ISSN 0970-3365

UDYOG PRAGATI

Vol. 37, No. 1
January-March, 2013

The Journal for Practising Managers

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NATIONAL INSTITUTE OF INDUSTRIAL ENGINEERING
Mumbai-400 087 INDIA

UDYOG PRAGATI - The Journal for Practising Managers

Vol. 37, No. 1, January-March, 2013

Udyog Pragati is published as a Quarterly Journal by the National Institute of Industrial Engineering.
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IN THIS ISSUE…

A Retrospective of Dr. Eliyahu Goldratt's Novels Focusing on Operations Management

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Abstract

Dr. Eliyahu Goldratt, one of the leading management thought leaders of recent times, passed away in June 2011. Apart from his contributions to manufacturing and operations management, and management in general, Goldratt popularized the genre of management novels - books comprising exposition of management concepts written in story form with lifelike characters. He authored five such books between 1984 and 2009, and it is interesting to note that they are full-length novels set in the apparently dry world of operations management. As a tribute to his contributions to the profession, we present here a retrospective review of these books and the insights from them.

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1. Introduction

The idea of using a story to convey a message or concept has been used by scriptures and wise men over the millennia in every civilization. This approach is well suited for business and management contexts, which involve functional aspects as well as human interactions and organizational complexities. Three such kinds of writings have been observed in literature over the years. Business fiction refers to works of popular literature that are set in the world of business - possibly with a message - for example the books by Arthur Hailey or Michael Crichton. Then, management fables and parables use mythical or allegorical formats to bring out managerial insights, such as in "The One Minute Manager" (1983) and its sequels. Finally, management novels are full-length books comprising exposition of management concepts in organizational settings, and written in story form. If done well, this approach can capture the human processes involved in addition to the situational context.

Fictional representations help the reader to take on various roles vicariously, and enhance understanding through imaginative enactment (Warren, 1989). Eventually the ideas work their way into one's thinking, and one also experiences suspense and the joy of situation resolution, an essential aspect of thinking process development. Reading such fiction dealing with business issues, conflicts, and dilemmas can also enlighten and sensitize the reader in a way that generates insights that are potentially different from those arising from the study of cases (Kennedy & Lawton, 1992), or other academic observations. Further, if innovatively dramatized, such books still leave some visualization to the reader's creativity.

Dr. Eliyahu Goldratt, one of the contemporary management thought leaders, stimulated the popularity of the genre of the modern management novel. Beginning with "The Goal", he authored five such books over 25 years between 1984 and 2009, and it is noteworthy that they are well-constructed full-length novels set in the apparently dry world of business operations. His success inspired many other authors to emulate the format in several areas of business and management. Dr. Goldratt passed away on 11th June 2011, and over his lifetime made several lasting contributions to Manufacturing and Operations, and Management in general. As a tribute to his contributions, we present a retrospective review of his Operations novels and the lessons/ insights from them.

2. Reviews of Goldratt's Operations Novels

Summary information about the books reviewed in this paper is shown in Table 1. We have excluded the prolific non-fiction writings by Goldratt, as well as novels by his associates or inspired by his writings. The reviews are presented in the chronological order of their original publication.

Table 1: Summary Information on Goldratt's Operations Novels

No.	Title	Co-authors	Year	Length	Main Operations Areas
1	The Goal	Jeff Cox	1984 (Later eds. 1994; 2005)	286 pp. (335; 396 pp.)	Manufacturing Planning & Control, Problem Solving, Drum Buffer Rope & Theory of Constraints (TOC)
2	It's Not Luck (Goal II)	-	1994	281 pp.	Manufacturing/ Marketing Interface, TOC Thinking Processes
3	Critical Chain	-	1997	246 pp.	Project Management with TOC, Critical Chain concepts
4	Necessary But Not Sufficient	Carol Ptak & Eli Schragenheim	2000	231 pp.	ERP/Advanced Planning Software Solutions in Operations
5	Isn't It Obvious	Ilan Eshkoli & Joe Leer Brown	2009	151 pp.	Retail Supply/ Demand Chain Management

2.1 "The Goal" (1984)

In 1979 a group of Israeli professionals, including 32-year old physicist Eliyahu Goldratt, brought out one of the earliest commercial Production Planning & Scheduling Software called Optimized Production Technology (OPT). To propagate the underlying concepts and help sell the software, Goldratt chose to write "The Goal", a book in novel format, with the help of creative writer Jeff Cox.

The book's protagonist Alex Rogo ("Rogo: to ask, inquire, or question" in Latin) is a plant manager of a troubled engineering job shop at UniCo, an American corporation. The plant's severe problems seem typical - high inventories, missed deliveries, and financial losses - despite having modern technology, skilled workforce, and apparently high efficiency levels. Alex is given three months to turn the plant around, or it must be closed down and he loses his job. His family life is in trouble too, largely due to his having too little time and attention for them. Indeed, during the story the crisis reaches the point where his wife actually walks out on him for some time.

