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ECONOMIC JUSTIFICATION FOR COMPUTER INTEGRATED MANUFACTURING SYSTEMS USING BREAK-EVEN ANALYSIS

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Abstract

Implementation of computer integrated manufacturing system (CIMS) is being attempted in many manufacturing industries, but the success of such attempts depends upon the profit potentials of CIMS. This paper attempts to study the economic justification of CIMS for its adoption in manufacturing enterprises. The break even analysis technique is used to illustrate that adoption of CIMS is economically justifiable. A case in point for HRC fuse from the Indian industry has been used to justify this methodology. The results show that CIMS is economically justifiable. It is observed that the rate of returns earned by CIMS is much higher than the rate of returns earned by existing production system. It is also reflected that even in the worst situation the company will be able to earn the positive rate of return if it uses CIMS.

1. Introduction

A Computer Integrated Manufacturing (CIM) system is designed to meet the efficiency of high production transfer line and flexibility of job shop to suit the batch production of mid volume and mid variety of products. Even though the use of CIM system gains considerable attention in developed economies, in the developing countries their implementation is not getting impetus due to the fact that top level management in many organizations are still skeptical about expected returns from such a system.

Any production system is economically justifiable when the income following the investment is greater than the capital sum invested. By computer integrated manufacturing, we mean reintegration or improved integration of manufacturing enterprise by providing computer assistance and control and high level integration automation at all levels of manufacturing industries, and by linking islands of automation into a distributed processing system. Today, CIMS requires a total productivity management oriented approach in order to attain a high level of profitability, customer satisfaction, flexibility and internal balance within the enterprise. Until, the introduction of microcomputer based technologies in the mid 1980s, the use of computer in manufacturing was very expensive for most engineering companies. During the 1980s, the art of software tended to match the price of hardware and hence was much cheaper than before. Now increasing computing power and the falling cost of hardware and software mean manufacturing enterprise can strive to attain the basic goals of profitability, growth and survival.

The main advantages of the CIMS over the traditional system are that CIMS:

(a) improves the quality of product;
(b) reduces the manufacturing lead time;
(c) increases the reliability of operation;
(d) increases the economies of scope in manufacturing;
(e) is flexible in operation so as to handle all kinds of change;
(f) is cost effective in operation;
(g) obtains satisfactory return on investment.

The major cost associated with the CIMS is pre-production cost. The pre-production cost includes major capital investment before the beginning of actual production. The pre-production cost includes computer hardware, computer software, equipment, installation cost and other miscellaneous expenses. The main advantage of CIMS lies in terms of reduction in operating cost. For example, when the CIMS is adopted there is 67% reduction in inventory cost, 76% reduction in labour, 84% reduction in WIP and 20% reduction in administrative expenses (Mohanty 1993).

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Thus the CIMS is economically justifiable only when reduction in these operating costs is more than the pre-production cost.

Now a days, many studies are being conducted for the justification of CIMS for their implementation in industrial production. Most of the researchers used NPV methods to show that CIMS is economically justifiable [e.g. Hutchinson (1976), Meyer (1982), Sullivan (1984), Kalhorst (1983), Park and Son (1988), Primrose and Leonard (1986)]. Mohanty (1983) used SP-NPV value as elaborated by Krinsky and Miltenburg (1991) for the economic justification of CIMS. The calculation of NPV invites a lot of problems. NPV calls for estimates of costs and revenue over the entire project life which is difficult to assess. Very often the life of the project can not be estimated accurately because of the fact that the machines can be used longer than life by good maintenance. Changes in costs and revenues also can not be predicted. The decision about the discount rate is another problem. NPV takes into account the entire life of the project, it is not able to take into account the short term uncertainties for example recessional situation prevailing in the industry concerned etc.. Therefore, the alternative methodology of justification for CIMS based on break-even analysis has been adopted in this research.

