CHAPTER - 5
5. A SIMULTANEOUS INTEGRATED PLANNING MODEL FOR WORKING CAPITAL MANAGEMENT

Most of the decision models developed in marketing, production and finance assume that the decisions made outside of a particular functional area as either irrelevant or as given in the model being developed. The decisions made in these areas implicitly assume that decision making is independent and the decisions made in the other sectors are treated either as constraints or as input data to the functional area under consideration. However, there is a need to study interrelationships among short run production, finance and marketing decisions so as to optimize the overall decisions made in a firm. Stated in other words, there is a need for a model to study the nature and form of interrelationships between decisions in different functional areas to provide a global character to the decisions made.
In general, the integrated models were developed as extensions of aggregate planning models, considering more of production and marketing than finance function. The finance sector was usually represented in these models by incorporating the decision variables that are concerned with cash balances and short-term borrowings. The short-term financing decisions are concerned with the choice of sources of short-term funds from a set of financial alternatives. Therefore, a simultaneous planning model incorporating full range of decision variables from all the three functional areas is needed for working capital management. The model should aim at determining the optimum working capital requirement coupled with the determination of optimal source of financing for working capital needs.

Previous studies in the area of planning models for working capital management reveal that the integration of the three sectors was not done in proper proportion. Tuite (1968) presented a model which integrated the selection of a marketing strategy with the selection of a production schedule when product demand was highly seasonal. He determined the optimal level of off-season discounts to be offered so that the combined costs of production and marketing are minimized. Bergstrom and Smith (1970) developed a multi-item production planning model that extends the LDR of HMMS in multi-item situations. Rather than assuming the demand for the items as given, the authors proposed estimating revenue versus sales curves for each product in each time period, the amount to be sold is considered as a decision variable dependent upon price and some other parameters. The model then seeks a solution to maximize the profit for the firm over the time horizon.
Thomas (1971) studied the problem of simultaneously smoothing production and inventory and setting advertisement levels. Leitch (1974) also proposed a model that combined the classic HMMS model and advertising-sales relations. One of the major contributions in the area of simultaneous decision models for production, marketing and finance was done by William W. Damon and Richard Schramm (1972). The authors developed a simultaneous model integrating the marketing, production and finance functions with maximizing the cash equivalent position of the firm as the objective. But the model suffers from the drawback that it did not consider the finance sector decision alternatives such as choice of sources of financial alternatives such as stretching of accounts payable, hypothecation of goods, short-term borrowings etc.

Robicheck et al (1967) considered wide variety of financial alternatives and failed to incorporate the other decision variables relating production and marketing. The model also assumed that the period-wise cash balances are known before financing. The authors made an attempt to interrelate working capital components in a linear programming frame work to determine the optimal financing decision alternatives. Taylor and Anderson (1979) employed a goal programming approach for the combined marketing and production planning. Gopal Sinha (1982) proposed two types of models, one for simultaneous planning of sales, production, inventory and working capital and the other for production planning, inventory and working capital in a linear multi-objective framework.
Optimizing models dealing with single working capital asset independently may produce inconsistent results as compared to the models that give simultaneous treatment to each working capital asset (Knight, 1972). Tavis (1973) determined optimal working capital policies by considering the linkages between credit, inventory and short-term borrowing. Sampath (1991) explained the conceptual, decisional and policy issues concerning financing of working capital.

To take advantage of the potential benefits of a simultaneous formulation of the firm's functional areas, a model is developed in the current study composed of multiple corporate level objective functions subjected to a set of constraints emanating from departmental requirements and definitional restrictions. In its most comprehensive form the model provides optimal choices of man hours worked, machine hours worked, material purchases, product demand and choice of sources of funds such as short-term borrowings, stretching of accounts payable and hypothecation of goods. These decisions indirectly determine production, materials and finished goods inventory levels, sales revenues and cash holdings.

5.1 Notation:

The notation used in the formulation of the simultaneous planning model of production, finance and marketing is given below.

\[ D_t = \text{Sales of the firm in period } t \text{ in number of units} \]
\[ P_t = \text{Production output in period } t \text{ in number of units} \]
\[ W_t = \text{No. of man hours required to be worked in period } t \]
\[ \begin{align*}
N_t &= \text{Number of machine hours to be worked in period } t \\
k_1 &= \text{Output per unit man hour} \\
k_2 &= \text{Output per unit machine hour} \\
\beta_1 &= \text{Proportion of the manual work} \\
\beta_2 &= \text{Proportion of the machine work} \\
\text{RMI}_t &= \text{Level of the raw material inventory at the end of the period } t \\
\text{FGI}_t &= \text{Level of finished goods inventory at the end of the period } t \\
L_t &= \text{Lead time for material procurement from source } k \\
M_{t-1,k} &= \text{Material ordered from source } k \text{ in period } t-1 \text{ and expected to be received in period } t, \text{ where } k=1,2, \ldots, K \\
\alpha &= \text{Proportion of material used in producing one unit of output} \\
w &= \text{Average Labour reward rate per hour} \\
m &= \text{Average machine rate per hour} \\
\alpha_m &= \text{Cash outflows per period per unit of material inventory held} \\
\alpha_s &= \text{Cash outflows per period per unit of finished goods inventory held} \\
R_t &= \text{Unit price of the finished goods in period } t \\
P_m &= \text{Unit cost of the raw material in period } t \\
C_{jt} &= \text{Proportion of the cash received in period } t \text{ due to sale in period } j, j \leq t \\
c_d &= \text{Cash discount received on each payment made for the material when the payment is first due} \\
\text{SP}_{jt} &= \text{Amount of accounts payable stretched in period } t \text{ that are first due in period } j, j \leq t \\
\text{AP}_{jt} &= \text{Accounts paid in period } t \text{ that are first due in period } j, j \leq t 
\end{align*} \]
\[ TAD_t = \text{Total amount due in each period } t \text{ due to stretching of accounts} \]
\[ map_{jt} = \text{Proportion of mandatory payments made in period } t \text{ towards the stretching of accounts that are first due in period } j, j \leq t \]
\[ BHG_t = \text{Bank borrowings on hypothecation of goods in period } t \]
\[ PHiG_t = \text{Payments made to bank in period } t \text{ towards hypothecation of goods} \]
\[ BHG_{max} = \text{Maximum permissible outstanding bank loan on hypothecation of goods} \]
\[ OHG_t = \text{Outstanding bank loan in period } t \text{ due to hypothecation of goods} \]
\[ mmh_t = \text{Proportion of margin money to be deposited in period } t \text{ with the bank to hypothecate the goods} \]
\[ DSTB_t = \text{Short-term borrowings due at the end of the period } t \]
\[ STB_t = \text{Amount of short-term borrowings in period } t \]
\[ RSTB_t = \text{Repayments made in period } t \text{ towards short-term borrowings} \]
\[ STB_{max} = \text{Maximum permissible amount of short-term borrowings} \]
\[ TR = \text{Tax Rate} \]
\[ GR_t = \text{Gross revenue in period } t \]
\[ E_t = \text{Expenses in period } t \]
5.2 The Model:

5.2.1 Production Sector

The production sector formulation has its foundation in the famous HMMS model. The current section deals with various production costs and the associated constraints. Aggregate production planning models consider the hiring and firing costs of the workforce. However, the current model leaves those costs as they contribute very little when compared with the other costs since it is a macro model. The progress of the technology towards automation of production shops made the machine processing time/cost as an important parameter that determines the level of production. The current model includes the number of man hours needed to be worked and the number of machine hours to be worked to determine the level of the activity.

\[ P_t = \beta_1' W_t + \beta_2' N_t + \beta_3'(W_t - W_t)^2 + \beta_4'(N_t - N_t)^2 \]

Where \( \beta_1' \) and \( \beta_2' \) are estimated from regression and

\[ \beta_1 = \beta_1' / k_1 \quad \text{and} \quad \beta_2 = \beta_2' / k_2 \]

The third and fourth terms in the above equation represent the inefficiencies associated with the working hours of labour and the machines. \( \beta_3' \) and \( \beta_4' \) are constant parameters. However, since the current model is a macro model, we may consider a linear production function by eliminating the inefficiency terms in the above equation and the level of the output is given by

\[ P_t = \beta_1' W_t + \beta_2' N_t \]
The various constraints associated with the production activity are:

a) *The material availability*:

The amount of material available in period $t$ is given by

$$\text{RMI}_{t-1} + \sum_{k \leq t} M_{k,t-1}$$

The material required in period $t$ is

$$\alpha P_t$$

the material requirement is less than or equal to the availability. Hence

$$\alpha P_t \leq \text{RMI}_{t-1} + \sum_{k \leq t} M_{k,t-1}$$

b) *Material balance equation*:

The end of period material inventory is always greater than or equal to zero

$$\text{RMI}_t = [\text{RMI}_{t-1} + \sum_{k \leq t} M_{k,t-1}] - \alpha P_t \geq 0 \quad \text{for } t=1,2,..,T$$

c) *Finished goods inventory balance*:

$$\text{FGI}_t = \text{FGI}_{t-1} + P_t - D_t \quad \text{for } t=1,2,...,T$$

*Production costs*

i) The complete set of cash flows associated with the man and machine hours in period $t$ is

$$w. \beta_1 W_t + m. \beta_2 N_t$$

ii) Cash outflows due to holding inventories in period $t$ are

Materials $\alpha_m \text{RMI}_t$

Finished goods $\alpha_f \text{FGI}_t$
5.2.2 Marketing Sector:

In the integrated model, the measures of the efficiency such as price and the advertising play a major role in determining the level of marketing activity in terms of the demand for a product. The assumption made in the current model regarding the demand of the product is that there is no back ordering permitted. It means that the demand is met in the period in which it occurs. In any given period the demand and the sales are considered to be identical. The form of the demand function is assumed to be

\[ D_t = \gamma_1 D_{t-1} + \gamma_2 A_t - \gamma_3 R_t \]

\( \gamma_1, \gamma_2, \) and \( \gamma_3 \) are the coefficients estimated across the decision periods.

In the current model the coefficients \( \gamma_1, \gamma_2, \) and \( \gamma_3 \) may be generated outside the model using a combination of regression and ARIMA process. The lag effects of advertising are not considered directly. However, the use of lagged demand compensates for this non-inclusion.

5.2.3 Finance Sector:

The short term financing decisions are relatively complex in nature. The choice of a source of short term funds from a set of financing alternatives is the difficulty being faced by many financial managers. In most of the occasions it is difficult to predict the superiority of one financial alternative over the others. In practice, approaches to the short-term financing problem vary considerably; consideration is given to such factors as explicit costs, restrictions, expediency, reliability of forecasts, cash buffers, industry practices etc. (Alexander A. Robichek and others, 1965).
A cash budget is a valuable source of information for a financial manager to determine the cash requirements at minimum cost to the firm. It is a financial statement which presents period-wise cash requirements, determined from the cash receipts and cash disbursements of firm. The difference between the receipts and disbursements as adjusted by the required change in minimum operating cash balances gives the cumulative cash requirement. Usually a number of sources for short term funds exists, including short term loans, unsecured line of credit, pledging of accounts receivable, stretching of accounts payable, hypothecation of goods etc.

As the current model is a macro model, only the short term loans, hypothecation of goods and stretching of accounts payable are considered as the sources of funds. Also the model does not assume that the cash requirements are known in advance.

5.2.3.1 Stretching of Accounts Payable:

It is assumed that the accounts can be stretched to a maximum of two periods and all accounts outstanding beyond 2 periods must be paid in the immediate next period. It is also assumed that in every period there will be certain amount of mandatory payments made to the suppliers. Suppliers allow for cash discounts if the payments are made in the period in which they are first due.

(i) Accounts first due in period t

In any given period t a portion of the amount due is stretched and the remaining portion is unstretched due to the mandatory requirements from the source. Hence the total amount due in period t is equal to sum of the amount stretched and the amount paid.

\[ TAD_t = SP_t + AP_t \]
The amount stretched can be expressed as a percentage of the total amount due as

\[ SP_{t-1} \leq (1-\text{map}_{t-1}) \text{TAD}_t \]

(ii) Accounts first due in period \( t-1 \)

The amount stretched in period \( t-1 \) is either paid or stretched further in period \( t \) or a combination of both can be done (a portion due may be paid and the remaining may be stretched). The outstanding amount in the current period \( t \) due to stretching of accounts in period \( t-1 \) is \( SP_{t-1,1} \). And the amount outstanding that can be stretched in the current period due to the stretching in the last period \( t-1 \) is \( SP_{t-1,t} \).

Hence the constraint on \( SP_{t-1,1} \) due to mandatory payments is

\[ SP_{t-1,1} \leq (1-\text{map}_{t-1}) \text{SP}_{t-1,t} \]

The amount actually due in the last period may be expressed as the sum of the amount paid last period, amount paid in the current period and the amount stretched in the current period for the accounts first due in the last period

\[ \text{TAD}_{t-1} = SP_{t-1,1} + \text{AP}_{t-1,1} + \text{AP}_{t-1} \]

(iii) Accounts first due in period \( t-2 \)

All the payments are made when the period for which the amount due is stretched for two periods, the firm must pay all accounts in the current period that were first due in period \( t-2 \)

\[ \text{AP}_{t-2,1} = SP_{t-2,1} \]

The total amount due that was first due in period \( t-2 \) must not exceed the total payments made in periods \( t-2, t-1 \) and \( t \).

\[ \text{TAD}_{t-2} = \text{AP}_{t-2,1} + \text{AP}_{t-2,11} + \text{AP}_{t-2,21} \]
The net cash outflow due to the stretching of accounts is given by

\[(1-c_0) \ AP_{11} + \ AP_{111} + \ AP_{121}\]

5.2.3.2 Hypothecation of goods:

Hypothecation of goods (raw material/finished goods) is a source of finance for the manufacturing and trading organizations. The amount that can be borrowed on hypothecation of goods from a bank is constrained by the value of the goods. Bank requires margin money to be paid by the borrower to hypothecate the goods. In this process, the bank usually deducts the margin money from the value of the goods, and the remaining value will be provided as loan on hypothecation of goods. The value of the goods for hypothecation in period \(t\) is calculated based on the end of inventory of period \(t-1\). The interest due on hypothecation of goods of the current period is assumed to be paid in the next period.

