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FINDING OUT THE PRODUCT MIX FOR A TEXTILE MANUFACTURING COMPANY USING A LINEAR PROGRAMMING MODEL

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Abstract

The present work aims at designing a Linear Programming Model for finding out the right product mix for a leading textile manufacturing company in India with the objective of profit maximization. Data such as contribution per metre produced, saleability index, loom type and width, number of looms available, machine hours available per day and production per loom shift (8 hrs of availability of a loom) are used in the present work. Using the LP, model, the number of products to be produced has been reduced from 74 to 39. Total contribution corresponding to the recommended solution will be Rs. 5,17,29,901 per month. This will result in a savings of one crore rupees for the company.

1 Introduction

The present work was carried out in a leading textile manufacturing company in India. In this work , 74 products that are currently produced are taken into consideration. The main objective is to reduce the number of products manufactured to a reasonable number from the current 74 so that the profit is maximized.

In order to find out the right product mix, necessary data such as contribution per metre produced, saleability index, loom type and width, number of machines available, machine hours available per day and production per loom shift (8 hrs of availability of a loom) were collected.A linear programming model has been designed and proposed to solve this product mix problem.

In the company, the manufacturing process involves spinning, weaving and processing. The end product is the processed fabric. The product mix is the right mix of products that the company can produce in such a way that it would be profitable. Linear Programming is a mathematical programming technique to optimize performance (ex: profit or cost) under a set of constraints (ex: machine-hours, man-hours, etc).

2 Problem Description

The company manufactures 74 different qualities of fabrics (74 different products). But all 74 products are not profitable to the company. Profits generated by some products are very low. Also , there is wide difference in the saleability of the products .

Hence there is a need for the company to define those products (best product mix) that would yield maximum profit to the company. A linear programming model is proposed to solve the above problem.

3 Objectives

Objectives of the present research work are given below:

1. To find out the right product mix that would yield highest profit to the business by using a Linear Programming Model.
2. To find out the list of products that has maximum contribution among existing products.
3. Assign right product to the right loom.

4 Formulating the Linear Programming Model

The main data used to design the model are given below in a tabular form

Loom type and width	Loom shifts needed to manufacture one metre of a product on a particular type of loom				Number of loom shifts available per month on a particular type of loom
	P_1	P_2	.....	P_n	
Gemini 84”	a_{11}	a_{12}	———	a_{1n}	10935
Picanol 48”					2363
Picanol 64”					3240
Picanol 69”					3443
Picanol 79”					3240
Picanol 103”					3240
HOWA 44”					4118
HOWA 60”					10058
Ruti 180cm					3240
Ruti 280cm					2430
Projectile 330cm	a_{m1}	a_{m2}	———	a_{mn}	13500
Contribution /metre					

Note : one loom shift is 8hrs of production in a loom

List of products produced currently by the company is shown in Table 1. Saleability of 74 products per month (in metres) are shown in **Table-2**. Loom shifts needed to manufacture one metre of each product are shown in Table 3. Linear Programming Model is designed in order to determine the optimum production volume of each of the products such that profit is maximized.

Let n be the number of products to be manufactured and m be the number of different loom types used.

Decision variable: A decision variable is used to represent the level of achievement of a particular course of action. The solution of the LP problem will provide the optimal value for each and every decision variable of the model. A generalized format of the decision variable is as follows:

Let $X_1, X_2 \ldots X_n$ be the production volumes (in metres) per month of the products $P_1, P_2 \ldots P_n$ respectively.

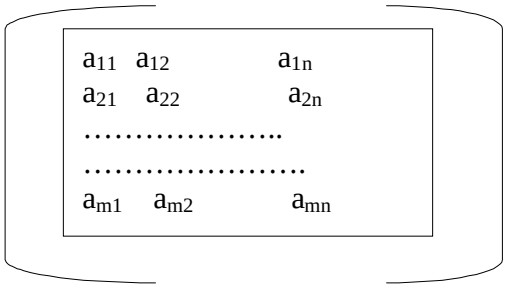
Objective function coefficient : It is a constant representing the profit.

Let $C_1, C_2 \ldots\ldots C_n$ be the profit per unit (profit per metre) of the products $P_1, P_2 \ldots\ldots P_n$ respectively.

