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hypothecation of goods and short-term borrowings. The major feature of the model is simultaneous determination of the functional parameters of marketing, production and finance in an integrated environment.

The model is applied to a paints manufacturing company for a period of 6 months (each month is a period). The unit selling price is considered as a predetermined parameter. The model consists of 130 variables and 147 constraints in its formulation. The multiple fractional objectives are transformed into linear goals with the prescribed values set for them by the management. The prescribed value for the current ratio is not less than 1.5 and the profitability ratio is not less than 0.3.

The results obtained from the model gave period-wise values of demand, production quantities, man-machine hours, raw material inventory, finished goods inventory, material order quantities from various sources, amount of stretched accounts payable, outstanding due on stretching of accounts payable, borrowings on hypothecation of goods, payments made towards borrowings on hypothecation, outstanding due on hypothecation, amount of short-term borrowings, repayment towards short-term borrowings, outstanding due on short-term borrowings and cash balances.

To conclude, the developed model is an optimization model which provides us the desired result under the stated circumstances.
6. SUMMARY OF FINDINGS AND CONCLUSIONS

A new generation global character has evolved in the recent past due to changes in the economic, political and technological arena. These changes have compelled the small industries culture to take new dimensions. As new technologies are adopted in different parts of the world and organizations undergo structural and technological changes, some fundamental shifts are taking place in the small-scale industrial sector.

The rapid growth of the small sector resulted in significant dividends. By the end of the year 2002, the number of registered units are 34.42 lakhs, in terms of production it is Rs.6,90,316 crores, in terms of employment the sector provides direct employment to about 192.23 lakh persons, in terms of the exports it accounts to Rs.71,244 crores.

In spite of its growth, the failure rate in the small sector continues to be high. By the end of 2002, there were about 8,68,021 sick units constituting approximately 37.65% of the total number of small scale industrial units in the registered sector. The prevalence of sickness in the SSI sector is due to few operational aspects such factors as lack of demand.
for the product, shortage of working capital, non-availability of raw material, power shortage, labour problems, marketing problems, equipment problems, management problems etc. The percent of sick units on account of lack of demand is 71.6% in the registered sector as against 84% in the unregistered sector. The percent of sick units on account of shortage of working capital is 48% in the registered sector against 47.1% in the unregistered sector. These two factors are the major contributors for the small industry sickness.

Working capital refers to the current assets of a firm and includes inventories, accounts receivable, cash and marketable securities. Working capital represents the portion of assets that circulates from one form to another in the ordinary conduct of business [Cohen, 1966]. The idea embraces the recurring transaction from cash to inventories to receivables to cash that forms the conventional chain of operations. At any point in time a firm must decide both the level of working capital consistent with its productive assets and how to finance these assets [Bierman, 1975]. Working capital management is the functional area of finance that covers all the assets of the firm. It is concerned with the adequacy of current assets as well as the level of risk posed by the current liabilities [Hampton, 1983].

Deciding how current liabilities should be used to finance current assets is one of the most important decisions concerning working capital management. Walker (1964) stated that a definite relationship exists between the degree of risk (liquidity) and the rate of return (profitability). The decisions made with respect to various working capital...
constituents are complex and interrelated. A high proportion of business failures are due to poor decisions concerning the working capital of the firm [Smith, 1975].

In order to minimize the combined costs of production, finance and marketing an integrated model, which determines the selection of marketing strategy with the selection of a production schedule and selection of optimum working capital decisions, is required. Single objective models suffer from the drawback that they cannot satisfy the conflicting objectives of the firm in an integrated approach for simultaneous decisions. The complex interrelationships inherent in working capital problem require the use of multiple objectives rather than single objective models. Linear fractional (ratio) criteria are frequently encountered in finance area in situations that employ financial ratios such as liquidity and profitability. Therefore, it is more appropriate to model the working capital in a simultaneous framework with multiple fractional objectives.