(a) The amount of loan obtained on hypothecation in period \(t\) is constrained by the value of the inventory of goods at the end of period \(t-1\)

\[\text{BHG}_t \leq (1-mm_l) \ [p_l^m \cdot \text{RMI}_{t-1} + R_l \cdot \text{FGI}_{t-1}]\]

(b) The amount of loan outstanding due to hypothecation of goods should be lower than that of the maximum permissible balance of loan.

\[\text{OHG}_t = \text{OHG}_{t-1} + \text{BHG}_t - \text{PHG}_t\]

\[\text{OHG}_t \leq \text{BHG}_{\text{max}}\]

As a rule, the outstanding bank loan due to the hypothecation of goods should not exceed the value of the goods hypothecated.
where the \(\text{CURL}_t\) is the current liabilities other than the bank borrowings and may include the amount stretched and other current liabilities.

### 5.2.3.3 Short-term borrowings:

The firm may obtain short-term borrowing from banks as well as from any other external sources. The firm may have a policy of having a maximum limit on short-term borrowings from various sources. The interest on short-term borrowings in the current period is assumed to be paid in the next period.

The constraint on the short-term borrowings is given by

\[
\text{DSTB}_t = \text{DSTB}_{t-1} + \text{STB}_t - \text{RSTB}_t
\]

\[0 \leq \text{DSTB}_t \leq \text{STB}_{\text{max}}\]

### 5.2.3.4 Cash Balance:

The firm is supposed to maintain a minimum cash balance of \(\text{CB}_{\text{min}}\). The cash balance at the end of period \(t\) is

\[
\text{CB}_t = \text{CB}_{t-1} + \text{TCIF}_t - \text{TCOF}_t
\]

and

\[
\text{CB}_t \geq \text{CB}_{\text{min}}
\]

(i) Total cash inflows in period \(t\) (TCIF):

(A) Collections from debtors:

\[
\sum_{j=k+1}^{t} (1-C_j) R_j S_j
\]

(B) Cash inflow from hypothecation of goods: \(\text{BHG}_t\)

(C) Cash inflow from short-term borrowings: \(\text{STB}_t\)
Hence the total cash inflows in period $t$ is the sum of the above three components

$$TCIF_t = \sum_{i=1}^{T} (1-C_i) R_i S_i J + BHG_t + STD_t$$

(ii) The total cash outflows in period $t$ (TCOF$_t$)

(A) Payments from creditors (Due to switching of accounts)

$$(1-c_d)AP_{t+1} + AP_{t+1} + AP_{t+2}$$

(B) Repayment to bank towards hypothecation of goods PHG$_t$

(C) Repayment to bank towards short term borrowings RSTB$_t$

(D) Interest payments

$$Interest on loan from hypothecation + Interest on short-term borrowings = r[DHG_t + DSTB_t]$$

(E) Other payments OPMTS$_t$

Hence the total cash outflow during period $t$ is

$$TCOF_t = [(1-c_d)AP_{t+1} + AP_{t+1} + AP_{t+2}] + PHG_t + RSTB_t + r[DHG_{t+1} + DSTB_t] + OPMTS_t$$

5.2.4 The Multiple Objective Functions

Maximizing the current ratio and the profitability ratio are considered as the multiple objectives for the current model.

5.2.4.1 Current Ratio (CR):

The current ratio is defined as the ratio of the current assets and the current liabilities. In the current model, the current ratio at the end of the planning horizon is required to be greater than or equal to the desired value set by the management.
The current assets include the inventory, cash on hand and the accounts receivables.

The end of period inventories are considered for calculations.

i) The value of the inventory in period $t$ is

$$RMI_t = p_{mi} + FGI_t - R_t$$

ii) The cash on hand in period $t$ is

$$= \text{Cash due to sales} + \sum_{i=1}^{n} \text{Cash received in period } t \text{ due to sales in period } (t-1)$$

Therefore the cash on hand is given by

$$= C_{t-1} - D_t + \sum_{j=1}^{L-1} C_{t-j} - R_{t-1} - D_{t-1}$$

where $n$ is the maximum number of periods for which the stretching of accounts receivable is permitted.

iii) Accounts Receivable in period $t$ is

$$= \sum_{i=1}^{n} \text{Accounts receivable in period } t \text{ due to credit sale in period } (t-1)$$

Where $L$ is the maximum number of periods for which the accounts receivable can be stretched

$$= \sum_{j=1}^{L} (1 - \sum_{i=1}^{j} C_{t-j-i}, R_{t-j}, D_{t-j})$$

Hence the total current assets may be expressed as.
Current Assets = \[ RM_{it} \cdot p_{m} + FG_{it} \cdot R_{t} \] + \[ C_{it} \cdot R_{t} + \sum_{j=1}^{n} C_{ij} \cdot R_{j} \cdot D_{j} \] + \[ \sum_{j=1}^{l} (1 - \sum_{i=1}^{n} C_{i,j-1}) R_{i,j-1} \cdot D_{i,j-1} \]

The current liabilities include the accounts payable (stretching of accounts), amount to be paid on hypothecation of goods, short-term borrowings, interest payments and other expenses.

i) The accounts payable due in period \( t \) is
\[ = (1-c_d) \cdot SP_{tt} + \sum_{i=1}^{n} SP_{i,tt} \]

ii) The amount due on hypothecation of goods in period \( t \) is
\[ = OHG_{tt} + BHG_{t} - PHG_{t} \]

iii) The amount due on short-term borrowings in period \( t \) is
\[ = DSTB_{tt} + STB_{t} - RSTB_{t} \]

iv) The interest due in period \( t \) is
\[ = \text{Interest due on loan from hypothecation of goods in period } t-1 + \text{Interest due on short-term borrowings in period } t-1 \]
\[ = r[DHG_{t-1} + DSTB_{t-1}] \]

v) The other payments due include salaries, power, taxes etc., in period \( t \) are
\[ = OPMTS_{t} \]