Objective function:

Maximize Profit , $Z = C_1X_1 + C_2X_2 + \ldots\ldots\ldots\ldots + C_nX_n$

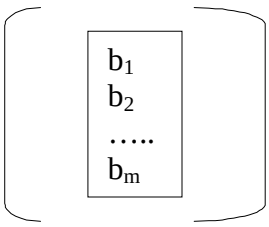
Technological coefficient : (a_{ij}) : It is the amount of resource i (loom shifts used for manufacturing one metre of a product) required for the activity j, where i vary from 1 to m and j varies from 1 to n. A generalized format is :



Where n represents the product type

m represents a particular loom type

Resource availability : The constant b_i is the amount of resource i available during the planning period (number of loom shifts available per month).



Set of constraints : It is a kind of restriction on the total amount of a particular resource required to carry out the activities at various levels.

$a_{11}X_1 + a_{12}X_2 + \ldots\ldots\ldots..+a_{1n}X_n <= b_1$

……..

……..

$a_{m1}X_1 + a_{m2}X_2 + \ldots\ldots\ldots + a_{mn}X_n <= b_m$

Non-negativity constraints: It is the market constraint available to the problem. Here market constraint is the saleability of a particular product. It is mentioned in the problem as below:

$0<=X_1<=S_1$, where S_1 is the value of saleability (in metres) per month of the product P_1.

Proposed linear programming model:

Maximize $Z = C_1X_1 + C_2X_2 + \ldots\ldots\ldots\ldots + C_nX_n$

$a_{11}X_1 + a_{12}X_2 + \ldots\ldots\ldots..+a_{1n}X_n <= 10935$

……

……

$a_{m1}X_1 + a_{m2}X_2 + \ldots\ldots\ldots + a_{mn}X_n <= 13500$

$0<=X_1<=S_1$

$0<=X_2<=S_2$

.....

.....

$0<=X_n<=S_n$

5 Assumptions

The following assumptions are made while designing the linear programming model.

1. ***Linearity*** **:** The amount of resource required for a given activity level is directly proportional to the level of that activity. For example, if the number of hours required on a particular machine (for a given activity level) is 5 hours per unit of that activity, then the total number of hours required on that machine to produce 10 units of that activity is 50 hours.
2. ***Divisibility :*** This means that fractional values of the decision variables are permitted.
3. ***Non-negativity :*** This means that the decision variables are permitted to have only the values which are greater than or equal to zero.

4. ***Additivity :*** This means that the total output for a given combination of activity levels is the algebraic sum of the output of each individual process.

6. Findings

1) Using the LP model, the number of products to be produced has been reduced from 74 to 39. This selection is based on the products having highest profit per unit (metre) and saleability. Product mix solution is shown in Table 4.
2) Product for each loom type is assigned based on profitability.
3) Provision is also made in such a way that if there is any need to test a new product, it is easier to feed necessary data about the new product and use the LP model to find out the best product mix.

7. Conclusion

The results of this linear programming model is very much useful to the textile company. Total contribution corresponding to the recommended solution will be Rs. 5,17,29,901 per month. This will enable the management to decide not to produce less profit contributing products and produce only those products which will yield very high profits to the company. **If the suggestions are implemented , the company will gain one crore rupees per month.**

References

1. Jay Heizer and Barry Render, 2006. Operations Management, Pearson- Prentice Hall, Upper Saddle River, New Jersey, U.S.A.
2. Frederick S. Hiller and Gerald J. Lieberman, 2005. Introduction to Operations Research, Mc Graw-Hill, New York, NY, 10020, U.S.A.
3. User Manual, LP88- Linear Programming package.

