AN APPLICATION OF BUSINESS BUDGETING: LINEAR PROGRAMMING APPROACH

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Purpose of Study: Some form of budgeting is an absolute necessity for the financial planning of business firms. Traditionally the budget is built along functional lines. Historically this planning process took place in several stages which entailed several loops. This made the finding of an optimal master plan a very difficult task. These difficulties have led to the realization that in order to develop an optimal master plan we must develop the functional budgets simultaneously instead of developing them in successive steps. It appears that linear programming concepts can be applied to obtain a simultaneous optimal solution to the budgeting problems.

Findings and Conclusions: The technique of linear programming makes it possible to optimize the firm's profit objective under constraints on sales, production capacity, purchases, financing, physical facilities, corporate goals, etc. and derive a series of budgets very quickly. This paper has demonstrated that it is feasible to apply linear programming to generate the firm's financial control budgets and financial statements.

ADVISER'S APPROVAL ______________________

AN APPLICATION OF BUSINESS BUDGETING:

LINEAR PROGRAMMING APPROACH

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CHAPTER I

INTRODUCTION

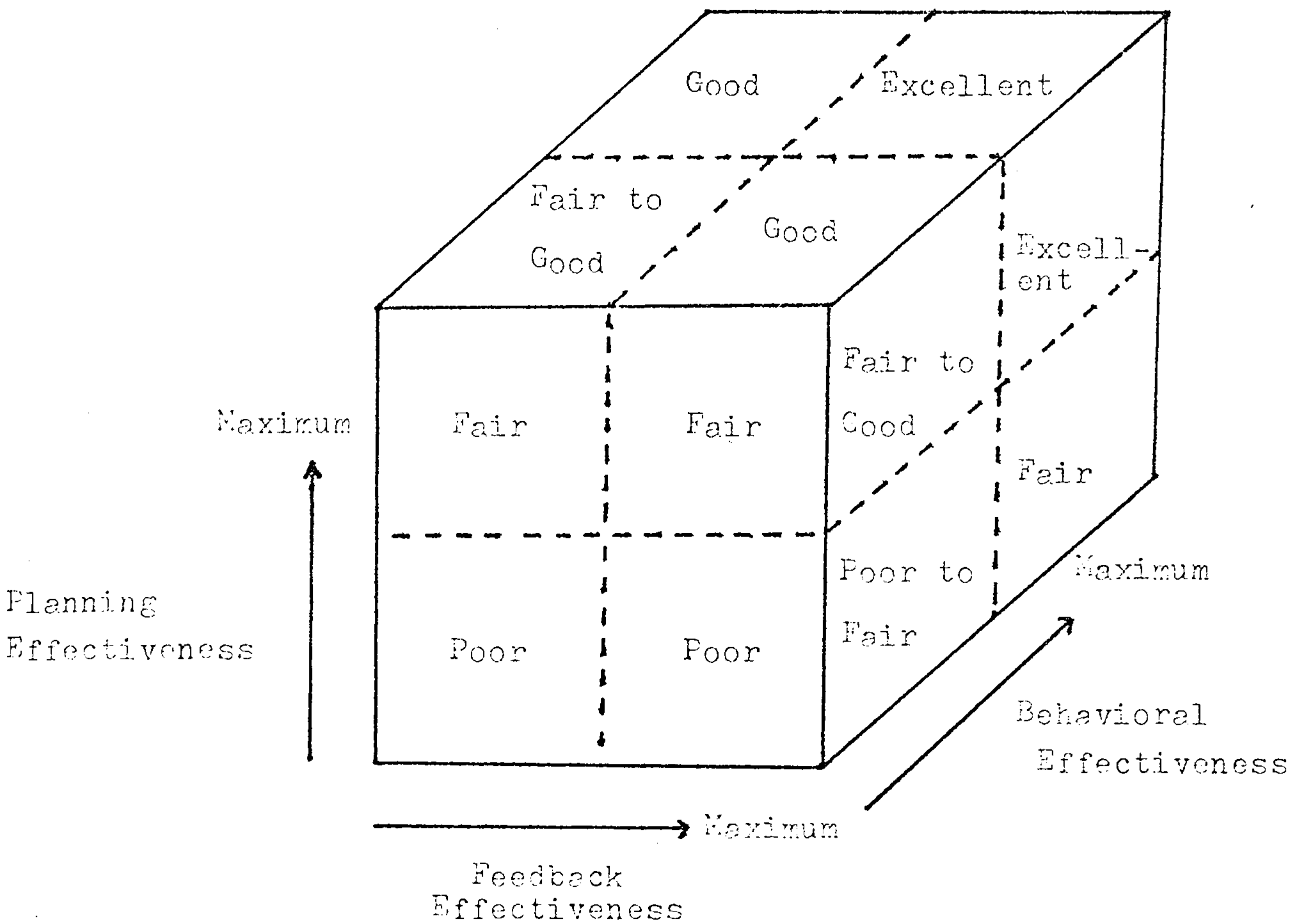
Budgeting is a process of resource allocation. The process may be applied within any revenue generating entity, whether it is a proprietorship or a corporation, profit or nonprofit, manufacturing or service organization. Operating budgets allocate the current revenue stream generated by the normal flow of goods and services, and capital budgets redistribute the total resources of an entity in a manner that maximizes total revenue over the long term planning horizon. One, therefore, could conclude that the budgetary concept is an intergral part of organizational management, whether it is financial planning for a small firm or for the large corporation. Brigham (26) thinks the process of budgeting is an inextricable part of the art of management. Some form of budgeting is today an absolutely necessary tool for the financial planning of business firms. Banks and various public institutions which channel funds, guarantee, and provide other types of financial assistance to business firms, regard a well functioning budgetary system as a necessary precondition for their positive decisions.

Budgeting can provide valuable guides to both high level executives and middle management personnel (18). Well formulated and effectively developed budgets make subordinates aware that top management has a realistic understanding of the nature of operations in the business firm. Such a budget can be an important communciation link between top management and the divisional personnel whom they guide. Business operations in today's economic environment are complex and are subject to heavy competitive pressures. In such an environment, many kinds of changes take place. The rate of growth of the economy as a whole fluctuates and these fluctuations affect different industries in a number of different ways. If a firm plans ahead, the budget and control process can provide management with a better basis for understanding the firm's operation in relation to faster reactions to developing events, thus increasing the firms's ability to perform effectively.

Ralph L. Benke Jr (2) thinks the effective operating budget process of today is three dimensional (Figure 1). The first dimension is the use of budgets as a planning device; the second is the use of the budget as a feedback device to insure that the employees of the organization are adhering to the plan, and the third is behavioral considerations. He thinks that the effective operating budget is one that devises plans in a manner that brings about a commitment of the employees to the success of the plan and establishes feedback that encourages the continuation of the commitment.

Figure 1

Effectiveness Of Operating Budget Process



Source: Utilizing Operating Budgets For Maximum Effectiveness, Managerial Planning, Ralph L. Benke, Jr, 1977, pp. 33

If the behavioral implications dimension is ignored, Ralph L. Benke Jr (2) thinks that one or all of the following problems may occur:

1. Budgets, as a planning device, will not be as effective as they could be.
2. Reports comparing actual performance to budgeted performance will not accurately reflect the extent to which plans are being accomplished by departments of organization.
3. The budgets may not be prepared or utilized in a manner that motivates employees to take actions that are in the best interest of the organization.
4. In extreme instances, improper preparation or utilization of budgets may cause severe internal problems, such as depressed morale, that affects the overall well-being of the organization.