The total current liabilities is given by
\[ \text{Current Liabilities} = \left[ (1-c_d) \cdot SP_{tt} + \sum_{i=1}^{n} SP_{i,tt} \right] + [DHG_{tt} + BHG_{t} - PHG_{t}] \]
\[ + [DSTB_{tt} + STB_{t} - RSTB_{t}] + r[DHG_{t-1} + DSTB_{t-1}] + OPMTS_{t} \]
The current ratio (CR) is given by

\[
\frac{\text{Net profit after taxes}}{(1-c_t) SP_{it} + \sum_{i=1}^{T} SP_{i, it}} = \frac{\left[ \text{RM}_{it} p_{mt} + \text{FGI}_{i} R_{it} \right] + \left[ \text{C}_{it} R_{it} D_{it} + \sum_{j=1}^{R} \text{C}_{ij} R_{ij} D_{ij} \right] + \sum_{j=1}^{R} \left[ (1-\sum_{k=1}^{R} \text{C}_{k, it}) R_{k, it} D_{k, it} \right]}{\left[(1-c_t) SP_{it} + \sum_{i=1}^{T} SP_{i, it}\right] + \left[ \text{DHG}_{i} + \text{BHQ}_{i} - \text{PHQ}_{i} \right] + \left[ \text{DST}_{it} + \text{ST}_{it} - \text{RST}_{it} \right] + \left[ \tau(\text{DHG}_{it} + \text{DST}_{it}) \right] + \text{OPMT}_{it}}
\]

### 5.2.4.2 Profitability ratio:

The profitability ratio is given by the ratio of the net profit after taxes and the net sales.

The profitability is calculated for the planning horizon under consideration with the following expression.

\[
\text{Net profit after taxes} = (1-TR) (\text{Gross revenue} - \text{expenses})
\]

The Gross revenue for the planning horizon of T periods is given by the sum of the sales revenue and the cash discounts received for T periods under consideration

\[
\text{GR}_t = \sum_{i=1}^{T} R_{it} D_{it} + c_d \sum_{i=1}^{T} AP_{i, it}
\]

The expenses include the cost of raw materials, inventory costs, depreciation, interest payments and the other expenses. Hence the expenses equation for period t is given by

\[
E_t = w \beta_1 W_t + m \beta_2 N_t + \alpha_m \cdot \text{RM}_t + \alpha_p \cdot \text{FGI}_t + p_{mt} \cdot \text{RM}_t + \text{DEP}_t + [\text{DHG}_{t-1} + \text{DST}_{t-1}] + \text{OPMT}_t
\]
Hence the profitability ratio is

\[
(1 - TR) \left\{ \sum_{i=1}^{n} R_i D_i + c_d \sum_{i=1}^{n} A_i P_i \right\} - \sum_{i=1}^{n} E_i \over \sum_{i=1}^{n} R_i D_i
\]

5.3 Application And Solution Of The Model To A Paints Manufacturing Company

The study that is presented here is an SSI unit engaged in the manufacture of enamel paints. The company was established in the year 1983 and has been running successfully till date. The unit was started with an initial outlay of Rs 20,00,000. As on today the shop floor consists of 13 ball mills, 5 bead mills, 5 pug mills, 2 sand mills, 28 tanks and 3 resin reactors. The break-even capacity of the plant is 18,00,000 liters per annum. The major strength of the unit is its human resources. The plant had availed government subsidy on land, plant and machinery.

Initially the plant had struggled to get the market for its products. Apart from that the company also faced with shortage of working capital, non-availability of raw materials and few technical problems. The very frequently occurring problems for the company are shortage of working capital and non-availability of raw material. The plant is staffed with 15 managers, 79 supervisors, 75 skilled labour, 35 semi-skilled labour and 100 unskilled labour. The plant is working in two shifts/three shifts depending on the demand and production requirements. The company is a successful unit yielding profits.
For the application of the current model to the unit described above, a six period planning horizon is considered. The demand for the product (enameled paint) is also determined in the model while assuming that the selling price of the product is a predetermined parameter.

5.3.1 Production Sector:

As mentioned earlier in section 5.2.1, a linear production function is considered. The man and machine inefficiency costs are neglected as they contribute very little to the total production costs in an automated production environment. Here we assume that there are three sources of supply of raw material. The lead time for the supply of the raw material is assumed to be one period from any source.

The equations representing the level of the production activity in various periods is given by

\[
\begin{align*}
P_1 &= \beta_1 W_1 + \beta_2 N_1 \\
P_2 &= \beta_1 W_2 + \beta_2 N_2 \\
P_3 &= \beta_1 W_3 + \beta_2 N_3 \\
P_4 &= \beta_1 W_4 + \beta_2 N_4 \\
P_5 &= \beta_1 W_5 + \beta_2 N_5 \\
P_6 &= \beta_1 W_6 + \beta_2 N_6
\end{align*}
\]

The material availability constraints are:

\[
\begin{align*}
\alpha P_1 &\leq RMI_0 + M_{10} + M_{20} + M_{30} \\
\alpha P_2 &\leq RMI_1 + M_{11} + M_{21} + M_{31} \\
\alpha P_3 &\leq RMI_2 + M_{12} + M_{22} + M_{32} \\
\alpha P_4 &\leq RMI_3 + M_{13} + M_{23} + M_{33} \\
\alpha P_5 &\leq RMI_4 + M_{14} + M_{24} + M_{34} \\
\alpha P_6 &\leq RMI_5 + M_{15} + M_{25} + M_{35}
\end{align*}
\]
The raw material balance equations are given by

\[ RMI_1 = RMI_0 + M_{1.0} + M_{2.0} + M_{3.0} - \alpha P_1 \]
\[ RMI_2 = RMI_1 + M_{1.1} + M_{2.1} + M_{3.1} - \alpha P_2 \]
\[ RMI_3 = RMI_2 + M_{1.2} + M_{2.2} + M_{3.2} - \alpha P_3 \]
\[ RMI_4 = RMI_3 + M_{1.3} + M_{2.3} + M_{3.3} - \alpha P_4 \]
\[ RMI_5 = RMI_4 + M_{1.4} + M_{2.4} + M_{3.4} - \alpha P_5 \]
\[ RMI_6 = RMI_5 + M_{1.5} + M_{2.5} + M_{3.5} - \alpha P_6 \]

The finished goods inventory balance equations are given by

\[ FGI_1 = FGI_0 + P_1 + D_1 \]
\[ FGI_2 = FGI_1 + P_2 + D_2 \]
\[ FGI_3 = FGI_2 + P_3 + D_3 \]
\[ FGI_4 = FGI_3 + P_4 + D_4 \]
\[ FGI_5 = FGI_4 + P_5 + D_5 \]
\[ FGI_6 = FGI_5 + P_6 + D_6 \]

No back ordering is permitted

\[ FGI_0 + P_i \geq D_i \]
\[ FGI_1 + P_2 \geq D_2 \]
\[ FGI_2 + P_3 \geq D_3 \]
\[ FGI_3 + P_4 \geq D_4 \]
\[ FGI_4 + P_5 \geq D_5 \]
\[ FGI_5 + P_6 \geq D_6 \]

Apart from the above constraints the upper and lower bounds on the raw material, finished goods, production capacities are also considered in the model formulation.
5.3.2 Marketing Sector:

The demand for the product is simultaneously determined within the integrated model. It is assumed that the unit selling price per litre of the enamel paint is known. As the company is a small scale industry, it has no exclusive advertisement expenditure incurred on regular basis. Hence as far as the marketing sector variables are concerned, the only unknown is the demand. Due to marketing limitations upper and lower bounds on the demand are also taken as constraints.