Table 1
List of products produced currently by the textile manufacturing company

Serial number	Product code	Local/ Export	Width (inches)	Loom type	Sales price	Variable cost	Production per month (metres)
1	NA 305	L	44	HOWA	34.75	11.95	26512
2	NWC3391	L	44	HOWA	23.00	10.16	19773
3	NSC 101	L	44	HOWA	25.46	11.99	1167915
4	PCDC98	L	44	HOWA	55.00	16.64	204103
5	NWC1114	E	48	PIC	15.30	12.15	204276
6	MKCL 1	L	48	PIC	24.00	13.31	15356
7	NSC101	L	48	PIC	25.46	12.01	1342833
8	NA3817	L	48	PIC	22.00	17.61	18508
9	NCR 22	L	48	PIC	22.15	10.72	16966
10	NCR340	L	48	PIC	42.91	22.58	4228
11	MWCR59	L	48	PIC	22.50	8.84	24142
12	ND1140	L	48	PIC	15.00	13.72	14940
13	ND260	L	48	PIC	24.00	14.66	21132
14	NTB14	L	48	PIC	22.50	9.06	17411
15	PCA98	L	48	PIC	34.50	10.14	71343
16	NWC1397	L	60	HOWA	30.66	14.38	131771
17	NWC3468	E	60	HOWA	30.93	14.14	386980
18	SC131	L	60	HOWA	28.25	15.18	40766
19	WC1012	E	64	PIC	33.90	19.10	162969
20	D2199	L	64	PIC	43.25	28.02	23176
21	NA1476	L	64	PIC	26.50	15.04	256466
22	NA1562	L	64	PIC	30.00	18.72	404005
23	NA2213	L	64	PIC	34.00	21.43	67709
24	NA2277	L	64	PIC	44.07	20.56	3911
25	NA2575	L	64	PIC	22.50	12.17	16216
26	NWC3765	L	64	PIC	37.00	21.23	29515
27	NCVG255	L	64	PIC	53.00	32.57	92239
28	NCVG268	L	64	PIC	55.80	34.07	17089
29	ND129	L	64	PIC	43.50	34.36	31544
30	ND295	L	64	PIC	45.50	32.47	14895
31	PCA429	L	64	PIC	50.48	15.74	4369
32	PCA444	L	64	PIC	24.00	15.14	57158
33	NA1990	L	69	PIC	32.00	15.94	80166
34	NWCR154	L	69	PIC	68.65	34.07	29297
35	NTUB38	L	69	PIC	40.00	20.82	16292
36	WC1012	E	71	RUTI	33.91	17.76	416944
37	NA1476	L	71	RUTI	26.50	14.68	127881

Table 1
List of products produced currently by the textile manufacturing company (continued)

Serial number	Product code	Local/ Export	Width (inches)	Loom type	Sales price	Variable cost	Production per month (metres)
41	ND129	L	71	RUTI	43.50	33.93	257006
42	ND295	L	71	RUTI	45.50	31.91	25641
43	PCDC98	L	71	RUTI	55.00	15.94	4950
44	WC1194	E	79	PIC	45.24	21.96	336193
45	WC1186	L	79	PIC	54.86	22.69	177714
46	NCR311	L	79	PIC	66.96	28.86	1635
47	NA2198	L	79	PIC	37.00	22.14	166358
48	NWCR13	L	79	PIC	72.00	31.08	49376
49	WC1194	E	84	GEM	45.24	22.29	1237424
50	NWC1397	L	84	GEM	30.66	14.62	31111
51	NWC3889	E	84	GEM	59.90	28.46	33808
52	SC131	L	84	GEM	28.25	15.42	167823
53	WC1012	E	84	GEM	33.91	19.54	238502
54	WC1186	L	84	PIC	54.86	22.86	57680
55	NWC136	L	103	PIC	57.67	26.33	274773
56	NWC2151	L	103	PIC	45.03	32.59	242800
57	NA1330	L	103	RUTI	44.50	34.59	88859
58	NA1330	L	110	RUTI	44.50	34.08	297540
59	NWC2151	L	110	PROJ	45.03	32.59	345161
60	WC1194	E	330	PROJ	45.24	21.94	466396
61	NA1189	L	330	PROJ	63.00	29.70	328181
62	NA1330	L	330	PROJ	44.50	34.43	503596
63	NWC136	L	330	PROJ	57.67	26.21	827112
64	NWC1397	L	330	PROJ	30.66	14.46	22990
65	NWC3468	E	330	PROJ	30.93	14.30	446509
66	WC1012	E	330	PROJ	33.91	19.20	17234
67	WC1186	L	330	PROJ	54.86	22.65	2653
68	NA1324	L	330	PROJ	51.50	26.34	33805
69	NA1476	L	330	PROJ	26.50	15.08	71298
70	NA1554	L	330	PROJ	66.85	32.70	17433
71	NA1563	L	330	PROJ	57.00	39.62	408630
72	NA1642	L	330	PROJ	61.00	41.88	71776
73	NA2340	L	330	PROJ	37.00	19.05	107491
74	NA1732	L	330	PROJ	55.00	28.00	43160
						Total	**13376082**