Against this backdrop Alex runs into his former Physics professor Jonah, probably based on Goldratt himself, at an airport. Jonah cleverly makes Alex realize that the fancy new robots at the plant have neither reduced costs nor increased sales; though Alex claims they have considerably improved efficiency. With Jonah's guiding questions, Alex is able to articulate that the goal of any organisation is simply to make money, now and in the future. He also culls out three key indicators of plant performance in support of the goal:

1. Throughput, the rate at which the system generates money through sales
2. Inventory, all the money that the system has invested in purchasing things for making what it intends to sell
3. Operating Expense, all the money the system spends in converting inventory into throughput

The aim, therefore, is to increase throughput while simultaneously decreasing inventory and operational

expenses. Alex discovers problems everywhere in the plant, with most attention given to firefighting of crises, and he is unsure where to even start. A key inspiration for solving the plant's problems comes to Alex during a hike with his son's troop of Boy Scouts. The troop moves much more slowly than he reckons it should, and keeps spreading out during its hike. He identifies that overall speed is determined by the slowest scout Herbie, and that troop spread is determined by the sequence of hikers. A dice-matchstick game helps to further clarify his thinking about statistical fluctuations, dependent events, and the problems of balanced lines. Based on these insights, he then relieves Herbie of some of his load to speed him up, and rearranges the sequence of hikers to keep the troop from spreading. Ultimately the troop speeds up as a whole and can complete its hike in time. While solving the problems of the hike, Alex also recognizes the analogies between troop speed and throughput, and between troop spread and inventory.

Alex now starts applying the insights from these analogies in his plant, and the machine NCX-10 and Heat Treatment are quickly identified as the bottlenecks. He exploits the bottlenecks by reducing loads, rearranging work-hour patterns, placing inspection points intelligently, and selectively augmenting capacity. Further tuning of performance is achieved by changing the Production Control system to identify parts feeding into the bottleneck and those that have critical due dates. Red-tagging is introduced to give such parts priority, and the entry of material from the input stage is regulated from the bottleneck.

Alex then extends his ideas to other aspects of plant operations, attacking different components of lead time. Through setup reductions, he cuts batch sizes by half which significantly improves inventories as well as lead times. A major contribution is the idea of a Transfer Batch, the quantity moved at a time, as distinct from the Process Batch which is the quantity produced in a single stretch. He also exposes some limitations of traditional Cost Accounting, which for example does not distinguish between costs at bottlenecks versus at partially idling non-bottleneck resources. These ideas have now taken shape as Throughput Accounting.

Like a happy ending in a good novel, eventually Alex saves his plant and is promoted to division head. He also averts the crisis in his marriage by applying the same principles. In order to articulate and develop his ideas Goldratt uses the Socratic approach: a process of arriving at a conclusion through a series of questions and answers, rather than by prescribing a solution. The problem solving approach used involves systematically finding bottlenecks, making improvements, hitting the next impediment and working on it, and so on. Eventually, it was generalized into the broader approach called Theory of Constraints (TOC).

Goldratt had only 3000 copies printed initially, and distributed them to friends, prospective clients, and at trade shows. However it soon became very popular, mostly by word of mouth, and is now one of the top-selling management books ever with millions of copies sold in over a dozen languages. It consistently shows up in business school reading lists and "Manager's Bookshelf" compilations. Some people must regret their initial judgements - the publishers who declined to publish it, and especially the co-author Jeff Cox. Goldratt himself wrote that Cox was so skeptical of the concept of a manufacturing novel that he insisted on an upfront cash fee for co-writing it, rather than take a share of the royalties!

Comments

"The Goal" is a landmark management book in terms of its content, novel format, and wide acceptance. One of the reasons why it appeals to practitioners is that they can identify with the situations, and that Alex even seems to think like them. The book also does a commendable job at portraying Manufacturing as demanding but important as well as intellectually challenging - a major contribution in itself, and perhaps more than what academicians have achieved (Pinedo, 1997). Several of the ideas articulated are now part of the foundations of Operations Management, in particular the concepts of flows, bottlenecks, and constraint-based planning. The scheduling approach was eventually encapsulated as "Drum Buffer Rope", where the Drum or bottleneck sets the system's pace, the Buffer protects the drum schedule, and the Rope

links material intake to the drum (Goldratt & Fox, 1986). The software OPT also launched the business software category of Capacity Constrained Production Planning & Scheduling.

Professional literature is replete with case studies and papers on application of these concepts over the last 25 years. However, academic acceptance was slow probably due to the algorithmic details not being well documented, and Simons & Simpson's outline exposition (1997) was one of the first though basic efforts at academic dissemination of the scheduling aspects. Ironically, one of the book's prime "goals" - to promote sales of the software - was not quite accomplished. Several managers commented that by systematic application of the principles outlined in the book they were able to achieve major improvements so simply and cheaply, that they didn't need to buy the software. Eventually, Goldratt had to leave his own company and went on to become a professional management guru full-time.

2.2 "It's Not Luck" (1994)

In this sequel, written solo by Goldratt, seven years have passed since Alex Rogo's turnaround of the plant in "The Goal". He is now Executive Vice-President of UniCo, given the responsibility of preparing for immediate sale of the diversified companies under his charge to release resources for the core business. He needs to make them so good that they either avoid being sold altogether, or get a lucrative price; as well as make them such role models that no owner meddles with their working. Alex's teams realize that the constraints lie in the markets rather than the plants, and they need to look for marketing breakthroughs to stimulate sales. Using Jonah's Thinking Processes to identify core problems and resolve conflicts, they evolve some innovative supply chain and marketing solutions. A couple of necessary conditions are added to the original "goal" of making money - to provide satisfaction to customers, and to provide a secure and satisfying work environment for employees.