The current work is an attempt to develop a model for working capital management that integrates the three vital sectors marketing, production and finance of a manufacturing concern. This work focuses on developing inventory models to determine optimum order quantity and cycle time while incorporating dependent demand, stretching of payments, short term borrowings, time value of money and cash flows, study the relative performance of small scale units using Data Envelopment Analysis and develop strategies for improvement of the performance of selected small scale industries and to develop and apply a simultaneous planning model for a small scale industry comprising of production, finance and marketing sectors for effective working capital management with multiple linear fractional objectives and linear constraints.
The thesis is organized into six chapters. Chapter 1 introduces the aim of the current study. This chapter emphasizes on the importance of planning models for working capital management for small scale industries. As it is a well known fact that in majority of the manufacturing industries inventory forms the major part of the working capital. The relative importance of the inventory is highlighted in this chapter. The significance of the simultaneous integrated working capital models is explained along with the broad frame work for the model development.

Chapter 2 is devoted for the development of five inventory models with diversified criteria. In the literature of inventory models the variations can be mainly brought in the demand for the item, delayed payment terms and consideration of the discounting approach for several inventory costs.

The Model I(*Inventory replenishment policy under supplier credit for dependent demand & discounted cash flow approach*) is developed with the assumption of the demand depending on the marketing variables such as price. This is a reasonable assumption and the same fact is proved by many of the earlier works. The model also considers the delay in payments and the discounted costs are taken so as to minimize the present value of various cost components. Three special cases are derived from the model which comply with the models developed by earlier contributors. Special case (i) deals with the situation when the demand is constant. For constant demand, the model reduces to that of Edward A Silver(1999). The special case(ii) is a situation when the payments are made immediately. The special case(iii) combines both the special cases mentioned above. The current model concludes that the optimum order quantity first decreases and
then increases with respect to the dependence factor between demand and price. This is due to the interaction between various costs that are present in the present worth equation. As it is a proven fact that the variable cost and fixed cost components in the total cost move in opposite direction and the combined costs first decrease and then increase. It is also concluded that the optimum replenishment quantity increases with the increase in the supplier permitted delay time for settling his accounts.

The Model III (Economic analysis of sinusoidal cash flow inventory system Present worth approach) presented in section 2.3 is developed to incorporate the concept of periodicity in a present worth framework. The sine function assumed in the model best describes the flow of inventory to and from the warehouse. Here it is assumed that a single item is procured from different vendors. During the period of procurement the items are not dispatched and they are simply accumulated in the warehouse. Only when the level of the inventory reaches the maximum desired level, the dispatch of the item takes place. The sine function behaviour is applied to the inventory holding cost. In the model a present worth function for sine function is developed in section 2.3.2.2 and applied to the inventory situation. Finally the optimum cycle time and the optimum order quantity are found for different values of discounting rate by considering a numerical example. It is concluded that the optimum cycle time and the optimum order quantity decrease with increase in discounting rate.

Model III (Evaluating investment in inventory with permissible delay in payments a discounted cash flow approach) aims at determining the optimum cycle time and the optimum order quantity when the vendor permits a delay in settling his accounts and the
manufacturer/retailer obtains bank finance to settle the accounts. The inventory holding cost is assumed to be separated from the interest charges paid/earned due to stock/sales. In this model the manufacturer/retailer borrows 100% purchase cost of the material from the bank to pay off the vendor's account at the end of the delay period, if the delay period is less than that of the cycle time. When the supplier permitted delay time is greater than that of the cycle time, the manufacturer/retailer can sell the items, accumulate the sales revenue and earn the interest for the cycle. In this case there is no need of getting bank finance as the sales revenue is ready in hand. The current model is put into a present worth framework by considering all discounted costs. The optimum cycle time and the optimum order quantity are found for this case of stretching of accounts in a present worth framework. It is shown that the optimum order quantity increases with an increase in the discount rate, when the permitted delay time for settling accounts is less than that of the cycle time. On the other hand the optimum order quantity decreases with an increase in the discounting rate, when the delay time is greater than that of the cycle time.