Table 2
Saleability of products

Serial number	Product code	Saleability per month (metres)
1	NSC101	1342833
2	WC1194	1237424
3	NSC101	1167915
4	NWC136	827112
5	NA1330	503569
6	WC1194	466396
7	NWC3468	446509
8	WC1012	416944
9	NA1563	408630
10	NA1562	404005
11	NWC3468	386980
12	NWC2151	345161
13	WC1194	336193
14	NA1189	328181
15	NA1330	297540
16	NWC136	274773
17	ND129	257006
18	NA1476	256466
19	NWC2151	242800
20	WC1012	238502
21	PCDC96	22318
22	NWC1114	204276
23	PCDC98	204103
24	WC1186	177714
25	SC131	167823
26	NA2198	166358
27	WC1012	162969
28	NWC1397	131771
29	NA1476	127881
30	D2199	118523
31	NA2340	107491
32	NCVG255	92239
33	NA1330	88859
34	NA1990	80166
35	NA1642	71776
36	PCA98	71343
37	NA1476	71298
38	NA2213	67709
39	WC1186	57680
40	PCA444	57158
41	PCA444	50927

Table 2
Salebility of products (continued)

Serial number	Product code	Saleability per month (metres)
42	NWCR13	49376
43	NA1732	43160
44	SC131	40766
45	NWC3686	33808
46	NA1324	33805
47	NA129	31544
48	NWC1397	31111
49	NWC3765	29515
50	NWCR154	29297
51	NA305	26512
52	ND295	25641
53	NWCR59	24142
54	D2199	23176
55	NWC1397	22990
56	ND260	21132
57	NWC3391	19773
58	NA3817	18508
59	NA1554	17433
60	NTB14	17411
61	WC1012	17234
62	NCVG268	17089
63	NCR22	16966
64	NTUB38	16292
65	NA2575	16216
66	MKCL1	15356
67	ND1140	14940
68	ND295	14895
69	PCDC98	4950
70	PCA429	4369
71	NCR340	4228
72	NA2277	3911
73	WC1186	2653
74	NCR311	1635

Table 3
Loom shifts needed to manufacture one metre of a product on a particular loom

Product code	Loom shifts needed to manufacture one metre of a product on a particular loom										
	GEM84"	PIC48"	PIC64"	PIC69"	PIC79"	PIC103"	HOWA44"	HOWA60"	RUTI180cm	RUTI280cm	PROJ 330cm
NA305						0.03467					
NWC3391						0.07586					
NSC101	0.03125					0.03749					
PCDC98						0.03564		0.03541			
NWC1114	0.02064	0.02373									
MKCL1	0.03543										
NSC101	0.02820										
NA3817	0.04269										
NCR22	0.02901		0.03233								
NCR340	0.04464										
NWCR59	0.02232										
ND1140	0.04587										
ND260	0.03543										
NTB14	0.02232										
PCA98	0.03794					0.03564		0.02285			
NWC1397							0.03467				
NWC3468							0.04536				
SC131							0.04536				
WC1012								0.03125			
D2199								0.02500			
NA1476	0.04010							0.03416		0.01739	
NA1562		0.01823	0.01569								
NA2213		0.03664									
NA2277		0.02687									
NA2575		0.03124									
NWC3765		0.01823									
NCVG255	0.02927	0.02604									
NCVG268	0.02687	0.02604									
ND129		0.04855									
ND295								0.02916			
PCA429		0.04426									

Table 3
Loom shifts needed to manufacture one metre of a product on a particular loom (continued)