2. Justification Methodology

Break-even analysis is a very useful tool for profit planning. It shows the relationship between volume of output, total costs and total revenue of the firm. At the break even point, the firm will have zero profit. Here the cost means the value of the material and non-material inputs consumed for producing the output sold during a year. Whether the payment for these inputs is made during the same year or not is not important. For example, if the machine is purchased in the year 1996, the purchase price of the machine will not be considered as cost in the year 1996 but it will be distributed over the expected life of the machine. That is depreciation on machine is considered as cost. In this paper, the depreciation has been computed by using straight line method.

The total revenue (R) of the firm is defined as:

$$R = PQ$$

where,

P : Price per unit

Q : Output in physical term.

The total cost (C) is the sum of total fixed cost (b) and the total variable cost (V). That is,

$$C=b + V$$

As a preliminary to break-even analysis, cost behaviour needs to be studied. Typically, costs are divided into three categories-fixed costs, variable costs, and semi-variable costs.

Fixed Costs: Almost every business incurs certain costs which are fixed in nature. These costs remain constant irrespective of change in the volume of output. They may represent depreciation charge, property tax, insurance, and rent which arise because the firm owns plant and equipment and hires factory premises, they may consist of interest burden on long-term debt. Fixed costs arise as a result of capacity creation and are invariant with respect to variation of activity or capacity utiilisation. They are a function essentially of time.

Variable Costs: Several important elements of costs very directly with output. For example, the total material cost varies linearly with output. Likewise, the cost of power and other utilities may vary directly with output. All such costs which vary directly with output are referred to as variable costs.

Semi-Variable Costs: Many cost items do not conform to the pattern of fixed costs or variable costs. Cost of telephone, for example, consists of a fixed tariff plus a variable tariff which becomes applicable beyond a certain number of calls. Such costs are referred to as semi-variable costs.

The total fixed cost does not depend upon the level of output. It remains fixed whatever the level of output, where as total variable cost varies directly with the level of output. That is, V=vQ (assuming the relationship is linear)

Where v is the variable cost per unit.

The profit Π is defined as difference between total revenue (R) and total costs (C). That is,

$$\Pi = R - C$$

$$\Pi = PQ - b - vQ$$

$$Q = \frac{\Pi + b}{P - v}$$

At the break-even point, Π = 0. That is break-even level of output (Q*) is defined as:

$$Q^* = \frac{b}{P - v} \qquad (2.1)$$

The margin of safety (S) is defined as the differences between the actual output (Q') and the break-even output. That is,

$$S = Q' - Q^*$$

If S > 0 (i.e. Q' > Q*), it means that the firm is earning positive profit.

If S < 0 (i.e. Q' < Q*), it means that the firm is incurring loss.

If S = 0 (i.e. Q' = Q*), it means that the firm is earning zero profit.

If the value of S is high enough, it means that the firm will be able to absorb the shocks arising out of the short-term uncertainties in the form of depressed market situation.

Differentiating (2.1) with respect to b, we get

$$\frac{\delta Q^*}{\delta b} = \frac{1}{P - v}$$

Thus, if there is an increase (decrease) in fixed cost, the firm will have to produce more (less) to break-even. Thus, the value of S will decline (increase).

Differentiating (2.1) with respect to v, we get

$$\frac{\delta Q^*}{\delta b} = \frac{b}{(P - v)2}$$

Thus, if there is a decrease (increase) in variable cost per unit, the value of Q* will decline (increase). That is, the value of S will increase (decrease).

When CIMS is adopted it increases the fixed costs (i.e. annual costs and depreciation cost) but reduces variable costs (i.e. production costs). Thus, the CIMS is economically justifiable only when decrease in Q* due to decrease in variable cost is more than the increase in Q* due to increase in fixed costs.

3. Illustrative Example:

In this research, a case study of High-Rupturing-Capacity (HRC) fuse cited by Mohanty (1993) has been used to show that CIMS is economically justifiable using break-even analysis.

A large scale Indian manufacturer of capital-intensive, high-technology-based products and projects for the last 50 years intends to incorporate the principles and practices of computer integrated manufacturing in its various operations to achieve the following objectives:

(a) to meet the consumer demand on time;

(b) to produce high quality of HRC fuse (100% inspection), and

(c) to achieve higher profits.