Model IV introduces the concept of the margin money in obtaining the bank finance when supplier permitted delay time exists i.e. the amount required to settle the supplier's account is a mixture of manufacturer/retailer's margin money and the bank finance money, when the permitted delay period is less than that of the cycle time. The bank provides only a fraction of the purchase cost of the items and the manufacturer/retailer need to supply the remaining amount to pay off the supplier's account. When the permitted delay time is greater than the cycle time, there is no need of bank finance at all since the sales revenue is in hand to pay off the account. The model
arrives at the expressions for the optimum cycle times for two cases. The model results are depending on the value of the 'denominator' of the optimum cycle time expressions under different cases. If the denominator is negative, then the optimum cycle time is infinity and the borrower opts to keep the loan money to the longest period possible. If the denominator is zero, the optimum cycle time is either infinity or \( T_2^* \) (optimum cycle time when the cycle time is less than or equal to delay time) associated with the least cost. If the denominator is positive, four different results are presented. At the end a comparative study of the present model is done with the models that are obtained by Goyal (1985) and Kuo-Jen Chung and others (2002). The comparative study has resulted in smaller optimum cycle times for the current model when compared with Goyal's model. But when compared with Chung's model, except for the case of \( N_1 < 0 \) and \( N_2 < 0 \), the optimum cycle times of the current model are equal to that of Chung's model. Even in the case mentioned above ( \( N_1 < 0 \) and \( N_2 < 0 \) ), it is reasonable to get longer cycle times since the earning rate \( (L_c) \) of margin money provided is lesser than that of the cost of capital \( (L_p) \) paid to the bank. This makes the denominator of the optimum cycle equation of the current model smaller than that of the denominator of the optimum cycle equation of the Chung's model.

Model V is an extension of the Model IV wherein the concept of hypothecation of goods is brought into. In this model, the amount of the bank finance that is obtainable is only a fraction of the purchase cost of the stocked inventory present at the time of borrowing the bank finance. It differs from the earlier model in the respect that in the earlier model the amount of bank finance obtainable is a fraction of the total purchase cost and it is independent of the amount of the stocked inventory. Hence this model deals with the
delayed payment terms, bank finance with margin money and hypothecation of the inventory. The results obtained in this model to determine optimum cycle times are similar to that of the previous model. But there is a change in the values of the cycle times for the same optimality conditions. A comparative study of the current model with the models of Goyal (1985) and Kun-Jen Chung and others (2002) is also made. The values of optimum order quantity and cycle time obtained using the current model are higher than that of the other two models. This is due to the introduction of hypothecation of goods component into the model.

On the whole chapter 2 is completely meant for developing the inventory models which have some practical utility in manufacturing and trading organizations. These models provide simultaneous culture as the models consider simultaneously the inventories, payment patterns, hypothecation of goods etc. These models are of immense help for the decision makers with regard to the optimum order quantities and optimum cycle times.

Chapter 3 describes the role, growth and sickness of small scale industries in India. The various protective measures taken up by the government is discussed in Section 3.1. In this section the definition of SSI with respect to size of investment is presented. The promotional measures for promoting the small scale industrial units is presented in Section 3.2. In Section 3.3 the growth of small scale industries is presented. There are 23,05,725 units in the country as on 31st March 2001. The total investment in the fixed assets is Rs. 6,90,316 crores. The current SSI sector has provided employment to 192.23 lakh persons.
Section 3.4 touches upon the distribution of SSIs based on the investment in plant and machinery, employment, export etc. Wide variations could be observed in terms of the investment in plant and machinery and the number of people employed in small scale industries. The credit facilities extended by the government, banks and other financial institutions for SSI sector are presented in section 3.5.

The sickness in the SSI sector is prominent due to various stated and unstated reasons. The sickness of SSI sector is discussed in Section 3.6. The various stated reasons for the sickness of a small scale industrial unit are Lack of Demand, shortage of working capital, Non-availability of raw materials, power shortage, labour problems, marketing problems, equipment problems and management problems. The statistics on the sickness of these units reveal that 'Lack of Demand' and 'Shortage of Working Capital' were the main reasons for sickness/incipient sickness in the SSI Sector.