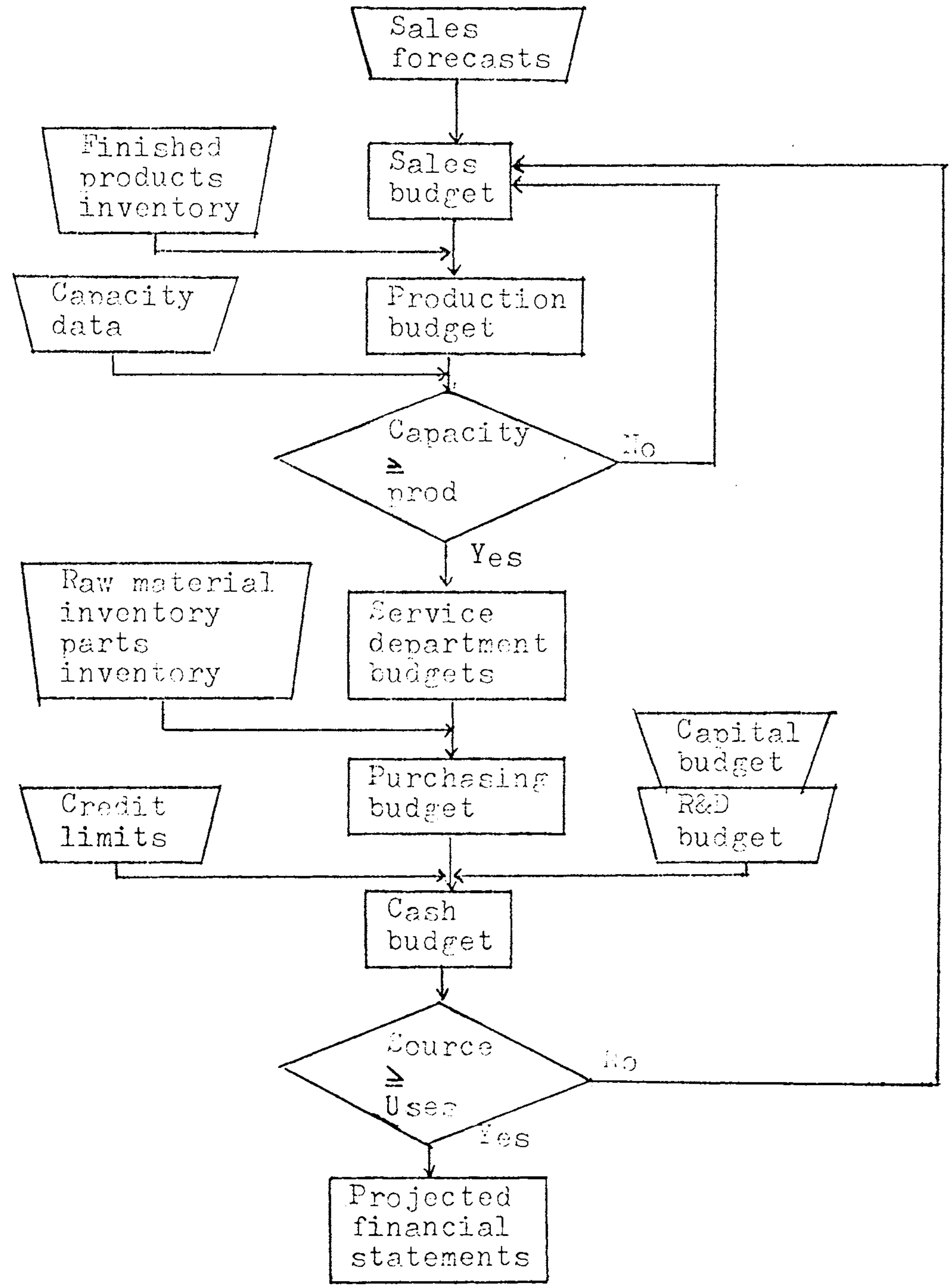
This report will not discuss the above three dimensional questions but will emphasize how to employ the linear programming model to extend many of the elements of the conventional budgeting process into a simple straightfoward set of algebraic formulas.

Traditionally the budget is built along functional lines. A typical procedure is to develop sales, inventory, production, purchasing, cash, and capital expenditure, as well as research and development budgets which are then assembled into a master budget together with the projected financial statements (17).

Many authors state that the sales budget must be taken as a starting point and the other budgets must be adjusted to it. Figure 2 represents a common budgeting procedure where we start with the sales budget and move to production, purchasing, and cash budgets. The sales budget is first developed on the basis of demand data by the use of a sales forecasting model. The sales budget and the beginning balance of the finished products are then used to develop the production budget. The capacity required by the planned production is compared to the available capacity. If the available capacity exceeds the required capacity or is equal to it, we can consider the production budget to be final and can move to the next functional budget. If the available capacity is less than the required capacity, we must return to the sales budget and leave out enough products to bring the required capacity to the level of the available capacity. When the sales and production budgets are adjusted to each other, we can prepare the budgets for the service departments. Futhermore, we can take the planned production and expand it into parts and raw material requirements. The fabricating parts and raw materials required for production and the beginning

Figure 2

Traditional Budgeting Process



Source: Journal of Business, Cheng Kung University, 1977
Veikko Jasskelainen, pp. 37

balance of fabricating parts and raw materials are then used to develop the required purchases of fabricating parts and raw materials. When we add these purchases to the supplies needed by the various production and service departments, we can develop the purchasing budget.

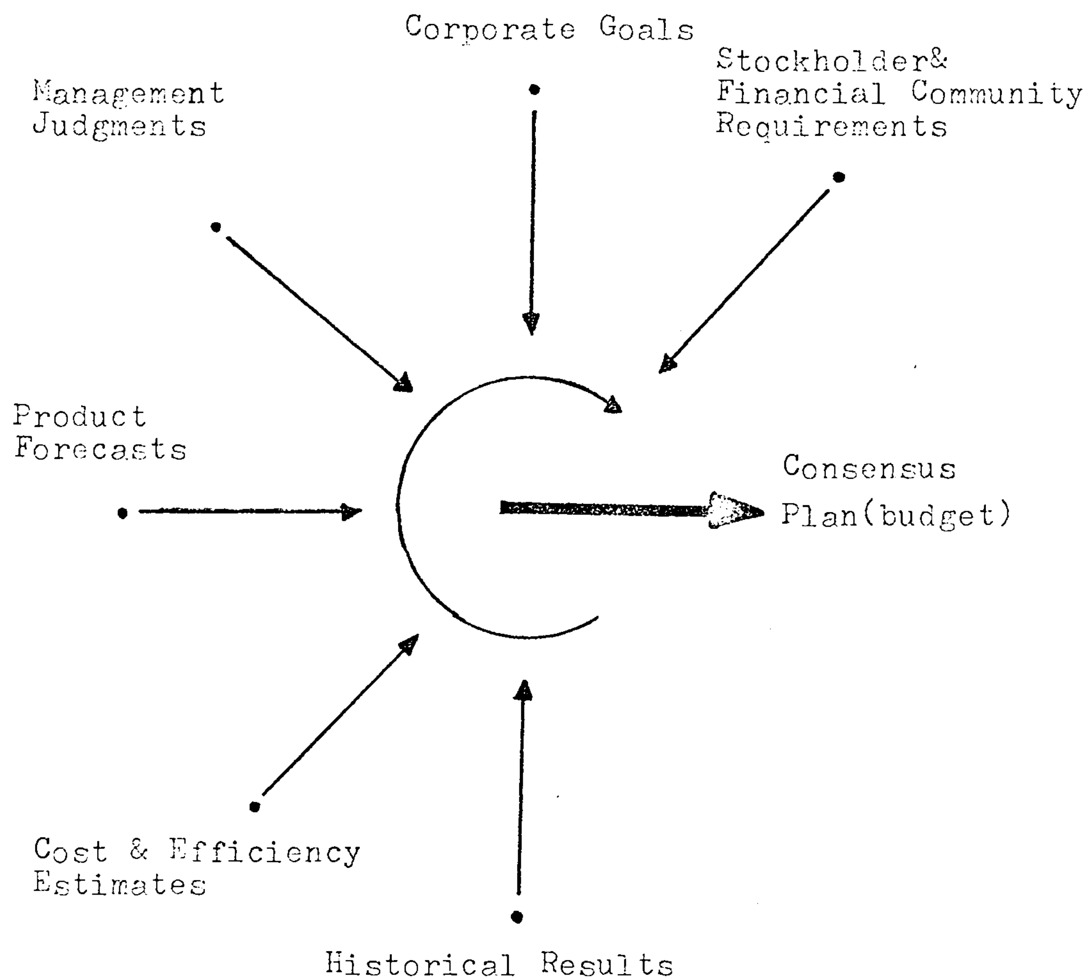
Starting from the initial balances reported in the firm's financial statements and taking into account the effects of sales, production, service department, and purchasing budgets as well as from capital expenditure and research and development budgets, we can figure out the financing needs for the period. The financing requirements are then compared to the available financing. If the available financing does not cover the needs, we must return to the sales budget and revise it by excluding products which tie up a considerable amount of funds in relation to their contribution. Then we must revise the remaining functional budgets to bring them in line with the revised sales budget. Figure 2 assumes that the capital budget as well as the research and development budget have been developed independently of the other functional budgets. A possible way to reduce the required financing is to decrease the planned investments in capital assets, or to make cuts in the R&D budget. Another possibility is to decrease the planned ending balances of finished products, parts, and raw materials.