The printing business makes wrappers and boxes for candies and similar products. The market is characterized by cost-based competition with large order sizes of up to six months requirements to achieve the best prices. The loss-making wrapper division is fast at art-work preparation and at changeovers, making short runs profitable, but not as good at long runners. Study reveals that the segment's customers end up with considerable obsolescence due to forecast errors and marketing/ product changes, with only 30% probability of using up the entire lot sizes. Changing the perspective, to view the producer and customer as a single linked community, results in modifying the metric from cost per unit *transacted* to cost per *usable* unit. This exploits the firm's flexibility advantage while countering the cost disadvantage, with orders now taken for two months quantity but deliveries executed only two weeks at a time. Selling the scheme involves making a 'mafia' offer that is too good to refuse, but which initially proves too complicated to sell, until the Sales team changes its approach to structure the deal from the buyers' viewpoint. Eventually the company gets 3-4 times the expected price, and is sold as a model of that business being a benchmark, school, and consultant all-in-one.

The cosmetics company manufactures hundreds of products sold through thousand of stores, and operates on forecast-driven push mode, with lead times of three months. Mismatches between demand and supply, coupled with product changes and introductions, cause overstocking/ obsolescence as well as stock-outs. The industry is characterized by large orders to enable discounts, but which cause liquidity problems for the stores. The trade-off between inventory and service is resolved by introducing centralized stocking, coupled with controlled regional stocks for ensuring responsiveness. Three weeks regional stocks are now held, and executed through daily replenishment based on actual consumption. Discount structures are changed to annual volume basis rather than being purely order quantity-based. Consignment sales are introduced whereby the store pays the company only on final sell-through, subject to allocation of adequate shelf-space. These initiatives result in this division also getting 3-4 times the originally expected price.

In the pressure steam business, it turns out that the equipment itself is sold nearly at cost, and the real

money lies in spare parts for service. This leads to streamlining of the spares support system. Eventually, the company repositions itself to become a steam service provider rather than an equipment supplier, and even hires the clients' best steam maintenance personnel despite a hiring freeze. The pricing approach is also changed to a flat monthly fee plus a usage based fee, with a penalty for long breakdowns. Ultimately the division avoids sale altogether, and is kept as a role model electro-mechanical job shop within the UniCo group itself.

The ideas used leverage the unique capabilities of each division, resulting in substantial improvements in the performance and profitability of the companies. Along the way Goldratt articulates his general problem-solving approach, and also discusses the nature of market segmentation and strategies to exploit it. As usual, there is a family sub-plot that is also resolved using the same techniques.

Comments

The book highlights some contemporary Operations Management concepts from Goldratt's unique perspective. The value of manufacturing flexibility and alternate commercial arrangements are demonstrated in the printing company. Risk pooling and replenishment concepts are used in inventory location and sizing decisions in the cosmetics firm. Finally, interesting approaches to bundling, selling and pricing services are shown in the steam business.

This book marks introduction of the Thinking Process techniques such as Cloud Diagramming, Reality Trees etc., which makes parts of it feel less like a novel and more of a professional book. The techniques also seem to be introduced a little suddenly, and one needs to read other TOC material to properly appreciate them. In order to stimulate sales of the book in subsequent years, it was re-titled as "The Goal II: It's Not Luck" to explicitly indicate its status as a sequel.

2.3 "Critical Chain" (1997)

Goldratt's third novel is about development and application of TOC concepts to Project Management. It is set in a Business school, where the protagonist Rick Silver is a faculty member who is told that he is unlikely to get tenure, unless he can develop meaningful courses that attract students to the Executive MBA program. This new approach is evolved during an elective course on Project Management being attended by several practicing project executives. TOC insights are provided by Johnny Fisher, a professor just back from a sabbatical spent at UniCo – the same company in which the first two novels were based.

Rick adopts a discussion-based format for the classes, and the students identify the major problems of Project Management as budget overruns, time overruns, and content compromises. Most of the treatment in the book is oriented towards the time aspects, which naturally influence the other two as well. They then articulate three mechanisms by which safety is inserted into projects. First, time estimates are based on a pessimistic experience resulting in every activity having considerable buffer time, though much of it is wasteful due to skewed probability distributions. Next, each management level adds its own safety factor to protect against estimation errors and execution uncertainties. Finally, estimators provide padding to guard against their senior levels making a global cut, the latter in turn motivated by all these protections leading to inflated project estimates.

However, all these safety provisions eventually get wasted due to three causes. First, the Student Syndrome - no rush, so start at the last minute - uses up most of the buffer right at the start of the activity/ project, effectively making everything critical especially the tedious jobs. Then Multi-tasking, sharing of the same resource by many activities, leads to either some tasks getting delayed at the cost of others, or all tasks getting slowed down due to time-sharing. Finally, Dependencies between steps due to precedence or resource constraints mean that delays accumulate but advances (early activity finishes) are wasted.

Rick and the class together begin thinking through the above problem areas. To help evolve the project management solutions, there is a review of Goldratt's planning and scheduling methodology, including discussions of the problems at UniCo, the boy scout/

soldier analogy from previous books, and an example of a steel production mill. Excessive safety in individual task estimates is reduced by planning based on median durations, with a combined "Project Buffer" provided at the end of the project. Paths subsidiary to the Critical Path should have "Feeding Buffers" inserted between their own task sequence and their connections to the main path. Tasks requiring constrained resources also require "Resource Buffers" ahead of them to ensure that nothing delays critical activities.