An attempt was made to study the operation of the manufacturing system of a particular product called a "high-rupturing-capacity" (HRC) fuse.

The constraint in the existing production system are as follows.

(a) The lead times and testing times are very high (amounting to 65% of total production time).

(b) The quality of the product is dependent on the quality of components over which the company's control is restrictive (20% rejection).

(c) There are space constraints due to the work in progress (WIP) inventory (40% capital blocked for WIP inventory).

With increase in the demand for HRC fuse, the lead time of the various operations needs to be reduced to a great extent (by 30% of total production time).

To achieve the above, the company is now interested in implementing a CIMS for the manufacturing operations. This break-even analysis described in section 2 was applied to study the justification process.

Mohanty partitioned the state of the economy into following three equally probable economic states:

State 1 : the downturn economy

State 2 : the normal economy

State 3 : the upturn economy

Break-even output and margin of safety is calculated for the existing production system (EPS) and CIMS by estimating the fixed costs, variable cost per unit and annual demand.

Table 1. Justification Analysis

	EPS			CIMS		
	State 1	State 2	State 3	State 1	State 2	State 3
$b(10^5$ Rs)	13.3	13.3	13.3	21.7	21.7	21.7
v (Rs)	180	180	180	53	53	53
P(Rs)	200	200	200	200	200	200
$Q^*(10^2$ U)	0.67	0.67	0.67	0.15	0.15	0.14
Q1 $(10^2$ U)	0.7	0.8	0.9	0.7	0.8	0.9
$S(10^5$ U)	0.03	0.13	0.23	0.56	0.66	0.76

U means units

Here the state of the economy is defined in terms of change in annual demand. State 1 is considered as the recessionary period in which annual demand is low for a given level of price. State 3 is considered as the boom period in which annual demand is high for a given level of price. State 2 lies between state 1 and State 3. Thus in all the three states, price is assumed to be constant. That is, it is assumed that if the firm was charging a certain price in State 2 and the firm charges the same price in State 1, the annual demand will decline in State 1. The variable cost per unit is also assumed to be constant in all the three states. This is because whenever there is change in output, the total variable cost (TVC) changes but the variable cost per unit remains the same. For example, suppose at present the firm produce x units of output and the variable cost per unit is:

$$\text{That is, } v = \frac{TVC]_{Q=x}}{x}$$

$$xv = TVC]_{Q=x}$$

If the level of output changes from x units to x' units, then

$$TVC]_{Q=x'} = \frac{TVC]_{Q=x}}{x} x'$$

Thus the variable cost per unit to produce x' units of output is

$$\frac{vx'}{x'} = v$$

which is the same as variable cost per unit to produce x units of output.

The estimate of break-even output and margin of safety for the three economic states for the EPS and CIMS are given in table 1. From the study, the following results are obtained:

1. In an economy downturn situation of state 1, the margin of safety in case of existing production system (EPS) is only 0.03 while it is 0.56 in case of CIMS. That is, if the annual demand decreases further by 4%, the company will start incurring the losses if it uses EPS. On the other hand if the company uses CIMS, it will incur loss only when the annual demand reduces further by 80% (which looks like an impossible situation). Thus the results show that even in the worst situation the company will be able to earn a good amount of positive profit if it uses CIMS.
2. It is also observed that, even in the worst case of economic downturn period (state 1), the margin of safety in case of CIMS is greater that the margin of safety in case of EPS in its economic upturn period (state 3).

For the case example, economic analysis favours the CIMS. Thus the CIMS is suggested for adoption.

4. Concluding Remarks:

This research shows that CIMS is economically justifiable using break-even analysis. It is reflected that even in the worst situation the company will earn the positive profit if it uses CIMS. That is, if CIMS is adopted, the increase in profit due to decrease in variable cost is much higher than the decrease in profit due to increase in fixed cost. Thus CIMS is suggested for adoption to increases the profitability and to cope with the emerging technologies in the area of manufacturing for variety of products.

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