Chapter 4 is aimed at studying the usefulness of Data Envelopment Analysis in evaluating the relative performance of SSI units. The heart of the analysis lies in finding the "best" virtual producer for each real producer. If the virtual producer is better than the original producer by either making more output with the same input or making the same output with less input then the original producer is inefficient. A typical statistical approach is characterized as a central tendency approach and it evaluates producers relative to an average producer. In contrast, DEA compares each producer with only the "best" producers.

In Section 4.1 various efficiency concepts are introduced. The three efficiencies viz., technical efficiency, allocative efficiency and cost efficiency are defined.
In section 4.2 the operationalization of DEA is discussed. Data usually are only available on a group of organisations which give limited information on theoretical best practice. First, it is unknown whether any of the organisations in the group, or sample, are achieving outright best practice. Second, the sample points will not cover all of the range of possible input combinations. Attempts are made to approximate best practice in the sample by estimating frontiers.

Section 4.3 describes how DEA is helpful for decision makers. By providing the observed efficiencies of individual agencies, DEA may help identify possible benchmarks towards which performance can be targeted. The weighted combinations of peers, and the peers themselves may provide benchmarks for relatively less efficient organisations.

In section 4.4 the scale efficiencies are discussed. The decomposition of the technical efficiency score into components resulting from, the scale of operations, surplus inputs which cannot be disposed of, and a residual or ‘pure’ technical efficiency. A further extension which is often important is to allow for differences in operating environments, this involves trying to adjust for factors which might be beyond managers’ control, and which thus possibly give some organisations an artificial advantage or disadvantage. The constant returns to scale DEA model do not include the scale of operations in it. A variable returns to scale model can easily be formulated by including a simple additional constraint to it. The scale efficiency of an organisation can be determined by comparing the technical efficiency scores of each producer under constant returns to scale and variable returns to scale. The distance from the respective frontiers determines technical
efficiency under each assumption. The distance between the constant returns and the variable returns frontiers determines the scale efficiency component.

Section 4.5 discusses the advantages and limitations of DEA. It can readily incorporate multiple inputs and outputs and, to calculate technical efficiency, only requires information on output and input quantities (not prices).

Sections 4.6 and 4.7 describes how DEA efficiency scores are calculated and how DEA is modeled. A DEA model in the form of a linear programming formulation is presented. The model presented is an input oriented model i.e. the objective is minimizing the inputs for a given level of outputs.

In section 4.8 two case studies are presented. The first case study is on the performance of rice mills. Ten sample rice mills are taken into consideration and constant returns to scale DEA and variable returns to scale DEA are applied to it. From the results of CRS DEA, it may be concluded that six out of ten rice mills are found to achieve 100 percent efficiency scores and the remaining four rice mills got less than 100 percent efficiency scores. The lowest efficiency score is found to be 0.80 for rice mill 8. Rice mill 4 is found to be truly efficient since it appears as a peer 4 time for the other rice mills.

The reason for applying both the constant returns to scale DEA and variable returns to scale DEA is to determine the scale efficiency. The scale efficiency of an organization can be determined by comparing the technical efficiency scores of each producer under constant returns to scale and variable returns to scale. The significance of scale efficiency is that small organizations can produce outputs with the same ratios of input to output as
can larger organisations. This is because there are no economies (or diseconomies) of scale present, so doubling all inputs will generally lead to a doubling in all outputs. However, this assumption is inappropriate in all situations. From the results of VRTS DEA, it may be concluded that there are no diseconomies of scale present in the ten mills as the CRTS DEA and VRTS DEA are similar. Non-increasing returns to scale DEA is applied to predict whether an organisation is bigger or smaller than its optimum size. From the study it is found that three out of ten mills are found to be bigger than their optimal size.

