linear programming techniques i.e. simplex method which was used for the maximization of profit in the leather footwear industry. There were 38 articles, from which it was to be decided that which article should be produced in how quantity so that profit could be maximized. Akpan, and Iwok (2018), conducted their research at the bakery by using the simplex method and the result showed that 962 units of a small loaf, 38 systems of the big loaf, as well as 0 units of the giant loaf, must be produced specifically to make a profit of N20385 (Workie et al., 2016). Workie, Alemu, and Asmelash (2016) carried out a study in the textile industry by using the simplex method and they concluded that the computational study of the techniques makes them offer a faster choice on the type and quantity of textile dyed materials to be generated that return much more income than methods acquired from trial and error methods to be enhanced by 72.63% and also 65.91% (Aregawi, 2018). Gameiro, Rocco, and Filho (2016) conducted their study by formulating the linear programming model for a dairy farm of Brazil; the outcomes showed that optimization models are appropriate techniques to assist in the planning as well as management of farming manufacturing, as well as to aid in estimating possible gains from the use of incorporated systems. Still, the percent of land use might boost up to 30.7% when the most affordable and also the highest diversification scenarios were contrasted (Woubante, 2017). The queue is prevalent in day to day life (Kalwar et al., 2018; Kalwar, Mari, et al., 2020; Kalwar, Marri, Khan, et al., 2021; Kalwar, Memon, et al., 2021; Khan, Khaskheli, et al., 2021b, 2021a; Khaskheli et al., 2020). Solaja et al., (2019) conducted their research in feed production mills; he suggested that choice makers ought to not base their decision on experience and intuition, yet on the analytical

Table 3: Comparison of cost and profit calculated as per traditional method and by suggested model.

|	Produced Pairs	Total Leather Cost (Rs)	Total Material Cost (Rs)	Total Labour Cost (Rs)	Total Overheads (Rs)	Total B pair cost (Rs)	Total Tooling cost (Rs)	Total Cost (Rs)	Total Profit
Model Output	42180	16020452	16341999	7720632	10545000	1034709	339660	52002452	23926524
Traditional Method Output	38081	16020452	18745824	8078258	10545000	1034708	339660	54763902	12434412
Difference	-4099	0	2403825	357626	0	-1	0	2761450	-11492112
Difference (%)	-11%	0%	13%	4%	0%	0%	0%	5%	-92%
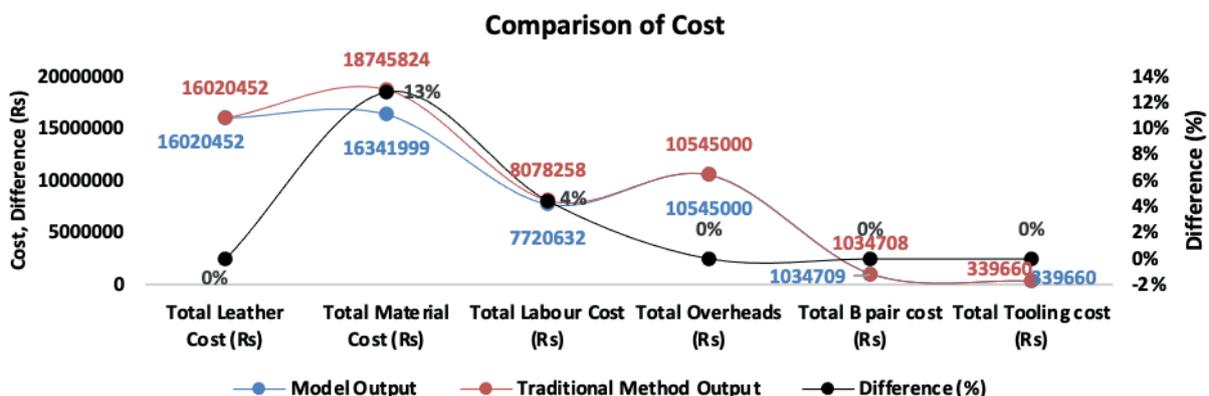
Figure 3: Comparison of traditional calculation and model calculations.

and also technical approach. Furthermore, managers must find out to apply linear programming techniques in production planning (Solaja et al., 2019). Anggoro et al., (2019) carried out his research at Bintang Bakery for the profit optimization; results indicated that the optimal profit level of Rp 19.750.000 would be achieved by creating 3740 flavored pieces of bread, 1300 packaged bread rolls and also 520 loaves of bread packaging Star Bakery industry experienced a profit rise of Rp 250.000 by utilizing the simplex method (Anggoro et al., 2019). Tesfaye et al., (2016) conducted a research in the textile sector in order to optimize the utilization of resources and profitability; the outcomes of the study illustrated that every one of the business resources were badly underutilized. This research showed that the resource usage of the case firm can be enhanced from 46.41% of the current resource usage to 98.57%. This shows that the new solution providers substantially optimize the resource utilization of enterprise. At the same time, with the brand-new remedy, the total profits each month of the case business can be raised from 365,699 birr per month to 897,844 birr per month (i.e., with an increment of 145.5%). Lastly, it is wrapped up that this exceptional profit increment of the business can absolutely improve its worldwide competitiveness (Tesfaye et al., 2016). Jain et al., (2019) optimized (made best use of) the net return of Central bank of India in the area of rate of interest from loans: he concluded that the maximum net return of the Bank is Rs.16.155 Crore by allocating the amount of Rs.7.5 Crore to Home loan, Rs.7.5 Crore to Agricultural loan, Rs.7.5 Crore to Car loan, Rs.67.5 Crore to Personal Loan, Rs.60 Crore to Education loan and none of the amount is for Commercial loan (Secured and Unsecured) and the maximum profit of investor is Rs.13,420 by investing the amount of Rs.40,000 to Saving account, Rs.1,20,000 to fixed deposit, Rs.40,000 to SCSS and none of the amount is for PPF (Gameiro et al., 2016). Addy (2014) improved production scheduling of the company by using simplex method; Interpretations of results obtained from the evaluation developed basis for recommendations to improve supervisory decisions. This was plainly shown from the outcomes of the linear programming model application for the study, which indicates that the 65 tons target from production of the six house wiring cables can be viable within prevailing constraints (Addy, 2014).

In the present research, result indicated that the profit would be Rs.23,927,384.33 if the calculated pairs of articles i.e. x2 = 2507, x3 = 17206, x14 = 2,2459, x19 = 9 would be produced and the profit would be maximized to 92%(Rs.11492112) and at the same time, total cost was increased by 5% (Rs. 2761450).

11. Conclusion

In developing countries like Pakistan, quantity (with desired quality) is the main element of decision-making when there is the question of profit. Similarly, in the case company, the philosophy of managers was to produce more to earn more. This paper contributes to the modification of that philosophy by including the element of intelligence in the decisions at the managerial level in a way that it could be easily decided which article should be produced in how much quantity so that the profit can be maximized. As in the present research paper, the model was developed by which the profit was maximized by 92%. Since it was a mathematical approach and can be justified concretely.

12. Future Implications

Many industries are known for the production of fast-moving consumer goods and there is the main problem of the marketing mix and profit maximization and cost minimization. This model can be modified and used in that scenario.

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Conflict of Interest

There was no conflict of interest found among the authors of thepresent research paper.

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