When the functional plans have been adjusted to the available financing, we can finally compute the projected income statement and projected balance sheet. If the planned profit is not satisfactory in relation to the capital employed in operations, we must return to some functional budget, revise it to improve the profit position, and then go through a chain of revisions in other functional budgets. This makes the finding of an optimal master plan very difficult. However, as shown in Figure 3, the technique of linear programming makes it possible to optimize the firm's profit objective under constraints on sales, production capacity, purchases, financing, utilization of personnel, physical facilities, corporate goals, etc., and derive a budget very quickly. Further, it is interesting to note that there is no starting point specified in Figure 3 since all inputs are considered simultaneously.

In this paper, the linear programming concept is applied to solve the firm's budgeting problems, and therefore produces a cash budget, production budget, purchase budget, projected income statement, and a projected balance sheet simultaneously rather than developing them in successive steps.

Figure 3

Planning Process



Source: A Computer Model Approach to Budgeting, Management Accounting, June, R. C. Murphy, 1975, pp. 34

CHAPTER II

RESEARCH METHODOLOGY

Linear Programming Model

The basic problem of linear programming, determining the optimal value of a linear function subject to linear constraints, has been successfully applied to several areas of economic activity. Oil refinery operations is the largest single field of application. It is of great interest to top management, not only because of its precise results, but also because of its applicability to many problems of varying complexity.

The calculations needed in linear programming are very simple but for more realistic problems they have to be performed so many times that it is very tedious to do them by hand or desk calculator. However, all calculations can be performed on a computer which can handle problems of a size which could not be solved otherwise.

Essentially, linear programming provides a means of selecting from a set of variables, according to cost, contribution or the like, in order to most effectively achieve a certain goal or objective. In applying linear programming to a problem, it is necessary to state the relationship between the associated variable in a set of linear equations. Therefore, the general linear programming formulation model can be shown as follows:

$$\text{Max.} \qquad Z = \sum_{j-1}^{n} C_j X_j$$

$$\text{Subject to} \qquad \sum_{j-1}^{n} a_{ij} X_j \leq b_i \quad \text{for } i = 1,2,\ldots m$$

$$\text{With} \qquad X_j \geq 0$$

Additionally, it should be emphasized that the linear programming model presented above can have other forms. Usually, it is assumed that the $b_i \geq 0$, but in some instances it may be desirable to allow $b_i \leq 0$, for some i. Although the problem presented above was formulated as a profit maximization, it creates no new complications to minimize the objective function Z. Furthermore, the constraints need not be of the form, ' less than or equal to' (≤), but instead can be of the form, 'greater than or equal to' (≥), or they can be strict ' equalities' (=).

Problem Identification

Tainan-Paints Incorporated, manufactures paints for both industrial uses and home painting in Taiwan. There are a large number of different shades of color and quality. There are two product groups, industrial paints and house paints. One unit of both paints is composed of ten gallons which is the minimum order size. The best sales season is spring and early summer. It is now the middle of April and the planning of operations for May is in process. The marketing management estimates that the firm can sell during the month of May, at most 3,600 units of industrial paints and 2,000 units of house paints. The sales price, f.o.b. at the factory, is $ 450 per unit for industrial paints. The normal terms of payment call for a 50 per cent payment on delivery and the remainder during the following month. The sales price of house paints is somewhat higher, $ 600 per unit, but on other hand, the financing requirements for this product are much heavier for it is sold on one month credit.

On the basis of the operations in April, the production manager estimates that the ending inventory for the month will be 600 units for industrial paints (INVENI). The peak sales season is in May and the stocks may be reduced during the month. The ending inventory for May is, therefore, only 360 units. The ending inventory for house paints (INVENH) for the month of April is 200 units. Since the season for house paints is June, the management requires the May ending balance to be at least 400 units. Work in process is assumed to remain at a constant level during the planning period.

The standard use of raw material is 2 units for each unit of industrial paint and 3 units for a unit of house paint. The beginning balance of raw material is 400 units. The raw material inventory is at an abnormally low level. For this reason, the management wants to increase it by the end of May. The required ending balance is 750 units. The standard price of raw material is $ 140 per unit. The terms of payment are 75 per cent down and the rest one month later.

Production is carried out in the mixing and packing departments. Both products go through both departments. The mixing of raw materials requires 2.5 standard labor hours for industrial paints and 3 standard labor hours for house paint per unit of product. The packing operation standard time is 0.2 hours per unit of product for both product groups. The total mixing capacity is 13,000 hours (PRODCAM) and the total packing capacity (PRODCAP) is 1,200 hours in May.

TABLE 1

CLASSIFICATION OF FIXED COST BUDGET

Administrative Expenses:			
Insurance	20,000		
Miscellaneous general expenses	60,000		
Total administrative expenses		$ 80,000	
Sales Expenses:			
Depreciation-store equipment	300		
Depreciation-delivery equipment	700		
Depreciation-building	500		
Advertising	180,000		
Store supplies	60,000		
Miscellaneous	20,000		
Total sales expenses		$ 267,500	
Production Expenses:			
Depreciation-equipment	25,000		
Depreciation-factory building	5,000		
Powerhouse expense	70,000		
Repairs and maintenance	50,000		
Insurance	10,000		
Miscellaneous expenses	30,000		
Total production expenses		$ 190,000	
Total fixed overhead			$ 537,500

Direct wages and associated variable overhead costs are $ 12 per standard labor hour in the mixing department and $ 8 per standard labor hour in the packing department. The firm uses a variable standard cost system where only the variable costs are considered to be product costs. The controller has prepared a variable overhead cost budget for May . Fixed costs are subdivided into depreciation and other fixed costs. About 80 per cent of other fixed cost must be paid in cash during the planning period. The remainder is paid in the following month. The classification of fixed cost is shown in Table 1.

The beginning balance as of the first of May is given below. The accounts receivable balance is the result of sales in April and it can all be collected during May.

Beginning Balance Sheet

Cash	$ 280,000	Accounts Payable	
Accounts Receivable	1,875,000	Raw Material	$ 1,020,000
Finished Product		Wages	18,650
Industrial Paints	186,960	Fixed Expenses	96,000
House Paints	91,520	Income Tax	150,000
Work in Process	117,100	Bank Loans	1,000,000
Raw Material	56,000	Share Capital	1,200,000
Fixed Asset	1,260,000	Undistributed Profit	381,930
	$ 3,866,580		$ 3,866,580

Raw materials have been purchased in April in accordance with normal payment terms. No changes are expected in the work force. This implies that the balance of accrued wages remains at a constant level over the period. Accrued fixed expences and income taxes shown in the beginning balance must be paid in May.

Existing bank loans must be amortized to the total of $ 400,000 during May. If the firm needs additional financing in May, it may take a new loan. The loan can be any amount up to the limit of $ 600,000. Existing loans and the new loan carry an interest of 12 per cent annually. New funds can be obtained from 30 day notes with interest payable in advance. In the projected income statement, we will observe only the interest for the first month. There are no dividend payments during May. The same is true for new capital expenditures. The cash balance at the end of April is higher than usual. The treasurer estimates that a closing balance of $ 150,000 covers the minimum safety requirements at the end of May.

Data Collection

There are two product groups, industrial paints and house paints. The marketing management has analyzed the demand conditions and has come to the conclusion that the upper limits of the sales of the two products are as shown in Table 2. The table shows also the estimated sales price. The two products are not substitutes.

TABLE 2

DEMAND OF THE PRODUCTS

Product	Selling Price, $/Unit	Selling Possibilities Units
I	$ 450	3,600
II	$ 600	2,000

Table 3 delineates the required plant capacity for each product and also shows available capacity.

TABLE 3

REQUIRED PRODUCTS CAPACITY AND TOTAL AVAILABLE CAPACITY

Department	Required Capacity h/unit Product I	Product H	Available Capacity Hours
Mixing	2.5	3.0	13,000
Packing	0.2	0.2	1,200

TABLE 4

ENDING INVENTORY AND BEGINNING INVENTORY

Product	Production	Desired Ending Inventory Units	Beginning Inventory Units
I	PI	360	600
H	PH	400	200

Table 4 presents the inventory budget of finished products. The required ending inventory must be based on the subjective estimates of management.