5.3.3 Finance Sector:

The finance sector mainly deals with the raising of short-term funds from various sources. The various sources of short-term finance considered in the current application are stretching of accounts payable, hypothecation of goods and short-term borrowings.

5.3.3.1 Stretching of Accounts payable:

Here it is assumed that accounts payable can be stretched for a maximum period of two months and all accounts outstanding for more than two months must be paid in the third month. Every month a certain amount must be repaid due to mandatory requirements. The firm may avail the cash discounts for the payments that are first due.

Accounts first due in period 6:

\[
\begin{align*}
\text{TAD}_6 &= \text{SP}_{66} + \text{AP}_{66} \\
\text{SP}_{66} &= (1-\text{map}_{66})\cdot \text{TAD}_6 \\
\text{SP}_{55} &= (1-\text{map}_{55})\cdot \text{SP}_{55} \\
\text{TAD}_5 &= \text{SP}_{55} + \text{AP}_{55} + \text{AP}_{56} \\
\text{AP}_{46} &= \text{AS}_{45} \\
\text{TAD}_4 &= \text{AP}_{44} + \text{AP}_{45} + \text{AP}_{46}
\end{align*}
\]
The net cash flow due to stretching of accounts in period 6 is

\((1-c_d) \ AP_{6} + AP_{5} + AP_{4} \)

**Accounts first due in period 5:**

\[
\begin{align*}
TAD_5 &= SP_{5} + AP_{5} \\
SP_{5} &\leq (1-\text{map}_{5}) \ TAD_5 \\
SP_{4} &\leq (1-\text{map}_{4}) \ SP_{4} \\
TAD_4 &= SP_{4} + AP_{4} + AP_{5} \\
AP_{3} &= AS_{3} \\
TAD_3 &= AP_{3} + AP_{4} + AP_{5}
\end{align*}
\]

The net cash flow due to stretching of accounts in period 5 is

\((1-c_d) \ AP_{5} + AP_{4} + AP_{3} \)

**Accounts first due in period 4:**

\[
\begin{align*}
TAD_4 &= SP_{4} + AP_{4} \\
SP_{4} &\leq (1-\text{map}_{4}) \ TAD_4 \\
SP_{3} &\leq (1-\text{map}_{3}) \ SP_{3} \\
TAD_3 &= SP_{3} + AP_{3} + AP_{3} \\
AP_{2} &= AS_{2} \\
TAD_2 &= AP_{2} + AP_{3} + AP_{4}
\end{align*}
\]

The net cash flows due to stretching of accounts in period 4 is

\((1-c_d) \ AP_{4} + AP_{3} + AP_{4} \)

**Accounts first due in period 3:**

\[
\begin{align*}
TAD_3 &= SP_{3} + AP_{3} \\
SP_{3} &\leq (1-\text{map}_{3}) \ TAD_3 \\
SP_{2} &\leq (1-\text{map}_{2}) \ SP_{2} \\
TAD_2 &= SP_{2} + AP_{2} + AP_{3} \\
AP_{1} &= AS_{1}
\end{align*}
\]

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\[
\text{TAD}_1 = AP_{11} + AP_{12} + AP_{13}
\]
The net cash flows due to stretching of accounts in period 3 is
\[(1-c_d) AP_{13} + AP_{23} + AP_{13}\]

**Accounts first due in period 2:**
\[
\begin{align*}
\text{TAD}_2 &= SP_{22} + AP_{22} \\
\text{SP}_{22} &\leq (1-\text{map}_{22}) \cdot \text{TAD}_2 \\
\text{SP}_{12} &\leq (1-\text{map}_{12}) \cdot \text{SP}_{11} \\
\text{TAD}_1 &= \text{SP}_{12} + AP_{11} + AP_{12} \\
\text{AP}_{02} &= AS_{01} \\
\text{TAD}_0 &= \text{AP}_{00} + \text{AP}_{01} + \text{AP}_{02}
\end{align*}
\]
The net cash flows due to stretching of accounts in period 2 is
\[(1-c_d) AP_{22} + AP_{12} + \text{AP}_{02}\]

**Accounts first due in period 1:**
\[
\begin{align*}
\text{TAD}_1 &= \text{SP}_{11} + AP_{11} \\
\text{SP}_{11} &\leq (1-\text{map}_{11}) \cdot \text{TAD}_1 \\
\text{SP}_{01} &\leq (1-\text{map}_{01}) \cdot \text{SP}_{00} \\
\text{TAD}_0 &= \text{SP}_{01} + \text{AP}_{00} + \text{AP}_{01}
\end{align*}
\]
The net cash flows due to stretching of accounts in period 1 is
\[(1-c_d) AP_{11} + \text{AP}_{01}\]

### 5.3.3.2 Hypothecation of goods:

The hypothecation of raw material and finished goods inventory only is considered here. It is assumed that there is a maximum limit on the amount of hypothecation of both raw material and the finished goods put together. It is necessary to make few mandatory payments towards the hypothecation of goods in each period. The hypothecating authority (such as a bank, a state govt., trading corporation etc.) deducts
the margin money from the calculated amount of hypothecation on goods. There is also a limit on the maximum outstanding balance on hypothecation of goods.

The amount of borrowings on hypothecation of goods is constrained by the value of the goods

\[
\begin{align*}
\text{BHG}_6 & \leq (1-\text{mmh}_6) [p_{m6} \cdot \text{RMI}_5 + R_5 \cdot \text{FGI}_5] \\
\text{BHG}_5 & \leq (1-\text{mmh}_5) [p_{m5} \cdot \text{RMI}_4 + R_5 \cdot \text{FGI}_4] \\
\text{BHG}_4 & \leq (1-\text{mmh}_4) [p_{m4} \cdot \text{RMI}_3 + R_4 \cdot \text{FGI}_3] \\
\text{BHG}_3 & \leq (1-\text{mmh}_3) [p_{m3} \cdot \text{RMI}_2 + R_3 \cdot \text{FGI}_2] \\
\text{BHG}_2 & \leq (1-\text{mmh}_2) [p_{m2} \cdot \text{RMI}_1 + R_2 \cdot \text{FGI}_1] \\
\text{BHG}_1 & \leq (1-\text{mmh}_1) [p_{m1} \cdot \text{RMI}_0 + R_1 \cdot \text{FGI}_0] \\
\end{align*}
\]

Constraint on balance of loan outstanding:

The equations showing the amount of outstanding loan in periods 1, 2, 6 are

\[
\begin{align*}
\text{OHG}_6 & = \text{BHG}_6 + \text{BHGI} - \text{PHG}_6 \quad \text{and} \quad \text{OHG}_6 \leq \text{BHG}_{\text{max}} \\
\text{OHG}_5 & = \text{BHG}_5 + \text{BHGI} - \text{PHG}_5 \quad \text{and} \quad \text{OHG}_5 \leq \text{BHG}_{\text{max}} \\
\text{OHG}_4 & = \text{BHG}_4 + \text{BHGI} - \text{PHG}_4 \quad \text{and} \quad \text{OHG}_4 \leq \text{BHG}_{\text{max}} \\
\text{OHG}_3 & = \text{BHG}_3 + \text{BHGI} - \text{PHG}_3 \quad \text{and} \quad \text{OHG}_3 \leq \text{BHG}_{\text{max}} \\
\text{OHG}_2 & = \text{BHG}_2 + \text{BHGI} - \text{PHG}_2 \quad \text{and} \quad \text{OHG}_2 \leq \text{BHG}_{\text{max}} \\
\text{OHG}_1 & = \text{BHG}_1 + \text{BHGI} - \text{PHG}_1 \quad \text{and} \quad \text{OHG}_1 \leq \text{BHG}_{\text{max}} \\
\end{align*}
\]

Hence the constraints on the loan outstanding due on hypothecation are

\[
\begin{align*}
\text{OHG}_6 & \leq (1-\text{mmh}_6) [p_{m6} \cdot \text{RMI}_5 + R_5 \cdot \text{FGI}_5 - \text{CURL}_5] \\
\text{OHG}_5 & \leq (1-\text{mmh}_5) [p_{m5} \cdot \text{RMI}_4 + R_5 \cdot \text{FGI}_4 - \text{CURL}_4] \\
\text{OHG}_4 & \leq (1-\text{mmh}_4) [p_{m4} \cdot \text{RMI}_3 + R_4 \cdot \text{FGI}_3 - \text{CURL}_3] \\
\text{OHG}_3 & \leq (1-\text{mmh}_3) [p_{m3} \cdot \text{RMI}_2 + R_3 \cdot \text{FGI}_2 - \text{CURL}_2] \\
\text{OHG}_2 & \leq (1-\text{mmh}_2) [p_{m2} \cdot \text{RMI}_1 + R_2 \cdot \text{FGI}_1 - \text{CURL}_1] \\
\text{OHG}_1 & \leq (1-\text{mmh}_1) [p_{m1} \cdot \text{RMI}_0 + R_1 \cdot \text{FGI}_0 - \text{CURL}_0] \\
\end{align*}
\]
5.3.3 Short-Term Borrowings:

Short-term borrowings may be obtained from banks. The amount of short-term borrowings is constrained by the maximum outstanding balance on the short-term borrowings

\[
\begin{align*}
DSTB_0 &= DSTB_5 + STB_0 - RSTB_6 & \text{and } & DSTB_6 \leq STB_{\max} \\
DSTB_5 &= DSTB_4 + STB_5 - RSTB_6 & \text{and } & DSTB_4 \leq STB_{\max} \\
DSTB_4 &= DSTB_3 + STB_4 - RSTB_6 & \text{and } & DSTB_3 \leq STB_{\max} \\
DSTB_3 &= DSTB_2 + STB_3 - RSTB_6 & \text{and } & DSTB_2 \leq STB_{\max} \\
DSTB_2 &= DSTB_1 + STB_2 - RSTB_6 & \text{and } & DSTB_1 \leq STB_{\max} \\
DSTB_1 &= DSTB_0 + STB_1 - RSTB_6 & \text{and } & DSTB_0 \leq STB_{\max}
\end{align*}
\]

5.3.4 The Multiple Objective Functions:

Two mutually conflicting objectives are considered for the model: maximization of current ratio and the profitability ratio. The model is solved by formulating these two objectives as goal constraints and writing the objective as minimizing the deviation from the goal.

5.3.4.1 Current Ratio:

The current ratio at the end of the 6th period is required to be maintained greater than or equal to the desired current ratio 1.5, set by the management.

The current ratio at the end of the 6th period is given by

\[
CR_6 = \frac{\text{Current assets}}{\text{Current liabilities}} = \frac{CA_6}{CL_6}
\]

\[
CA_0 = [p_{0.8} RMI_{6} + R_6 \cdot FGI_6] + [C_{6.1} R_0, D_0 + C_{3.6} R_3, D_3 + C_{4.6} R_4, D_4] + (1 - C_{5.6} - C_{5.5}) R_5, D_5
\]

\[
+ (1 - C_{4.6} - C_{4.5} - C_{4.4}) R_4, D_4
\]

\[
CL_0 = [(1 - c_0) SP_{6.6} + SP_{5.6}] + [DHG_{5.6} + B/HG_{6.6} - PHG_{6.6}] + [DSTB_5 + SB_{6} - RSTB_6] + [DHG_{5} + DSTB_{6}] + OPMTS_6
\]

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Hence the required current ratio may be written as

\[ \frac{CA_5}{CL_5} \geq 1.5 \]

and hence the goal may be written as

\[ CA_6 - 1.5 CL_6 + S_1^+ - S_1^- = 0 \]

Where \( S_1^+ \) and \( S_1^- \) are the devotional variables

### 5.3.4.2 Profitability Ratio

The profitability ratio is given by the ratio of the net profit after taxes and the net sales during the periods from 1 to 6. The desired profitability by the management of the company is 0.3 or more. Hence the profitability goal may be formulated as under.

Gross revenue over the six periods is

\[ GR_T = [R_1D_1 + R_2D_2 + R_3D_3 + R_4D_4 + R_5D_5 + R_6D_6] \]

\[ + c_0[AP_11 + AP_22 + AP_33 + AP_44 + AP_55 + AP_66] \]

The net sales is given by

\[ NETS_T = [R_1D_1 + R_2D_2 + R_3D_3 + R_4D_4 + R_5D_5 + R_6D_6] \]