The second case study in this section is performed on 20 different SSI units for this case. Constant returns to scale efficiencies, variable returns scale efficiencies and non-increasing returns scale efficiencies are calculated and analysed for the relative performance. A comparative analysis of the results of Discriminant analysis as obtained by Rajagopal (1997) and that of the DEA is carried out. This analysis is carried out to see that there is any misclassification of the units. On the basis of combined analysis of 20 sample SSI units, there are three low performing units falling into high performing group and no single high performing unit is falling into low performing group. On the other hand according to discriminant analysis there are 2 low performing units falling into high performing group and two high performing units falling into low performing group. However the advantage with DEA is that for all the low performing units, the peer units are from high performing group only. Likewise no unit of low performing group turned out to be a peer for a high performing group. Hence it may be concluded that DEA as a tool for classification and sickness prediction has performed at least as good as discriminant analysis.

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Further DEA is applied to high performing group (HPG) and low performing group (LPG) separately and conclusions are drawn regarding the performance of the SSI units under consideration. Out of 20 SSIs the high performing group is observed to contain 11 SSI units and the low performing group is observed to contain 9 SSI units in it. Within HPG it is observed from DEA result that only one unit is inefficient amongst 11 units. Within LPG also there is only one unit which is relatively inefficient.

Chapter 5 aims at developing and applying a simultaneous planning model for a small scale industry. The structure of the model comprises of multiple fractional objectives with linear constraints. Maximizing current ratio and profitability ratio form the multiple objectives and the constraints are formulated based on the constraints on the raw materials, finished goods, man-machine hours, demand and sources of short-term financing such as stretching of accounts payable, hypothecation of goods and short-term borrowings. The major feature of the model is simultaneous determination of the functional parameters of marketing, production and finance in an integrated environment.

The model is applied to a paints manufacturing company. Such a model, it is hoped, would lead to better decisions as the interaction among the functional variables are considered and a total systems approach is followed. The unit selling price is considered as a predetermined parameter. The model consists of 130 variables and 147 constraints in its formulation. The multiple fractional objectives are transformed into linear goals. The prescribed values set by the management for the two goals are that the current ratio is not less than 1.5 and the profitability ratio is not less than 0.3.
The results obtained from the model gave period-wise values of demand, production quantities, man-machine hours, raw material inventory, finished goods inventory, material order quantities from various sources, amount of stretched accounts payable, outstanding due on stretching of accounts payable, borrowings on hypothecation of goods, payments made towards borrowings on hypothecation, outstanding due on hypothecation, amount of short-term borrowings, repayment towards short-term borrowings, outstanding due on short-term borrowings and cash balances.

To conclude, the simultaneous integrated model for working capital is an optimization model that provides us the optimum results under the stated circumstances.

**Scope for future work:**

It is a known fact that the scope of the inventory models is unlimited. Since the number of parameters in any inventory system is very high and most of them are uncertain in nature. An inventory model may be developed by considering that the demand is dependent on both the price as well as the level of advertisement expenditure i.e., the demand is expressed as a function of price and advertisement. An inventory model with permitted delay period on creditors and debtors side may also be considered as another variation and may be developed in a discounted cash flow framework. The uncertainties may be introduced into the models by relaxing the assumption of deterministic nature of the parameters.
DEA can be a very useful analytical technique that serves as an important 'first step' tool in comparative analysis. But users also need to recognise its limitations as an input to the development of organizational policy. Its theoretical predictions of potential efficiency gains may not be translatable into actual gains when factors such as uncertainties involve in the measurement of inputs and outputs, quality parameters, fundamental differences between individual units and the costs of implementing changes are fully accounted for.

The DEA studies may be extended to calculate the cost and allocative efficiencies. An extension of work that may be undertaken to account for the differences in the operating environments of different decision making units.

The Simultaneous integrated model developed is a macro model and has several assumptions being made for ease of modeling and solution. Only linear cost components are considered in the production cost by eliminating the inefficiency costs that result due to man-machine work, which are quadratic in nature. The model may be extended to include those non-linear terms and can be formulated as a non-linear model. In the finance sector of the model only stretching of accounts payable, hypothecation of goods and short-term borrowings are considered as the short-term sources of finance. But the other sources such as bill discounting, line of credit, etc., may be included. Though the short-term investment in the Indian context is impracticable in respect of SSI units, this component may also be incorporated in the model to give a global character to the model.

The uncertainties associated with the functional variables may be implemented in a chance constrained programming model.