Table 5 shows the beginning balances and desired ending balances of raw materials and the standard costs of raw materials. These costs will be employed to develop the purchasing and cash budgets as well as the projected income statement. It is clear that the existence of a standard cost system is a factor which greatly simplifies the data collection work of budget models.

TABLE 5

USAGE AND RAW MATERIAL INVENTORIES

RAW MATERIAL	USAGE, UNIT/ UNIT OF PRODUCT	TOTAL AMOUNT USED	DESIRED ENDING BALANCE	BEGINNING BALANCE	PRICE $/UNIT
R	2	2PI	200	375	$ 140
	3	3PH	200	375	$ 140

TABLE 6

THE VARIABLE COSTS OF PRODUCTS

Cost Item	Product I	Product H
Direct Materials		
2 units of material R a$140	280.0	
3 units of material R a$140		420.0
Direct Wages and Variable Costs		
2.5 hours in mixing a$12	30.0	
0.2 hours in packing a$8	1.6	
3.0 hours in mixing a$12		36.0
0.2 hours in packing a$8		1.6
TOTAL VARIABLE COSTS, $/UNIT	311.6	457.6

Table 6 presents the cost structure of the two products. This firm uses a variable standard cost system where only the variable costs are considered to be product costs. The costs for direct material must be consistent with the raw material usage. The variable costs and direct wages of the firm are also shown in Table 6.

From the beginning balance sheet, we know that the beginning balance of cash and accounts receivable are adequate for the financing of operations. The dollar figures for inventory balances must again be consistent with the physical quantities presented in earlier tables. The beginning balances of raw materials in Table 5 have been multiplied by the standard prices of raw materials. Similarly, the beginning balances of finished products in Table 4 have been multiplied by the standard costs of Table 6. We know that work in process remains at the level of the beginning balance during the period of the problem and therefore, we show only a dollar figure. This allows us to simplify the model, in that we can establish the relationship between the final products and the raw materials directly without having to set up another set of relationships between work in process and the final products.

The first item on the liabilities side of the balance sheet, the accounts payable balance resulting from raw material purchases, must be paid during the period. Accrued wages in the amount of $ 18,650 must also be paid. However, the work force is kept on an even level and accrued salaries and wages will therefore, also remain constant from period to period. For this reason the beginning balance of

$ 18,650 also represents the ending balance. Accrued income tax must all be paid in the planning period. The existing bank loan will require two payments during the period, interest in the amount of $ 10,000, and the amortization of $ 400,000. These payments must be made regardless of other plans. The shareholders' capital remains unchanged during the period. There are no dividend payments during May. The same is true for new capital expenditures.

The fixed cost shown in Table 7 are subdivided into depreciation and other fixed costs. This table is derived from Table 1.

TABLE 7

FIXED COST BUDGETS

Fixed Selling Expense		
Depreciation	-	
Other	80,000	$ 80,000
Fixed Administration Expense		
Depreciation	1,500	
Other	260,000	$267,500
Fixed Manufacturing Expense		
Depreciation	30,000	
Other	160,000	$190,000

Table 7 also shows the fixed selling, administration and manufacturing expenses. About 80 per cent of the other fixed cost must be paid in cash during the planning period. The remainder is paid in the following month.

Apart from the data presented in the previous tables, we need additional information for the development of the model. The beginning balance of accounts receivable will be collected during the period. According to the prevailing terms of payment, 50 per cent of sales of products are collected during the planning period and the remainder during the following month. The beginning balance of accounts payable for raw material is paid in full during the period. The purchase of raw materials, ZR, involves a payment of 75 per cent during the same period and the rest one month later. The minimum safety requirement is estimated to be $ 150,000 by the treasurer. New loans can be taken in any desired amount which must not exceed the limit of $ 600,000. The note is secured by the firm's accounts receivable. The loan interest rate is 12 per cent annually and is payable in advance. Finally it is assumed that no capital expenditures are made during the planning period.

Data Analysis and Model Formulation

The first step in the procedure is formulation of a budget model on the basis of the preceding data. Since this company uses a variable standard cost system, fixed overhead is excluded from the cost of products and is regarded as an expense immediately. The firm's objective is to maximize the difference between the sales revenue and various costs. In this problem, we must consider variable selling, manufacturing and financing costs. The objective function can be presented as follows:

<u>Objective Function</u>

(1) Max. Z =

$$(450 - 311.6)YI + (600 - 457.6) - R$$

The objective, Z, now stands for the difference between the sales revenue and all variable costs, i.e., the variable, YI, represents the sales of industrial paints, YH, the sales of house paints, and, R, the interest expense for the period. The sales price of the industrial product is $ 450 per unit. The manufacturing costs are $ 311.60.

Maximum Sales Constraints

The objective is to be achieved subject to various constraints. First of all, we must observe the estimated maximum demand for both products which was presented in Table 2:

$$(2) \quad YI \qquad \qquad \leq 3600$$
$$YH \leq 2000$$

The constraints require that sales of both products must be less than or equal to the estimated maximum demand of the respective product.

Finished Goods Inventory Constraints

The sales and production of each product must be related via constraints which take the beginning and ending balances of finished products into account. We let the variables, PI and PH represent the production of the two products. Observing the data presented in Table 5, we can formulate the constraints:

$$(3) \quad 600 + PI \leq YI + 360$$

$$200 + PH \leq YH + 400$$

The first constraint states that the beginning balance of industrial paints, 600 units, plus its production, PI, must be greater than or equal to the sales, YI, and required ending balance, 360 units. The second constraint is interpreted in an analogous manner.

Maximum Capacity Constraints

The constraint relating the capacity required in the production to available capacity is formulated on the basis of Table 3:

$$(4) \quad 2.5\ PI + 3\ PH \leq 13000$$

$$0.2\ PI + 0.2\ PH \leq 1200$$

Raw Materials Inventory Constraints

The beginning balance of raw material, R, plus the amount purchased during the period , must be greater than or equal to the amount used in production and the required ending balance:

(5) $400 + ZR \geq 2\ PI + 3\ PH + 750$

The constraint is interpreted that the beginning balance of raw material, 400 units, plus the purchase for the period, ZR, is greater than or equal to 2 PI, plus 3 PH, plus the required ending balance of 750 units.

Cash Constraints

TABLE 8

CASH WORKSHEET

Available funds			
Beginning cash balance		$ 280,000	
Accounts receivable balance		1,875,000	$ 2,155,000
Less fixed cash expenditures			
Raw materials		$ 1,020,000	
Fixed expense		96,000	
Accrued income tax		150,000	
Existing loans			
Amortization	$ 400,000		
Interest	10,000	410,000	
Fixed costs			
Sales	$ 64,000		
Administration	208,000		
Manufacturing	128,000	400,000	2,076,000
Excess of receipts over expenditures			$ 79,000
Minimum ending cash balance			150,000
Net cash expenditure			$ 71,000

The cash constraints require that the beginning cash balance plus cash receipts from various sources must be greater than or equal to various cash expenditures plus the required minimum ending balance. The sum of the beginning cash balance and the accounts receivable balance is available for the financing of operations. From this, we must deduct the payment for accounts payable, accrued income taxes, amortization of existing bank loans, as well as interest on the outstanding balance, and the fixed expenses payable in cash, as shown in Table 8.

From the Cash Worksheet, (Table 8), we know that the excess of receipts over expenditures is $ 79,000. The amount of new loans taken is given by the variable, V. The policy of this company is to maintain the desired cash amount of $ 150,000, thus at end of May, we will see cash balances are $ 150,000. In this application, there are two sources of variable cash receipts, i.e., sales and the proceeds from new loans. The variable cash expenditures are caused by raw material purchases and direct wages and variable overhead of manufacturing. We get the following constraint:

$$(6) \quad (0.5)\,(450)YI + 79{,}000 + V \geq 150{,}00 + 0.75\,(140)ZR + 31.6\,PI + 37.6\,PH + (0.01)V$$

Fifty per cent of the YI sales revenue is collected in the same period in which the sales take place. The variable, YI, represents the number of units sold and the sales price is \$ 450. Therefore, the sales revenue of industrial paints is 450 YI, and the cash collections are (0.5) 450 YI. No cash collections are taken on house paints, since it is sold on one period credit. The variable, ZR, represents the unit of raw material, R, purchased. 75 per cent of these purchases must be paid during the same period. It follows that (0.75) 140 ZR represents the cash expenditures resulting from the purchases of raw material, ZR. The direct wages and variable manufacturing costs of the products are \$ 31.60 and \$ 37.60, respectively. The total amount of cash payments resulting from the production is therefore, 31.6 PI - 37.6 PH. The interest expense on new loans is 0.01 V, since the loan will only be outstanding for one month and interest is payable in advance.