The expenses over the planning horizon are

\[ E_T = \sum_1^6 E_i = E_1 + E_2 + E_3 + E_4 + E_5 + E_6 \]

\[ E_1 = w_1 \beta_1^1 W_1 + m_1 \beta_1^2 N_1 + \alpha_m \cdot RMI_1 + \alpha_s \cdot FGI_1 + p_m \cdot RMI_1 + DEP_1 \]

\[ + f[DHG_0 + DSTB_0] + OPMTS_1 \]

\[ E_2 = w_2 \beta_2^1 W_2 + m_2 \beta_2^2 N_2 + \alpha_m \cdot RMI_2 + \alpha_s \cdot FGI_2 + p_m \cdot RMI_2 + DEP_2 \]

\[ + f[DHG_1 + DSTB_1] + OPMTS_2 \]
\[ E_3 = w \beta_1 \cdot W_3 + m \beta_2 \cdot N_3 + \alpha_m \cdot \text{RMI}_3 + \alpha_s \cdot \text{FGI}_3 + p_{m1} \cdot \text{RMI}_3 + \text{DEP}_3 + \tau [\text{DHG}_2 + \text{DSTB}_2] + \text{OPMTS}_3 \]

\[ E_4 = w \beta_1 \cdot W_4 + m \beta_2 \cdot N_4 + \alpha_m \cdot \text{RMI}_4 + \alpha_s \cdot \text{FGI}_4 + p_{m1} \cdot \text{RMI}_4 + \text{DEP}_4 + \tau [\text{DHG}_3 + \text{DSTB}_3] + \text{OPMTS}_4 \]

\[ E_5 = w \beta_1 \cdot W_5 + m \beta_2 \cdot N_5 + \alpha_m \cdot \text{RMI}_5 + \alpha_s \cdot \text{FGI}_5 + p_{m1} \cdot \text{RMI}_5 + \text{DEP}_5 + \tau [\text{DHG}_4 + \text{DSTB}_4] + \text{OPMTS}_5 \]

\[ E_6 = w \beta_1 \cdot W_6 + m \beta_2 \cdot N_6 + \alpha_m \cdot \text{RMI}_6 + \alpha_s \cdot \text{FGI}_6 + p_{m6} \cdot \text{RMI}_6 + \text{DEP}_6 + \tau [\text{DHG}_5 + \text{DSTB}_5] + \text{OPMTS}_6 \]

Hence the profitability ratio is given by

\[
\frac{(1-TR)(GR - E_t)}{\text{NETS}_t}
\]

Since the desired ratio is greater than or equal to 0.3, the profitability goal may be written as

\[
(1-TR)(GR - E_t) - 0.3 \cdot \text{NETS}_1 + S_2^+ - S_2^- = 0
\]

Where \( S_2^+ \) and \( S_2^- \) are the deviational variables of this goal.

### 5.3.5 The Data

The data used for the model described in section 5.2 is shown in the following table 5.1.

The initial values for few parameters are also presented in the. Since the current model under consideration is tested for a six period planning horizon, the model requires the initial values for the parameters before the start of the planning horizon. In the table the subscript \( i=1,2,\ldots 6 \).
Table 5.1: The Model constants and initial Values

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Value</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>$R_i$</td>
<td>36</td>
<td>The unit selling price of the enamel paint in rupees in period i</td>
</tr>
<tr>
<td>$P_{cm}$</td>
<td>15</td>
<td>The unit cost of raw material</td>
</tr>
<tr>
<td>$a_m$</td>
<td>0.50</td>
<td>Inventory carrying cost of raw material per liter per month</td>
</tr>
<tr>
<td>$a_t$</td>
<td>0.50</td>
<td>Inventory carrying cost of enamel paint per liter per month</td>
</tr>
<tr>
<td>$w$</td>
<td>12</td>
<td>Labour wage rate in rupees per hour</td>
</tr>
<tr>
<td>$m$</td>
<td>60</td>
<td>Machine operation cost in rupees per hour</td>
</tr>
<tr>
<td>$\beta_1$</td>
<td>0.25</td>
<td>Proportion of the manual work</td>
</tr>
<tr>
<td>$\beta_2$</td>
<td>0.75</td>
<td>Proportion of the machine work</td>
</tr>
<tr>
<td>$k_1$</td>
<td>5</td>
<td>Output in liters per unit man hour</td>
</tr>
<tr>
<td>$k_2$</td>
<td>15</td>
<td>Output in liters per unit machine hour</td>
</tr>
<tr>
<td>$r$</td>
<td>0.12</td>
<td>Rate of interest per annum on any source of finance</td>
</tr>
<tr>
<td>$RM_{10}$</td>
<td>2,88,000</td>
<td>Initial raw material inventory in liters</td>
</tr>
<tr>
<td>$FG_{10}$</td>
<td>2,40,000</td>
<td>Initial finished goods inventory</td>
</tr>
<tr>
<td>$M_{10}$</td>
<td>83,600</td>
<td>Material ordered in period 0 from source 1 and expected to be received in period 1 (ie first period of the six period planning horizon)</td>
</tr>
<tr>
<td>$M_{20}$</td>
<td>40,000</td>
<td>Material ordered in period 0 from source 2 and expected to be received in period 1 (ie first period of the six period planning horizon)</td>
</tr>
<tr>
<td>$M_{30}$</td>
<td>30,000</td>
<td>Material ordered in period 0 from source 3 and expected to be received in period 1 (ie first period of the six period planning horizon)</td>
</tr>
<tr>
<td>$c_d$</td>
<td>0.1</td>
<td>Proportion of cash discounts received</td>
</tr>
<tr>
<td>$L_k$</td>
<td>1</td>
<td>Lead time in terms of no. of periods from source k</td>
</tr>
<tr>
<td>$map_{11}$</td>
<td>0.2</td>
<td>Proportion of mandatory payments made in period 1 due to stretching of accounts in period j</td>
</tr>
<tr>
<td>$mmh_{11}$</td>
<td>0.2</td>
<td>Proportion of margin money to be deposited in period 1 with bank for the purpose of hypothecation of goods</td>
</tr>
</tbody>
</table>
5.3.6 Results Obtained From The Simultaneous Integrated Planning Model For Working Capital Management For A Paints Manufacturing Company

Using the data presented in the above table the model described above is run for its optimum values of the decision variables of production, marketing and finance sectors. Lindo 6.1 software is used to run the model for its solution. The results obtained for different functional sectors are presented in the following tables.

5.3.6.1 Marketing Sector

The liters of paint to be sold in each period that is generated in the simultaneous model for six periods is presented in the table 5.2 below.
Table 5.2: Period-wise demand for paint in liters

5.3 6.2 Production Sector

The liters of paint to be manufactured each period based on the initial amount of 2,40,000 liters of paint available in the stock is presented in the table 5.3 below.

### Table 5.3: Period-wise production of paint in liters

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Demand(Ltrs)</td>
<td>1,50,000</td>
<td>5,83,333</td>
<td>2,20,000</td>
<td>2,20,000</td>
<td>1,50,000</td>
<td>2,20,000</td>
</tr>
<tr>
<td>Production quantity(ltrs)</td>
<td>2,73,333</td>
<td>2,20,000</td>
<td>2,20,000</td>
<td>2,20,000</td>
<td>3,00,000</td>
<td>2,20,000</td>
</tr>
</tbody>
</table>

The number of man hours and machine hours to be worked each period are presented in the table 5.4 below.

### Table 5.4: Period-wise man-machine hours requirement

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man hours</td>
<td>54,667</td>
<td>44,000</td>
<td>44,000</td>
<td>44,000</td>
<td>44,000</td>
<td>44,000</td>
</tr>
<tr>
<td>Machine hours</td>
<td>1116</td>
<td>898</td>
<td>898</td>
<td>898</td>
<td>898</td>
<td>898</td>
</tr>
</tbody>
</table>

The raw material stocks at the end of each period are presented in the table 5.5 below.