At execution stage, regular alerts are required about work progress, so that the next activity chain is ready to begin its segment as soon as actually needed. Proper sizing and monitoring of buffers helps to limit the impact of delays and uncertainty. Also, time-cost tradeoffs and penalties need to be worked out when dealing with vendors in the project environment, and performance metrics devised accordingly. The term Critical Chain is defined as the longest chain of "dependent" steps in a project, where the dependency could be due to precedence (the usual Critical Path view) or resource constraints.

Ultimately, Rick's students apply their lessons in their own companies and save significant time and money. Industry is obviously pleased with the B-school's efforts and agrees to a long-term association - resulting in Rick earning tenure.

Comments

Critical Chain Project Management has become a recognized part of the broader field of Project Management. Specialized software incorporating these concepts as well as add-ins for commercial tools are now available. Several organizations have reported success at applying the concepts and tools in resource-constrained environments. Though the book is aimed mostly at scheduling aspects, several project content related issues are also pertinent, especially in high tech or infrastructure projects. More persuasion effort is needed, beyond what is shown, on how to get estimators to give lean estimates over the long-term. The Critical Chain itself is actually an evolved representation of the Critical Sequence concept already used in resource constrained project scheduling literature.

The classroom setting is useful to illustrate the process of interactively drawing out problems, causes, and solutions – not all new but with a fresh perspective. However the concepts are easier to appreciate if one has read other books by Goldratt or on TOC, but then the incremental value addition would also be lower. In terms of format, the book feels somewhat textbook-like in some parts, perhaps unsurprising given the classroom context.

2.4 "Necessary But Not Sufficient" (2000)

Goldratt's fourth novel is co-authored with a former APICS President (Carol Ptak) and the developer of Goldratt's instructional simulations (Eli Schragenheim) respectively. It documents the perspectives of BGSoft, an Enterprise Resource Planning software company, and its systems integrator. Facing possible declines in profitability and Wall Street valuations due to saturation in the high-end market, the company decides to target the mid-market segment which necessitates a change in its business approach. Meanwhile the software itself is growing increasingly complex, with trade-offs between capabilities and problem-solving vs. response time needing to be resolved.

Based on observations at successful users, BGSoft builds in the Drum-Buffer-Rope logic evolved in earlier Goldratt books into its software's planning engine. The ERP software and bottleneck schedule are linked through custom-programming, with weekly planning runs. Recognizing the need for more sophisticated tools, it then acquires an Advanced Planning & Scheduling firm to help with optimizing bottleneck schedules and handling dependent setups. The new software is a finite-capacity scheduler, with the objective of shipping customer orders on time considering material, capacity and tool availability. Its output is a "Best Practical" Master Schedule rather than a mathematically optimal one. Safety time is used to avoid propagation of disruptions, and safety capacity provided to cope with disturbances. Actual execution is controlled using Buffer Management techniques.

BGSoft also incorporates systemic changes in Supply Chain Management and Replenishment practices. Lead times and stock levels are tightened, with smaller and

more frequent shipments. Inventory is redistributed to exploit better accuracy of pooled forecasts, at a combination of plant and regional warehouses with daily replenishment pulled by consumption, to achieve a good balance between inventory and response time. Metrics are introduced for On-time and Inventory performance, evaluated by Throughput Dollar-Days and Inventory Dollar-Days respectively. Since competition these days is increasingly between supply chains rather than individual companies, the Production/ Distribution/ Engineering solutions need to be extended across the chain to improve inter-company collaboration rather than be limited to intra-company level.

The business case development for ERP is a useful approach in itself, especially since the mid-market segment is much more conscious of business benefits and value-for-money. The usual benefits hyped up as "seamless integration" and "improved visibility across the chain" are not really meaningful unless they can be translated into financial gains. To illustrate, it is shown how to quantify the value of invoice error reduction; material cost savings resulting from purchasing consolidation; inventory reduction and lower stock-outs etc. The sales approach also needs to change across different levels and functions in the organization: rather than being aimed at just the IT professionals who are concerned with technologies and configurations, it needs to address middle-management concerns such as process improvement and lead time reduction. Finally, the approach must assess the net bottom line impact that top management is interested in, especially at SMEs.

From a technology usage perspective, a large software implementation is beneficial only if it helps to challenge assumptions and remove limitations. The greatest benefits are realized by those who change the rules so as to make use of the new capabilities, rather than keep working the usual way. Several software industry trends show up as innovative marketing solutions, for example outsourcing of ERP/IT as a service with value/volume based pricing. The book also offers new mechanisms for consulting, and using pilot assignments for gaining pre-sale credibility. Further, integrated services involving the vendor, system integrator, and consultant are more valuable from the customer's perspective. Project Management tools are also introduced for the technology people themselves to help manage multiple IT initiatives. Ultimately, technology is shown as only one part of overall business improvement.

Comments

The Production solutions make use of Drum-Buffer-Rope concepts from "The Goal", while the Distribution initiatives are based on Supply Chain Management solutions in "It's Not Luck", and the multi-project management solutions draw from "Critical Chain". As such, the focus is on application of earlier concepts rather than evolving new approaches; however, the lessons and solutions are better appreciated if one has read the previous books. The business case development exercise and financial quantification of IT-based improvements offer interesting learning contributions.