The firm can improve its cash position by taking new loans if this is desirable. However, the creditors have stipulated a limit of \$ 600,000. This is taken into account by the following constraint:

$$(7) \quad V \qquad \leq 600{,}000$$

Interest Expenses Constraint

Finally, we need a constraint to compute the interest expenses which were deducted from the contribution in the objective function:

(8) $R = 0.01\ V + 10{,}000$

This equation implies that new loans and existing loans require the payment of interest of 1 per cent per period. We have formulated the constraint so that the variable, R, representes the sum of the interest of new and existing loans ($ 10,000 = $ 1,000,000 $\times$ 0.01).

All variables must be non-negative:

(9) $YI,\ YH,\ PI,\ PH,\ ZR,\ V,\ R \geq 0$

Linear Program Presentation Model

This problem has ten constraints in addition to the non-negativity constraint to maximize (1) subject to the constraints (2) to (9). Rearranging the constraints, we get the following model:

$$\text{Maximize } Z = 138.4\,YI - 142.4\,YH - R$$

Subject to

$$
\begin{array}{rcl}
YI & \leq & 3,600 \\
YH & \leq & 2,000 \\
YI - PI & \leq & 240 \\
-YH + PH & \geq & 200 \\
2.5PI + 3.0PH & \leq & 13,000 \\
0.2PI + 0.2PH & \leq & 1,200 \\
-2.0PI - 3.0PH + ZR & \geq & 350 \\
225YI - 31.6PI - 37.6PH - 105ZR + 0.99V & \geq & 71,000 \\
V & \leq & 600,000 \\
-0.01V + R & = & 10,000
\end{array}
$$

and

$$YI,\ YH,\ PI,\ PH,\ ZR,\ V,\ R \geq 0$$

Where

YI = sales of industrial paints

YH = sales of house paints

PI = production of industrial paints

PH = production of house paints

ZR = purchases of raw material

V = amount of new loans

R = interest of new loans and existing loans

TABLE 9

FOR KEYPUNCHING OF THE INPUT CARDS

	YI	YH	PI	PH	ZR	V	R	RHS
CONTRIB	138.4	142.4					-1	
SALESI	1							3,600
SALESH		1						2,000
INVENI	1		-1					240
PRODCAM			2.5	3				13,000
PRODCAP			0.2	0.2				1,200
LOAN						1		600,000
INVENH		-1		1				200
RAW			-2	-3	1			350
CASH	225		-31.6	-37.6	-105	0.99		71,000
INTEREST						-0.01	1	10,000

We can solve this problem using the simplex algorithm by hand or computer. We also can use the IBM computerized package (MPSX) to obtain a solution. The first step is to convert the constraint set to a set of strict equalities. When the constraint is ' less than or equal to ' inequality, it is necessary to add a slack variable, (S_j), and rewrite it as an equality. When the constraint is an equality, it is not possible to add a slack variable. However, it is handled by use of an artifical variable (A_j). Unlike a slack or surplus variable, an artifical variable has no physical meaning. It is basically a dummy variable that is employed to allow the simple and rapid generation of an initial basic solution. When the constraint is ' greater than or equal to ' inequality, it is handled by using a surplus variable, (S_j), and again we introduce an artifical variable, (A_j), to rewrite it as the equalty.

Now we can construct an initial simplex, as shown in Table 10.

INITIAL TABLEAU

CB	BASIS	138.400 X 1	142.400 X 2	0.000 X 3	0.000 X 4	0.000 X 5	0.000 X 6	-1.000 X 7
0.000	S 1	1.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	S 2	0.000	1.000	0.000	0.000	0.000	0.000	0.000
0.000	S 3	1.000	0.000	-1.000	0.000	0.000	0.000	0.000
0.000	S 4	0.000	0.000	2.500	3.000	0.000	0.000	0.000
0.000	S 5	0.000	0.000	0.200	0.200	0.000	0.000	0.000
0.000	S 6	0.000	0.000	0.000	0.000	0.000	1.000	0.000
-10000.000	A 1	0.000	-1.000	0.000	1.000	0.000	0.000	0.000
-10000.000	A 2	0.000	0.000	-2.000	-3.000	1.000	0.000	0.000
-10000.000	A 3	225.000	0.000	-31.620	-27.000	-105.000	0.990	0.000
-10000.000	A 4	0.000	0.000	0.000	0.000	0.000	-0.010	1.000
	ZJ	-2250000.000	10000.000	336000.000	396000.000	1040000.000	-9800.000	-10000.000
	CJ-ZJ	2250138.000	-9857.598	-336000.000	-396000.000	-1040000.000	9800.000	9999.000

CB	BASIS	0.000 S 1	0.000 S 2	0.000 S 3	0.000 S 4	0.000 S 5	0.000 S 6	0.000 S 7
0.000	S 1	1.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	S 2	0.000	1.000	0.000	0.000	0.000	0.000	0.000
0.000	S 3	0.000	0.000	1.000	0.000	0.000	0.000	0.000
0.000	S 4	0.000	0.000	0.000	1.000	0.000	0.000	0.000
0.000	S 5	0.000	0.000	0.000	0.000	1.000	0.000	0.000
0.000	S 6	0.000	0.000	0.000	0.000	0.000	1.000	0.000
-10000.000	A 1	0.000	0.000	0.000	0.000	0.000	0.000	-1.000
-10000.000	A 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-10000.000	A 3	0.000	0.000	0.000	0.000	0.000	0.000	0.000
-10000.000	A 4	0.000	0.000	0.000	0.000	0.000	0.000	0.000
	ZJ	0.000	0.000	0.000	0.000	0.000	0.000	10000.000
	CJ-ZJ	0.000	0.000	0.000	0.000	0.000	0.000	-10000.000

CB	BASIS	0.000 S 8	0.000 S 9	-10000.000 A 1	-10000.000 A 2	-10000.000 A 3	-10000.000 A 4	SOLN 1
0.000	S 1	0.000	0.000	0.000	0.000	0.000	0.000	3600.000
0.000	S 2	0.000	0.000	0.000	0.000	0.000	0.000	2000.000
0.000	S 3	0.000	0.000	0.000	0.000	0.000	0.000	240.000
0.000	S 4	0.000	0.000	0.000	0.000	0.000	0.000	13000.000
0.000	S 5	0.000	0.000	0.000	0.000	0.000	0.000	1200.000
0.000	S 6	0.000	0.000	0.000	0.000	0.000	0.000	600000.000
-10000.000	A 1	0.000	0.000	1.000	0.000	0.000	0.000	200.000
-10000.000	A 2	-1.000	0.000	0.000	1.000	0.000	0.000	350.000
-10000.000	A 3	0.000	-1.000	0.000	0.000	1.000	0.000	71000.000
-10000.000	A 4	0.000	0.000	0.000	0.000	0.000	1.000	10000.000
	ZJ	10000.000	10000.000	-10000.000	-10000.000	-10000.000	-10000.000	************
	CJ-ZJ	-10000.000	-10000.000	0.000	0.000	0.000	0.000	

CHAPTER III

PROBLEM SOLUTION AND ANALYSIS

Analysis of Computer Solution

The optimal solution of this application is presented in Appendix 1. From the computer printouts, we can observe that the program added a slack variable where appropriate and that the slack variables are now in the optimal solution. The value of slack variables is the difference between the following figures:

	ACTIVITY	UPPER LIMIT
SALESH	1,174	2,000
PRODCAM	12,522	13,000
PRODCAP	947	1,200

Unutilized sales of house paints are the difference between the upper limit on demand, 2,000 units, and actual planned sales, 1,174 units, or 826 units. The upper limit of total mixing capacity and total packing capacity do not effectively bind the optimal solution. Consequently, the slack variable associated with these two constraints is also at a positive level. By deducting the figure in the ACTIVITY column on the PRODCAM and PRODCAP row from the figure in the UPPER LIMIT column on the same row, we can see that unutilized mixing capacity and packing lines exist in the optimal solution. We can now list the optimal program:

Sales

YI = 3,600 units

YH = 1,174 units

New Loans

V = $ 600,00

Interest

R = $ 16,000

Production

PI = 3,360 units

PH = 1,374 units

Raw Materials

ZR = 11,192 units

Sensitivity Analysis

From the MPSX printouts in Appendix 1, we obtain the following list:

	LOWER LIMIT	UPPER LIMIT
SALESI	NONE	3,600
SALESH	NONE	2,000
INVENI	NONE	240
PRODCAM	NONE	13,000
PRODCAP	NONE	1,200
LOAN	NONE	600,000
INVENH	200	NONE
RAW	350	NONE
CASH	71,000	NONE
INTEREST	10,000	10,000

Algebraically, LOWER LIMIT means the lowest value the activity can attain and still be feasible and UPPER LIMIT means the highest value the activity can attain and still be feasible. For example, the value of LOAN in the following figures:

	LOWER LIMIT	UPPER LIMIT
LOAN	NONE	600,000

it indicates that the new loan can be taken between 0 and 600,000 and the solution will remain feasible. It is termed a feasible solution for the linear programming model if any set of variables (ie, YI, YH, PI, ...) satisfies the constraint set and the non-negativity restrictions. Obviously, there are infinite solutions within the feasible solution space.

In this problem, we are seeking to allocate quantities of resources to maximize profit. Observe in the optimal tableau in Appendix 2, that the $C_j - Z_j$ values for $C_1 - Z_1 = 0$ and $C_2 - Z_2 = 0$. These values are the marginal values, or opportunity costs, associated with the product PI and PH. The fact that the opportunity costs are zero for both real products, indicate that we are producing as much of each one as is possible, given our resource constraints. Observe in the optimal tableau in Appendix 2, that the $C_j - Z_j$ values for S_1, S_3, S_6, S_7, S_8, S_9 are 131.69, 97.59, 0.389, 142.4, 42.4, 0.4, respectively. These values are the marginal values, or opportunity costs, of YI, INVENI, LOAN, INVENH, RAW and CASH, respectively. For example, we can say that the value of these marginal values indicate that the contribution value will decrease by $ 131.69 if the availability of YI sales is reduced by one unit from its present 3,600 units. The marginal value of a resource can also be thought of as the change that occurs in the objective function as a result of utilizing an incremental unit of that resource.

Since the main emphasis of this paper is the application of linear programming to the budgeting process, we now turn to this topic.

Generation of Budgets

Taking the computer output, the model, and the underlying data, we can now formulate the budgets for the various functions of the firm as well as the projected financial statements. All of the firm's budgets will be compatible since they are derived from the optimal solution.

Sales, Production and Purchase Budgets

The sales budget can be developed by taking the values of YI and YH in the optimal solution.

TABLE 11

SALES BUDGET

	Industrial Paints			Home Paints		
	Price	Units	$	Price	Units	$
Sales	$450.00	3,600	1,620,000	$600.00	1,174	704,400
Cost of Sales	$311.60	3,600	1,121,760	$457.60	1,174	537,222
Contribution			498,240			167,178

The production and inventory budgets can be derived by taking the optimal values of the variables, YI, YH, PI, and PH. We can also develop the budget for raw material purchases on the basis of the production variables, PI and PH, and variable for raw material purchases, ZR.

TABLE 12

PRODUCTION AND INVENTORY BUDGET IN UNITS

	Industrial Paints	Home Paints
Desired Ending Inventory	360	400
Plus: Sales	YI = 3,600	YH = 1,174
Total Requirements	3,960	1,574
Less: Beginning Inventory	600	200
Required Production	PI = 3,360	PH = 1,374

TABLE 13

BUDGETED RAW MATERIAL PURCHASE IN UNITS

	Raw Materials
Desired Ending Inventory	750
Plus: Production Requirements	2 PI = 6,720
	3 PH = 4,122
Total Requirements	11,592
Less: Beginning Balance	400
Required Purchase	ZR = 11,192

Cash Budget

A cash budget can be constructed with the help of terms that appear in constraint 6. We know that the ending balance of cash is the required minimum amount of $ 150,000, so new loans are included in the optimal solution. Since the loan taken during the period involves interest expenses, which reduce the value of the objective function, the solution will include new loans only to the minimum possible amount. Excessive cash would appear in the model only in the case where no new loans are needed. We can set

TABLE 14

CASH BUDGET

Beginning Cash			$280,000
Cash Receipts			
Fixed			
Accounts receivable balance		1,875,000	
Variables			
Sales			
I: (0.5)(450)YI = (0.5)(450)(3,600)	810,000		
H: (0)(600)YH = (0)(600)(1,174)	0	810,000	
New loans		600,000	3,285,000
Funds Available			$3,565,000
Cash Expenditures			
Fixed			
Accounts payable			
Raw materials	1,020,000		
Fixed expense	96,000		
Income tax	150,000	1,266,000	
Existing loans			
Amortization	400,000		
Interest	16,000	416,000	
Fixed expense (From Table 7)		400,000	
Variable			
Production			
I: (31.6)PI = (31.6)(3,360)	106,176		
H: (37.6)PH = (37.6)(1,374)	51,662		
Purchase			
(0.75)(140)ZR = (0.75)(140)(11,192)	1,175,160	1,332,998	3,414,998
Ending Cash Balance			$150,002

up a cash budget starting from the beginning cash balance, adding to it the various cash receipts and deducting from it the various cash expenditures on Table 14.

Projected Income Statement

TABLE 15

PROJECTED INCOME STATEMENT

Sales		$ 2,324,400
Less: Standard Cost of Sales		1,658,982
Contribution		665,418
Less: Interest Expense		R= 16,000
The value of Objective Function		649,418
Less: Fixed Costs(From Table 7)		
Sales	80,000	
Administration	267,500	
Manufacturing	190,000	537,500
Profit Before Tax		111,918
Less: Income Tax(50%)		55,959
Net Operating Profit		$ 55,959

The projected income statement can be drawn up by beginning with the contribution of the sales budget and deducting from it interest expenses and the fixed cost budgets. The fixed costs are given in Table 7. The optimal value of variable R gives the total interest expenses for both the existing and new loans.

The projected income statement is computed assuming that the federal income tax is 50 per cent and that the taxes accrued in this period are paid in the next period. It follows that we must include the accrued income taxes in the liabilities of the projected balance sheet. We know that the firm may take a new loan. This loan carries an interest of 12 per cent annually with interest payable in advance. Assume that the new loan will be taken for only one month. The optimal value of the objective function can be read from computer outputs and is the difference between the total contribution and the interest statement in Table 15.

Projected Balance Sheet

The beginning balance sheet, optimal solution, and the projected income statement are utilized to develop the projected balance sheet which is given in Table 16. The ending cash balance of the cash budget also gives the cash

TABLE 16

PROJECTED BALANCE SHEET

ASSETS

Current Assets			
Cash (From Table 14)		150,002	
Account receivable			
I: (0.5)(3600)(450)	810,000		
H: (600)(1174)	704,400	1,514,400	
Inventory			
Raw materials		105,000	
Work in process		117,100	
Finished products			
I: (311.6)(360)	112,176		
H: (457.6)(400)	183,040	295,216	2,181,718
Fixed Assets			
Beginning balance		1,260,000	
Depreciation		37,500	1,222,500
			$ 3,404,218

LIABILITIES AND STOCKHOLDERS' EQUITY

Accounts Payable			
Raw material			
(140)(0.25)(11192)		391,720	
Accrued wages		18,650	
Accrued income tax(From Table 15)		55,959	
Accrued fixed expense		100,000	566,329
(500000 - 400000)			
Bank Loans			
Beginning balance	1,000,000		
Amortization	400,000	600,000	
New Loans		600,000	1,200,000
Share Capital			1,200,000
Undistributed Profit			
Beginning balance		381,930	
Profit for the period		55,959	437,889
			$ 3,404,218

balance of the balance sheet. The accounts receivable balance has been developed by taking the value of the variables YI and YH and multiplying these by the fraction of the sales prices that remain uncollected at the end of period.