Product code	Loom shifts needed to manufacture one metre of a product on a particular loom										
	GEM84"	PIC48"	PIC64"	PIC69"	PIC79"	PIC103"	HOWA44"	HOWA60"	RUTI180cm	RUTI280cm	PROJ 330cm
PCA444	0.04145							0.03541	0.03275		
NA1990			0.04553								
NWCR154			0.03013								
NTUB38			0.03348								
WC1012	0.05344										
NA1476		0.04010							0.03416		
PCA444		0.04145							0.03275		
PCDC96								0.02500			
D2199									0.02906		
ND129									0.03400		
ND295		0.04536						0.02245			
PCDC98						0.03658		0.03859			
WC1194	0.05047			0.04394							
WC1186	0.05047										
NCR311				0.04579							
NA2198				0.05155							
NWCR13				0.04101							
WC1194	0.04986									0.03478	
NWC1397	0.03837						0.04214			0.01256	
NWC3886	0.02103										
SC131	0.01834						0.02768				
WC1012	0.04325	0.05689						0.04689		0.01685	
WC1186	0.04567			0.02856						0.05689	
NWC136					0.05021						0.03800
NWC2151									0.04539		
NA1330	0.03852							0.04213		0.04392	
NA1330										0.03855	
NWC2151					0.02885				0.03544		
WC1194	0.03668			0.02866						0.04667	
NA1189										0.03800	0.03800
NA1330					0.01456				0.02498		
NWC136				0.02878						0.03676	

Table 3
Loom shifts needed to manufacture one metre of a product on a particular loom (continued)

Product code	Loom shifts needed to manufacture one metre of a product on a particular loom										
	GEM84"	PIC48"	PIC64"	PIC69"	PIC79"	PIC103"	HOWA44"	HOWA 60"	RUTI180cm	RUTI280cm	PROJ 330cm
NWC1397	0.01989						0.02445			0.03556	
NWC3468							0.03889			0.04221	
WC1012	0.02431	0.01543						0.02589		0.03112	
WC1186	0.03446									0.04885	
NA1324										0.04321	
NA1476		0.01321						0.02441		0.03579	
NA1554									0.03800		0.038
NA1563									0.04712		
NA1642									0.03856		
NA2340									0.03800		0.038
NA1732									0.04475		

Table 4
Product mix solution obtained using the proposed linear programming model

Loom type	Product serial Number	Recommended product for manufacturing	Recommended production (in metres) per month	Contribution per metre produced	Net return
GEMINI 84"	1	NWC3886	33808	31.44	10,62,923
	2	WC1186	2653	32.00	84,896
	3	WC1194	324304	22.95	74,42,776
HOWA 44"	4	NA305	26512	22.80	6,04,474
	5	NSC101	109829	13.47	14,79,400
HOWA 60"	6	NWC3468	221726	16.79	37,22,782
	7	SC131	167820	13.07	21,93,407
PICANOL 48"	8	NCR22	16966	11.43	1,93,921
	9	NCR340	4228	20.33	85,955
	10	NSC101	50157	13.45	6,74,614
	11	NTB14	17411	13.44	2,34,003
	12	NWC1114	204270	3.15	6,43,450
	13	NWCR59	24142	13.66	3,29,779
	14	PCA98	71343	24.36	17,37,915
PICANOL 64"	15	NA1562	404000	11.28	45,57,120
	16	NA2277	3911	23.51	91,948
	17	NA2575	16216	10.33	1,67,511
	18	NCVG255	79246	20.43	16,19,000
	19	NCVG268	17089	21.73	3,71,343
	20	NWC3765	29515	15.77	4,65,451
	21	PCA429	4369	34.74	1,51,779
PICANOL 69"	22	NA1990	44241	16.06	7,10,521
	23	NTUB38	16292	19.18	3,12,480
	24	NWCR154	29297	34.58	10,13,090
PICANOL 79"	25	NCR311	1635	38.10	62,293
	26	MWCR13	49376	40.92	20,20,465
	27	WC1194	27653	23.28	6,43,771
PICANOL 103"	28	NWC136	64528	31.34	20,22,308
PROJECTILE 330cm	29	NA1189	328180	33.30	1,09,28,394
	30	NA1554	17433	34.15	5,95,336
	31	NA2340	107490	17.95	19,29,445
	32	NWC136	9650	31.46	3,03,594
RUTI 180cm	33	D2199	118520	15.71	18,61,949
	34	ND295	6043	13.59	82,133
	35	PCA444	1097	9.23	10,125
	36	PCDC96	1397	37.32	52,136
	37	PCDC98	4950	39.06	1,93,347
	38	WC1012	17234	15.95	2,74,882
RUTI 280cm	39	NWC2151	64243	12.44	7,99,185

Total return = Rs. 51729901 per month