Though not as independently value-adding as the earlier novels, "Necessary But Not Sufficient" does integrate multiple concepts into a single whole. It also sheds some light on the thinking that goes into an Advanced Planning tool such as Capacity Constrained Planning & Scheduling, which indeed was Goldratt's initial contribution area. However being an expository novel the algorithmic aspects are not fully described, and non-operations aspects of ERP are given little attention. While the book does make clear that technology alone may not be enough, it is not established properly why technology is deemed to be absolutely necessary, rather than being just desirable.

2.5 "Isn't It Obvious" (2009)

Goldratt's fifth and final novel is set in the Retail business with emphasis on Supply Chain Management aspects such as Sourcing, Inventory, Warehousing and Distribution. The story is about a family-managed regional chain of home textile stores, where the founder CEO's daughter heads the Purchasing function, and the latter's husband is the manager of the store where much of the action happens. A facility emergency

forces the store to move most of its inventory back to the regional warehouse. In-store inventory of each item now has to be tightly capped at twenty days average sales, with daily replenishment as needed only of items sold. At the warehouse, a designated area is set up with replenishment stocks for that store, and any shortages are met using residuals from other stores' fulfillments. Stocking levels are chosen to represent the trade-offs between stock-out (lost sale) vs. surplus stock (inventory and markdown). Inventories are monitored and fine-tuned using decision rules to adjust stock levels based on ratios of actual to planned stocks.

When extending this locally successful approach across multiple stores, the frequency and complexity of material handling needed increases considerably. This challenge is met by adapting the model practiced in the books business, which is also characterized by SKU proliferation, and a combination of bulk sales with many small deliveries. A common mini-warehouse is now set up to serve all the stores in the region, with replenishment triggered by lean reorder levels; this approach results in lower aggregate space/ stocks due to pooling benefits. Internal mismatches between demand and supply are managed through a judicious combination of pooled central storage and decentralized local stocking, with transshipment if needed to match up local shortages/ excesses. In order to cope with region-level mismatches, a central warehouse is created near the port to provide inventory deployment flexibility.

Persuading people of the merits of the new system requires substantial effort, especially since store managers are conditioned to hold large stocks, and even fear closure when inventories are kept low! The classical inventory saw-tooth diagram is used to explain the system, and demonstrate the benefits of changing from the fixed order quantity/ reorder point based system to a periodic (daily) review and replenishment system. Even so, the COO feels that it is just an exchange of inventories - warehouse stocks are now four times store stocks, reverse of the industry norm - and that the system's inefficiencies are being exploited to boost local performance, rather than improving the system itself.

At the supplier end, sourcing is largely done from the India and the Far East. While low procurement cost is a major motivator, quality inconsistency and delivery undependability cause immediate review and even cancellation. Intense price negotiations are initially based on order quantity discounts, but are later tied up to assortment and expedited delivery commitments. External mismatches between forecast accuracy and product availability are met by forecasting at most aggregated level - dyed fabric - but dealing with longer lead times through supply chain/ logistics partnering arrangements. Long-term bulk orders are eventually placed, with dyed fabric pre-positioned at suppliers three months in advance, and fulfillment executed through phased deliveries. The impact of higher shipping costs is reduced by combining multiple items into single container consignments. Bonuses are later introduced for supply chain partners based on inventory turns, and for achieving over 95% delivery performance.

The net result of these initiatives is a significant sales increase without corresponding changes in the number of customers entering the stores. Further, inventory levels are considerably reduced leading to large increases in turnover ratio (to supermarket levels), as well as improved Return-on-Investment. Ultimately, the approach becomes so successful that the chain expands nationally and then globally. During the story, Goldratt's problem-solving approach is demonstrated as the managers think through their situations. As usual, a family/ personal life sub-plot is inter-twined with the main plot.

Comments

The co-authors are professional creative writers, which results in the book's tightly scripted flow. Some things are obviously dramatized for contrast, for example the six month original stock level (based on three month's production lead time and six to seven weeks delivery time) is high by contemporary standards. Indeed, companies in the textile and apparel industry where this novel is based are already performing better. Likewise, many proposed solutions such as those on inventory location and order fulfillment have been in

use in other sectors for some time, and Distribution aspects had already appeared in "It's Not Luck".

The pace and relatively short length mean that some human and managerial aspects are not developed fully. For example, many changes are accepted too easily with little real resistance, and some people are too cooperative - it helps that two of the key characters are a married couple from the owner-family and a third is their best friend. Further, marketing linkages are not examined in full depth, such as item assortment/ selection decisions, forecasting and executing new item introductions, impact of store display design, discounting etc. However, the book does bring together several Supply Chain management aspects together in an intuitive format, and is a useful read though perhaps not quite a major breakthrough (Srivastava, 2011).

3. General Discussion and Concluding Remarks

It can be observed from the above summary descriptions that the scope of the books gradually expands from Manufacturing to a wide range of Operations aspects such as Supply Chain Management, Marketing linkages, Retailing & Distribution, software-enabled solutions, and Project Management. "The Goal" in particular is a management trend-setter in its own right, and "Critical Chain" is a recognized approach in the Project Management domain. The other three are less widely known, perhaps being viewed more as extensions of "The Goal". "Isn't It Obvious**"** has special historical importance being Goldratt's last original completed book in any genre.

All the books demonstrate an underlying approach to systematic problem solving, commonly referred to as the Theory of Constraints (TOC), which was incorporated from the 2nd edition of "The Goal" (1994). The approach is often used by improvement-focused groups as a means of structuring their diagnosis and solution process:

Step 1: Identify the system's constraints.

Step 2: Decide how to exploit the system's constraints.