The raw material ending balance is developed by multiplying the unit ending balances of Table 13 by their respective standard costs. The ending balance of work in process is the same as the beginning balance, since no change was assumed during the period. The ending balance of finished products is the physical inventory of Table 12 multiplied by the respective standard manufacturing costs. Fixed assets are reduced by depreciation.

Accounts payable balances are developed by multiplying the raw material purchases by that fraction of the purchase price which is not paid during the period. Accrued salaries and wages are assumed to remain at the level of the beginning balance. Accrued interest is due to the new loans. It is the value of the variable, R, in the optimal solution less $ 100,000 which refers to the interest payments included in the fixed cash expenditures. The accrued income tax was calculated in the projected income statement. The accrued fixed expense is the remainder of other fixed costs which will be paid in the following month. The end of period loan balance is computed by taking the beginning loan balance and subtracting the loan amortization payment from it and then adding the new loans taken during May. The value of variable, V, is $ 600,000 in the optimal solution. Equity is increased during May by the net operating profit, $ 55,959.

CHAPTER IV

SUMMARY AND CONCLUSION

In most cases, the master budget is the best practical approximation to a formal model of the total organization: it's objectives, it's inputs, and it's output. If the master budget serves as a 'total decision model' for top management, then decisions about strategies for the forthcoming period may be formulated and altered during the budgetary process. Traditionally, this has been a step-by-step process whereby tentative plans are gradually revised (9). This makes the finding of an optimal master plan very difficult, because the time required to assemble the budget is so great. However it is now feasible to take many of the elements of the conventional budgeting process and convert them into a functional planning tool through the technique of linear programming. Management can react quickly to events and to revisions in predictions of various aspects of operations by linear programming. This application makes it possible to optimize the firm's profit objective under constraints on sales, production capacity, purchases, financing, utilization of personnel and physical facilities etc.

In addition to the time saving, Murphy (19) thinks that linear programming also provides the following benefits:

1. Shortening the planning cycle time. By removing the computational effort associated with budgeting, it is frequently possible to delay the start of the budgeting process until all the inputs are available. As most budget analysts are well aware, it is difficult enough to project sales for next month, much less give a monthly sales estimate for fiscal 1982 during June of 1981. Shortening the planning cycle time can, therefore, improve the quality of the basic sales forecasts because of more reliable data.
2. Continuous forecasting. By removing much of the tedium associated with the budgeting process, it becomes feasible to continuously update the forecast of operations on a month-by-month basis throughout the fiscal year and, in some instances, extend the planning horizon of budget preparation to a second fiscal year.

In the future, much of the interaction and interdependence of decisions will be formalized in mathematical models-'total models' that are sometimes called financial planning models (14). These models are mathematical statements of relationships in the organization among all of the operating and financial activities,and of other major internal and external factors that may affect decisions. Many models are constructed and working. They are used for budgeting, for revising budgets with little incremental effort, and for comparing a variety of decision alternatives as they affect the entire firm. The models speed the budgetary process because the sensitivity of income and cash flows to various decisions can be tested promptly via a simulation (9). Moreover, mathematical probabilities can be incorporated in these models, so that uncertainty can be dealt with explicitly rather than informally.

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APPENDIX 1

MPSX PRINTOUT

SOLUTION (OPTIMAL)

TIME = 0.35 MINS. ITERATION NUMBER = 8

...NAME...	...ACTIVITY...	DEFINED AS
FUNCTIONAL RESTRAINTS	640418.24617	CONTRIB RHSD

SECTION 1 - ROWS

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	.DUAL ACTIVITY
1	CONTRIB	BS	649418.24617	649418.24617-	NONE	NONE	1.00000
2	SALES1	UL	3600.00000	.	NONE	3600.00000	131.69597-
3	SALES1	BS	1174.00454	825.99546	NONE	2000.00000	.
4	INVEN1	UL	240.00000	.	NONE	240.00000	97.57187-
5	PRODCAM	BS	12522.01361	477.98639	NONE	13000.00000	.
6	PROJCAP	BS	946.80031	253.19969	NONE	1200.00000	.
7	LOAN	UL	600000.00000	.	NONE	600000.00000	.38982-
8	INVEN1	LL	200.00000	.	200.00000	NONE	142.40000
9	RAW	LL	350.00000	.	350.00000	NONE	42.40499
10	CASH	LL	71000.00000	.	71000.00000	NONE	.40386
11	INTEREST	EQ	10000.00000	.	10000.00000	10000.00000	1.00000

SECTION 2 - COLUMNS

NUMBER	.COLUMNS	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT.	..UPPER LIMIT.	.REDUCED COST.
12	YI	BS	3600.00000	138.40000	.	NONE	.
13	YH	BS	1174.00454	142.40000	.	NONE	.
14	PI	BS	2360.00000	.	.	NONE	.
15	PH	BS	1374.00454	.	.	NONE	.
16	ZR	BS	11192.01361	.	.	NONE	.
17	V	BS	63000.00000	.	.	NONE	.
18	R	BS	16330.00000	1.00000-	.	NONE	.

SECTION 1 - ROWS AT LIMIT LEVEL

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT. ..UPPER LIMIT.	LOWER ACTIVITY UPPER ACTIVITY	...UNIT COST.. ...UNIT COST..	..LOWER COST.. ..UPPER COST..	LIMITING PROCESS.
2	SALES1	UL	3600.00000	.	NONE 3600.00000	240.00000 3802.64276	131.69592- 131.69592		FI PRODCAM
4	INVEN1	UL	240.00000	.	NONE 240.00000	835.54541- 1445.41828	97.57184- 97.57184		PRODCAM SALESH
7	LOAN	UL	600000.00000	.	NONE 600000.00000	181865.00000 656746.78125	.38982- .38982		YH PRODCAM
8	INVENH	LL	200.00000	.	200.00000 NONE	625.99536- 1374.00391	142.39999 142.39999-		SALESH YH
9	RAW	LL	350.00000	.	350.00000 NONE	185.04120- 4292.41602	42.40499 42.40499-		PRODCAM YH
10	CASH	LL	71000.00000	.	71000.00000 NONE	14820.68750 484553.75000	.40386 .40386-		PRODCAM YH
11	INTEREST	EQ	10000.00000	.	10000.00000 10000.00000	5999.99609- INFINITY	1.00000 1.00000-		R NONE

SECTION 3 - ROWS AT INTERMEDIATE LEVEL

NUMBER	...ROW..	AT	...ACTIVITY...	SLACK ACTIVITY	..LOWER LIMIT.	..UPPER LIMIT.	LOWER ACTIVITY	UPPER ACTIVITY	...UNIT COST..	...UNIT COST..	..LOWER COST..	..UPPER COST..	LIMITING	PROCESS.
3	SALESH	BS	1174.00456	825.99542	NONE	2000.00000	.00165	1332.18945	138.83838-	2797.34766-			LOAN	SALESI
5	PRODCAM	BS	12522.01367	477.98633	NONE	13000.00000	9000.00391	13283.46367	46.27946-	219.55225-			LOAN	INVENI
6	PRODCAP	BS	946.89096	253.10904	NONE	1200.00000	306.43811	1014.51819	691.01172-	1549.72241-			SALESI	INVENI

SECTION 4 - COLUMNS AT INTERMEDIATE LEVEL

NUMBER	.COLUMN.	AT	...ACTIVITY...	..INPUT COST..	..LOWER LIMIT. ..UPPER LIMIT.	LOWER ACTIVITY UPPER ACTIVITY	...UNIT COST.. ...UNIT COST..	..LOWER COST.. ..UPPER COST..	LIMITING PROCESS.
12	YI	BS	3599.99902	138.39990	. NONE	239.99902 3599.99902	131.69592- INFINITY-	6.70358 INFINITY	SALESI NONE
13	YII	BS	1174.00391	142.39990	. NONE	200.00000- 1332.13878	138.83838- 2797.34766-	3.56152 2939.74756	LOAN SALESI
14	FI	BS	1360.00000	.	. NONE	235.59502- 4435.54541	131.69592- 97.57184-	131.69592- 97.57184	SALESI INVENI
15	FII	BS	1274.00439	.	. NONE	200.00098 1332.18927	138.83838- 2797.34863-	138.83838- 2797.34863	LOAN SALESI
16	ZI	BS	11102.01172	.	. NONE	7670.00195 11612.41675	46.27946- 397.65955-	46.27946- 397.65955	LOAN FAW
17	V	BS	599999.75000	.	. NONE	181864.75000 599999.75000	.38982- INFINITY-	.38982- INFINITY	LOAN NONE
18	F	BS	15999.99609	1.00000-	. NONE	31818.64844 15999.99609	38.98184- INFINITY-	39.98184- INFINITY	LOAN NONE