### Table 5.5: Period-wise raw material inventory

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Material Inventory(Ltrs)</td>
<td>1,04,000</td>
<td>40,000</td>
<td>2,00,000</td>
<td>4,31,257</td>
<td>71,257</td>
<td>10,64,003</td>
</tr>
</tbody>
</table>
The order size for the procurement of raw material from various sources in each period is presented in the table 5.6 below (The order placed in period $t$ is expected to be received in period $t+1$).

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Source 1</td>
<td>2,64,000</td>
<td>2,81,884</td>
<td>0</td>
<td>0</td>
<td>64,889</td>
</tr>
<tr>
<td>Source 2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Source 3</td>
<td>0</td>
<td>0</td>
<td>2,46,116</td>
<td>4,63,111</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 5.6: Period-wise raw material order sizes from different sources

The results shown in the above table indicate that in each period the material is ordered from a single source. This result is based on the pure mathematical balance of the related constraints, but in practice the amount of order may be distributed among the sources 1, 2 and 3 as per the availability.

The finished goods inventory at the end of each period is presented in the table 5.7 below.

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Finished goods inventory (Ltrs)</td>
<td>3,10,000</td>
<td>55,304</td>
<td>0</td>
<td>70,000</td>
<td>2,20,000</td>
<td>2,90,000</td>
</tr>
</tbody>
</table>

Table 5.7: Period-wise finished goods inventory

5.3.6.3 Finance Sector

The results obtained for various financial parameters are presented in order of stretching of payables, hypothecation of goods and short-term borrowings.

5.3.6.3.1 Stretching of Accounts Payable

The table 5.8 presented below indicates the amounts of accounts receivable to be stretched in different periods. It is assumed that the stretching of accounts receivable is
permitted only to a maximum of two periods. The stretched amount must be repaid in the third period.

<table>
<thead>
<tr>
<th>Period(j)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount stretched in period j</td>
<td>0</td>
<td>0</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>that is first due in period 1(Rs.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount stretched in period j</td>
<td>---</td>
<td>3,11,111</td>
<td>3,11,111</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>that is first due in period 2(Rs.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount stretched in period j</td>
<td>0</td>
<td>---</td>
<td>0</td>
<td>0</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>that is first due in period 3(Rs.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount stretched in period j</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0</td>
<td>0</td>
<td>---</td>
</tr>
<tr>
<td>that is first due in period 4(Rs.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount stretched in period j</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0</td>
<td>---</td>
</tr>
<tr>
<td>that is first due in period 5(Rs.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Amount stretched in period j</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0</td>
</tr>
<tr>
<td>that is first due in period 6(Rs.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5.8: Period-wise stretching of accounts payable

The table 5.9 presented below indicates the amount paid in each period towards the stretched accounts. As mentioned earlier an amount outstanding for two periods must be paid in the third period.
<table>
<thead>
<tr>
<th>Period $j$</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amount paid in period $j$ that is first due in period 1(Rs.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Amount paid in period $j$ that is first due in period 2(Rs.)</td>
<td>---</td>
<td>77,778</td>
<td>0</td>
<td>3,11,111</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Amount paid in period $j$ that is first due in period 3(Rs.)</td>
<td>---</td>
<td>---</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>---</td>
</tr>
<tr>
<td>Amount paid in period $j$ that is first due in period 4(Rs.)</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Amount paid in period $j$ that is first due in period 5(Rs.)</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Amount paid in period $j$ that is first due in period 6(Rs.)</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 5.9: Period-wise amounts paid towards stretching of accounts

The table 5.10 presented below indicates the total amount due at the end of each period due to the stretching of accounts.

<table>
<thead>
<tr>
<th>Period</th>
<th>Total amount due(Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,88,889</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 5.10: End of period due on stretching of accounts

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5.3.6 3.2 Hypothecation of goods

Another source of financial alternative incorporated in the current model is hypothecation of goods. The raw material and the finished goods may be hypothecated to a bank and loan may be obtained. The maximum limit on the total amount of hypothecation and the maximum due outstanding on hypothecation are also taken as constraints along with the other flow balance constraints in the model for each period. The table 5.11 presented below details the summary of period-wise borrowings, repayments and the outstanding due on hypothecation of goods.

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borrowings (Rs.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>36,05,333</td>
</tr>
<tr>
<td>Payments (Rs.)</td>
<td>8,00,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Outstanding due (Rs.)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>36,05,333</td>
</tr>
</tbody>
</table>

Table 5.11: Transactions on hypothecation of goods

An initial outstanding due for an amount of Rs. 8,00,000 is paid to the bank in the first period itself. Again in the 6th period an amount of Rs 36,05,333 is borrowed on hypothecation, which remains as the outstanding amount at the end of the planning horizon (at the end of the 6th month).

5.3.6 3.3 Short term borrowings

The maximum limit on the total amount of short-term borrowings and the maximum outstanding balance on short-term borrowings are also considered as the constraints along with the other flow balance constraints involved in short-term borrowings. The table 5.12 presented below details about the period-wise borrowings, repayments and outstanding amount.
Table 5.12: Transactions on short-term borrowings

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Short term Borrowings (Rs.)</td>
<td>0</td>
<td>0</td>
<td>3,57,143</td>
<td>0</td>
<td>10,00,000</td>
<td>0</td>
</tr>
<tr>
<td>Repayments on short-term borrowings (Rs.)</td>
<td>0</td>
<td>10,00,000</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Outstanding due on short-term borrowings (Rs.)</td>
<td>10,00,000</td>
<td>0</td>
<td>3,57,143</td>
<td>3,57,143</td>
<td>13,57,143</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 5.12: Transactions on short-term borrowings

5.3.6.3.4 Cash Balance

The table 5.13 presented below details about the end of period cash balance for the planning horizon under consideration.

<table>
<thead>
<tr>
<th>Period</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total amount due (Rs.)</td>
<td>39,99,000</td>
<td>95,39,000</td>
<td>2,62,68,142</td>
<td>3,62,50,176</td>
<td>4,46,75,316</td>
<td>5,43,25,792</td>
</tr>
</tbody>
</table>

Table 5.13: End of period cash balance

5.3.7 Conclusions

Working capital decisions are complex and relate the three vital sectors of an organization: marketing, production, and finance. A simultaneous planning model requires a systems approach integrating the full range of decision variables from all the three functional areas. This chapter aims at developing and applying a simultaneous planning model for a small scale industry. The structure of the model comprises multiple fractional objectives with linear constraints. Maximizing current ratio and profitability ratio form the multiple objectives and the constraints are formulated based on the limitations of the raw materials, finished goods, man-machine hours, demand and sources of short-term financing such as stretching of accounts payable.