Step 3: Subordinate everything else to the above decision.

Step 4: Elevate the system's constraints.

Step 5: If during the above step a constraint has been broken, go back to Step 1, i.e., do not let inertia become a constraint.

The description of thinking processes includes extraction of insights and knowledge, through reasoning and deliberation. Typically the managers concerned evolve the solutions themselves, through asking the right questions. Mentoring is usually provided by an advisor - insider or outsider - with special insights, such as the now iconic Jonah in "The Goal", Prof. Silver in "Critical Chain", and various wise men in other books. The reader often reaches the solution only *just* before it is presented in the narrative, though he/ she may not have been able to articulate/ verbalize it unaided; this approach also helps to reinforce thinking. Even when dealing with common topics in Operations, the treatment brings things out in a manner different from conventional literature. The novel format also helps to bring out that the journey may be as important as the solution itself.

Apart from the problem solving approach, there is some description of how to explain the solutions and convince others. However this persuasion is depicted as much easier than reality, for example the use of a "mafia offer" that cannot be refused. A family/ personal life sub-plot is another common feature, perhaps to illustrate that the characters are real humans, though these interludes often seem like digressions. These personal issues and conflicts are resolved using essentially the same techniques. However, the characters or the plot are not well-developed enough for the books to be regular literary novels, though the professional writer-aided books such as "The Goal" and "Isn't It Obvious" are better attempts than others.

The steadily reducing book lengths over the years are also noticeable. Some book segments are not always tightly scripted, for example the theoretical coverage and diagramming techniques in "It's Not Luck" and "Critical Chain" are almost text-book like in parts.

In general, the material is sought to be presented as simple, though at times it ends up seeming a little over-simplified.

The story format has been used in management literature over the years, though "The Goal" remains the most successful. Apart from Goldratt's works, prominent have been books about leadership, teams and change management like Blanchard & Johnson's "One Minute Manager" (1983), Johnson's "Who Moved My Cheese" (1999) and their sequels. These are typically shorter books of around 100 page length, and written as parables and fables.

Jeff Cox, co-author of "The Goal", later partnered with other experts to write management books in story form. With William Byham he wrote books about empowerment such as "Zapp!" (1988) and sequels, in parable format. In the Marketing area, he co-authored "Quadrant Solution" (1993) and a subsequent book with Howard Stevens as novels set in business situations. Recently he revisited Operations with "Velocity" (2009), a novel with Jacob & Berglan as co-authors, about combining Lean with Six Sigma and TOC.

The most natural proliferation motivated by Goldratt has been in the category of Operations Novels. For example, Prof. Hill used the format to disseminate his approach to Manufacturing Strategy in "The Strategy Quest" (1994). The reengineering years saw Bertain's "The New Turnaround" (1993) and Swartz's epic-length "The Hunters and the Hunted" (1994), both in Manufacturing scenarios. Jacobs & Whybark's short case-based novel "Why ERP" (2000) provided an academic perspective about ERP implementations. Books written using novel-cum-narrative formats to showcase implementation of TOC concepts include Covington's "Tough Fabric" (1996) in the apparel industry, and Acord's "A Better Way" (1997) in the furniture industry.

Interestingly, Goldratt's last two novels have significant Indian connections conforming to the common stereotypes – software and low-cost outsourcing. In "Necessary But Not Sufficient", the ERP software development centre is located in India, and the Chief Scientist of the Advanced Planning & Scheduling software firm is of Indian origin. In "Isn't It Obvious", the textile sourcing is mostly from India, and one of the protagonists visits India frequently for exploration and negotiations. There is also a hint of quality and delivery dependability difficulties when dealing with the suppliers, but that is easily out-weighed by the advantage in cost and flexible commercial arrangements.

Goldratt also seeks to convey that change management is as important as the improvements themselves, and that a survival crisis can really trigger change, as shown in many of the books. He also emphasizes the value of developing critical thinking abilities. Through the books, he shares his own perspectives on various contemporary issues in operations, such as just-in-time, impact of variability, supply chain management, computer-based systems, and manufacturing excellence (the last a sub-title of the original edition of "The Goal"). All in all, the books span a wide portfolio of problem areas and useful solution approaches related to Operations Management in particular and management in general.

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E-Recruitment: The Evolving Face of Recruitment- A Study

* Dr. Mayank Agarwal

Abstract

Human resource is no longer considered a business requirement; rather it has distinguished itself as one of the core assets of any organization. The statement by Mr. Narayan Murthy, "My Company's assets walk out of the door every evening," truly captures the dynamics of new economy. With such a great emphasis on human capital, it is critical for every organization to resort to means that offer quality recruitment solutions at competitive costs. This is where the realm of e -Recruitment starts. The Internet is no longer just a rage; it has now become a very powerful and effective tool at everybody's disposal.

A significant proportion of Indian organizations are using the Internet to facilitate the recruitment process in some way, but many are using e-enabled processes alongside traditional methods rather than relying solely on e-recruitment.

The most significant progress has been made in using online methodologies at the front end of the recruitment process, in terms of advertising posts and receiving application forms. Increasing numbers of Indian organizations are also using Internet-based technology to track applications and communicate with and manage relationships with applicants.

In an increasingly competitive recruitment market, it is critical that organizations maximize their use of the Internet in the recruitment process, or risk losing out on quality applicants as the Internet becomes the standard job search and application medium for job seekers.