APPENDIX 2

SIMPLEX PRINTOUT

BUDGET PROBLEM

```
SOLUTION NOT OPTIMAL, ENTER VAR. =   X 1   LEAVING VAR. =   S 3   PIVOT POINT =     1.000
SOLUTION NOT OPTIMAL, ENTER VAR. =   X 3   LEAVING VAR. =   A 3   PIVOT POINT =   193.400
SOLUTION NOT OPTIMAL, ENTER VAR. =   X 7   LEAVING VAR. =   A 4   PIVOT POINT =     1.000
SOLUTION NOT OPTIMAL, ENTER VAR. =   X 6   LEAVING VAR. =   X 3   PIVOT POINT =     0.005
SOLUTION NOT OPTIMAL, ENTER VAR. =   X 5   LEAVING VAR. =   A 2   PIVOT POINT =     1.000
SOLUTION NOT OPTIMAL, ENTER VAR. =   X 4   LEAVING VAR. =   A 1   PIVOT POINT =     1.000
SOLUTION NOT OPTIMAL, ENTER VAR. =   X 2   LEAVING VAR. =   S 6   PIVOT POINT =   356.162
SOLUTION NOT OPTIMAL, ENTER VAR. =   X 3   LEAVING VAR. =   S 1   PIVOT POINT =     1.000
```

		138.400	142.400	0.000	0.000	0.000	0.000	-1.000
CB	BASIS	X 1	X 2	X 3	X 4	X 5	X 6	X 7
0.000	X 3	0.000	0.000	1.000	0.000	0.000	0.000	0.000
0.000	S 2	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
138.400	X 1	1.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
0.000	S 4	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
0.000	S 5	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
142.400	X 2	-0.000	1.000	-0.000	-0.000	-0.000	-0.000	-0.000
0.000	X 4	-0.000	-0.000	-0.000	1.000	-0.000	-0.000	-0.000
0.000	X 5	-0.000	-0.000	-0.000	-0.000	1.000	-0.000	-0.000
0.000	X 6	-0.000	-0.000	-0.000	-0.000	-0.000	1.000	-0.000
-1.000	X 7	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	1.000
	ZJ	138.400	142.400	0.000	0.000	0.000	0.000	-1.000
	CJ-ZJ	0.000	0.000	0.000	0.000	0.000	0.000	0.000

		0.000	0.000	0.000	0.000	0.000	0.000	0.000
CB	BASIS	S 1	S 2	S 3	S 4	S 5	S 6	S 7
0.000	X 3	1.000	0.000	-1.000	0.000	0.000	-0.000	0.000
0.000	S 2	0.047	1.000	-0.615	-0.000	-0.000	-0.003	-1.000
138.400	X 1	1.000	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000
0.000	S 4	-2.359	-0.000	0.444	1.000	-0.000	-0.008	-0.000
0.000	S 5	-0.191	-0.000	0.063	-0.000	1.000	-0.001	-0.000
142.400	X 2	-0.047	-0.000	0.685	-0.000	-0.000	0.003	1.000
0.000	X 4	-0.047	-0.000	0.615	-0.000	-0.000	0.003	-0.000
0.000	X 5	1.359	-0.000	0.056	-0.000	-0.000	0.008	-0.000
0.000	X 6	0.000	-0.000	-0.000	-0.000	-0.000	1.000	-0.000
-1.000	X 7	-0.000	-0.000	-0.000	-0.000	-0.000	0.010	-0.000
	ZJ	131.696	0.000	97.572	0.000	0.000	0.390	142.400
	CJ-ZJ	-131.696	0.000	-97.572	0.000	0.000	-0.390	-142.400

		0.000	0.000	-10000.000	-10000.000	-10000.000	-10000.000	
CB	BASIS	S 8	S 9	A 1	A 2	A 3	A 4	SOLN 1

0.000	X 3	-0.000	0.000	0.000	0.000	-0.000	0.000	3359.999
0.000	S 2	-0.298	-0.003	1.000	0.298	0.003	-0.000	825.995
138.400	X 1	-0.000	-0.000	-0.000	-0.000	-0.000	-0.000	3599.999
0.000	S 4	-0.853	-0.009	-0.000	0.853	0.009	-0.000	477.988
0.000	S 5	-0.060	-0.001	-0.000	0.060	0.001	-0.000	253.199
142.400	X 2	0.298	0.003	-1.000	-0.298	-0.003	-0.000	1174.005
0.000	X 4	0.298	0.003	-0.000	-0.298	-0.003	-0.000	1374.005
0.000	X 5	-0.107	0.009	-0.000	0.107	-0.009	-0.000	11192.000
0.000	X 6	-0.000	-0.000	-0.000	0.000	0.000	-0.000	599999.800
-1.000	X 7	0.000	-0.000	-0.000	-0.000	0.000	1.000	15999.980
	ZJ	42.405	0.404	-142.400	-42.405	-0.404	-1.000	649418.100
	CJ-ZJ	-42.405	-0.404	-9957.598	-9957.594	-9999.594	-9999.000	

** SOLUTION IS OPTIMAL ***

OPTIMAL SOLUTION IS AS SHOWN BELOW. ALL OTHER VARIABLES ARE ZERO IN VALUE

```
X 3 =   3359.999
S 2 =    825.995
X 1 =   3599.999
S 4 =    477.988
S 5 =    253.199
X 2 =   1174.005
X 4 =   1374.005
X 5 =  11192.000
X 6 = 599999.800
X 7 =  15999.980
```

OBJECTIVE FUNCTION VALUE = 649418.100

DEFINITION OF VARIABLES FOLLOWS

VARIABLES X1 THRU X 7 ARE ORIGINAL DECISION VARIABLES.

VARIABLES S1 THRU S 6 ARE THE SLACK VARIABLES ASSIGNED TO THE LESS THAN OR EQUAL TO CONSTRAINTS, ASSIGNED IN THE ORDER THE CONSTRAINTS WERE READ.

VARIABLES S 7THRU S 9 ARE THE SURPLUS VARIABLES ASSIGNED TO THE GREATER THAN OR EQUAL TO CONSTRAINTS, ASSIGNED IN THE ORDER THE CONSTRAINTS WERE READ.

VARIABLES A1 THRU A 3 ARE THE ARTIFICIAL VARIABLES ASSIGNED TO THE GREATER THAN OR EQUAL TO CONSTRAINTS, ASSIGNED IN THE ORDER THE CONSTRAINTS WERE READ.

VARIABLES A 4 THRU A 4 ARE THE ARTIFICIAL VARIABLES ASSIGNED TO THE EQUAL TO CONSTRAINTS, ASSIGNED IN THE ORDER THE CONSTRAINTS WERE READ.

STATEMENTS EXECUTED= 10221

CORE USAGE OBJECT CODE= 10200 BYTES,ARRAY AREA= 65680 BYTES,TOTAL AREA AVAILABLE= 133120 BYTES

DIAGNOSTICS NUMBER OF ERRORS= 0, NUMBER OF WARNINGS= 0, NUMBER OF EXTENSIONS= 0

COMPILE TIME= 0.14 SEC,EXECUTION TIME= 0.23 SEC, 15.32.17 SUNDAY 15 MAR 81 WATFIV - MAR 1980 V2L0

VITA

YOULISH RU

Candidate for the Degree of

Master of Business Administration

Title of Study: AN APPLICATION OF BUSINESS BUDGETING: LINEAR PROGRAMMING APPROACH

Major Field: Business Administration

Biographical:

Personal Data: Born in Tainan, Taiwan, April 24, 1950, the son of Mr. and Mrs. Ku-Lin Ru.

Educational Data: Graduated from Tainan Second High School, Tainan, Taiwan, 1969; received a Bachelor of Science degree in Industrial Management in June 1974 from National Cheng Kung University and completed the requirements for the Master of Business Administration degree at Oklahoma State University, Stillwater, Oklahoma in May, 1981.

Professional Experience: Production Control, Taiwan Sharp Co., Ltd, 1976-1977; Marketing Analyst, Tong Yuan Electric&Machinery Co., Ltd, 1977-1979.