There is tremendous growth in the use of online systems to track and manage candidate applications, especially for larger organizations, where there will be significant benefits in terms of efficiency, cost, and capability to monitor and report on recruitment activities. There is also significant potential for relevant and objective online screening and assessment tools to add value in terms of matching the competencies and skills of the job applicant with the requirements of the organization in an efficient and cost-effective manner.

Dhruvakanth B Shenoy, Vice President-Marketing, Asia, Monster.com, India observes "The growth in the e-recruitment industry has been fuelled with the adoption of technology by prospective employers and Internet penetration. Organizations have cut costs by almost 80 percent over traditional recruitment modes by moving over to the online recruitment process."

Online recruitment is now a standard part of the recruitment process for many companies and organizations. But why? And is it worth it? In other words, what are the advantages and disadvantages of online recruitment?

Key Words: *E Recruitment, HR Procedures, Online Recruitments, Internet, Services*

Introduction

Finding the right employee for a business is sometimes time-consuming and difficult, but using online employee recruitment helps fill a vacancy faster. Online recruitment widens the number of prospective employees, increases the pool of qualified applicants, and helps you close the gaps at your place of business.

The buzzword and the latest trends in recruitment is the "E-Recruitment". Also known as "Online recruitment", it is the use of technology or the web based tools to assist the recruitment process. The tool can be either a job website (like naukri.com), the organization's corporate web site or its own intranet. Many big and small organizations are using Internet as

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a source of recruitment. They advertise job vacancies through worldwide web. The job seekers send their applications or curriculum vitae (CV) through an e-mail using the Internet. Alternatively job seekers place their CV's in worldwide web, which can be drawn by prospective employees depending upon their requirements.

Online recruitment agencies are looking to remove the headaches associated with finding the right person or job. Appealing to both active and passive job seekers, recruitment web sites save companies and job hunters both time and money. Online recruitment is not just restricted to specific web sites either; many major companies are using some form of e-Recruitment, enabling candidates to e-mail their CVs to the human resources department. E-Recruitment, though at nascent stage, is becoming a part of corporate strategy with increasing numbers of companies setting aside budgets for online recruitment. E-Recruitment practices (using the Internet to find candidates for job openings) have established some roots in the business world, but are far from refined. However, the primary benefit is clear and convincing: You can get your message out to more candidates, faster.

Emerging market opportunities for e -Recruiting firms include the following:

* Market demands are shifting to end -to-end services.
* Skills assessment has become a key -differentiating factor.
* Contingent workforce services are the next frontier of the e-recruiting market landscape.

RECRUITMENT AND THE INTERNET

The emergence of the internet as an interactive medium has been a major influence on the recruitment industry. There are now online sourcing channels such as job boards, classified sites, public recruitment databases, search engines, social networking sites and corporate career sites, all of which are far superior to paper-based job posting. Online recruitment is faster, cheaper and easier than paper-based advertising, and it enables companies to reach a wider audience of both active and passive candidates. As a result, the recruitment software market has undergone massive growth to support these up and coming channels of recruitment, as well as support the usual recruitment processes.

OBJECTIVES

- To analyze the e-recruitment industry and its operations in India.
- To analyze the e-recruitment market in India and know about the players in the same industry
- To critically analyze the effectiveness of online recruitment system
- For making effective recommendations to online recruitment system for its better performance
- To understand the trend of the e-recruitment industry, and study the services given by them
- To study about the future prospects and developments of e-recruitment industry

METHODOLOGY

The study covers the online job portals in India and their performance. Data collection is completely based on secondary sources like – websites; Magazines & Journals; Books and Electronic Newspapers. Moreover a personal interaction with relevant subject experts to generate appropriate information.

The collected information was scientifically and systematically classified and tabulated.

ABOUT THE INTERNET

Internet has already become the 'dominant media' in most internet user's lives. More internet users use internet with much higher frequency and intensity at homes than they use any other medium. From the 'media' perspective, net users not only make a good 'marketing audience' but also a 'better quality' consumer class. They are definitely more employed; more educated and have much higher incomes and socio-economic status than users of any other medium. Last but not least, internet is the only medium that

is a full scale 'marketing medium' and not just a 'communication' or 'infotainment' medium. It offers 'unmatched' possibilities in not just advertising but also in informing, interacting, engaging and eventually transacting in real time.

SOME STATISTICS ABOUT THE INTERNET AND ITS USAGE

- 51 mn 'active' internet users in India, 40 mn urban and 11 mn rural
- Growth of 8% (after a shrinkage of 5% last year)
- Internet reaches 10% Indian households and 4.4% Indians (2/3rd households have 'multiple' users in them)
- 97% are regular users and 79% use daily. High base of 'daily users' and increased base of 'online buyers' indicates growth in 'depth' (pond becoming 'fishier')
- 23% access it on mobile phones (3 times over last year), though most of these users are 'dual' users (PC + Mobile)
- 'Dual' users access internet on their mobiles habitually - 2 out of 3 access 'daily' and 1 in 3 uses it for more than an hour daily
- Almost all 'dual ' users (95%) have GPRS enabled phones and most have activated GPRS service on them
- 'WAP enabled' data services (72%) and 'GPRS activated' direct browsing (61%) are the most popular mode of mobile internet usage
- Over half of all internet users are 'employed', and half of those employed are 'corporate employees'
- 2/3rd of those employed are 'head' of the household (the rest 1 in 3 being the 'other earning members 'of 'multi-income' families)
- '25-35 years' forms the 'single' largest age group among internet users. A highly educated lot, almost half of all net users belong to SEC 'A' and 'B'
- Their 'average' claimed monthly family income is Rs. 17,960 (3 times the national average)
- They show significantly higher 'ownership levels' of most household and financial assets – at least 2 times higher for the more 'evolved' modern day assets

WHAT IS E-RECRUITMENT?

E-recruitment is an online recruitment where the recruitment is done through electronic resources. It utilizes the web based tools, techniques and technologies. It is the speed that counts in these days of changing times and technologies. When employers want to fill the slots quickly, they prefer e-recruitment to traditional recruitment. E-recruitment is also known as internet recruitment. It may also be called emerging recruitment, evolving recruitment and effective recruitment.

Table 1 Traditional Recruitment Vs E-Recruitment

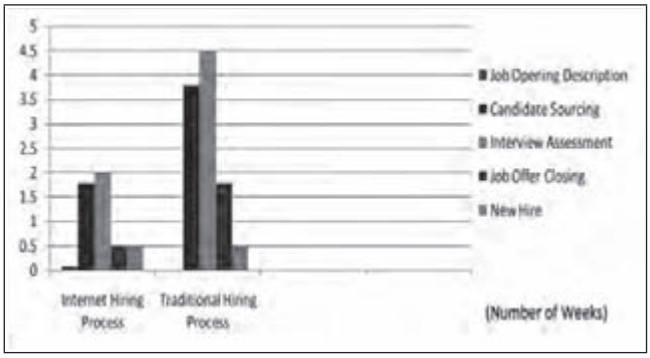
Recruitment process	Traditional recruitment	E-recruitment
Attracting candidates	Using sources that are not technology supported, like advertisements, flyers, spokespersons, to draw as many applicants as possible to contact the organization	Using the organization's reputation, product image, online technology and other methods to draw as many potential applicants as possible to the organization's website. There organizations can present themselves
Sorting applicants	Using a paper-based test for applicants to create a manageable applicant pool	Employing sophisticated, standardized online tests to screen candidates, and to winnow the applicant pool to a manageable number
Making contact	Contacting the sorted applicants by phone or mail and having face to face conversations	Using automated hiring management systems to contact the most desirable candidates very quickly, before they are snapped up by another company
Closing the deal	Making the phone call, setting up the meeting and shaking hands	Making the phone call, setting up the meeting and shaking hands

The process of e-recruitment involves the elimination of ineligible and unsuitable candidates through automation process. There are resume scanners that

filters automatically online and provides the right candidates to the employers on platter.

E-recruitment is a cost-effective online recruitment. It is useful when there is sudden shortage of skilled manpower and also if the company bags a new contract and if it wants job seekers with specific skill set, mindset and tool set then e-recruitment is the only solution. Precisely, E-recruitment is the mantra for successful recruitment in this technology world.

Figure 1 Time spent on hiring process when using the traditional or by using the internet



THE E-RECRUITMENT SECTOR

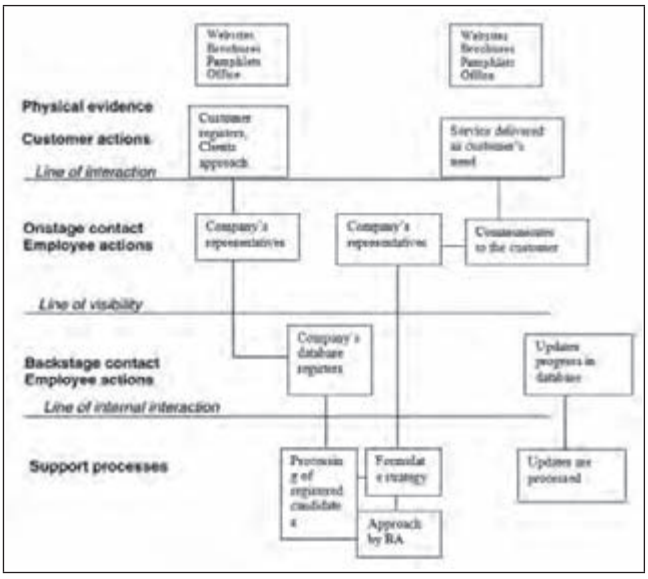
While the Indian recruitment industry is still reeling from the impacts of the financial crunch around the world, one significant area which has actually witnessed a growth in such a conflicting situation is the e-recruitment market. Growing at a pace of about 100 to 150 per cent, this recruitment mode promises to increase its share from the present 2 per cent to 10 per cent in the next 3-4 years. The Internet, in fact, has completely revolutionized the role of the traditional recruiter. Gone are the days where cold calling and candidate networking were the only option available to identify new potential candidates. Now it's about searching through hundreds of thousands of CV's placed on personal web pages and browsing online corporate staff directories. In a candidate-starved (quality candidate) market, the Internet can prove a valuable resource for finding potential candidates who are not necessarily looking to change their current jobs but would be open to the 'right' opportunity. Meanwhile in a candidate rich marketplace, we can use the Internet to find relevant 'live' job vacancies where companies have advertised directly on the web. You can also use the Internet to find information on company's financial results, their budget information, who has been recently appointed, and business wins & losses. In fact, with the right search techniques, you can normally find exactly what you are looking for.

Presently, the total Indian recruitment market is approximately around Rs 500- 600Crores. The decade old online recruitment industry in India seems to be flooded with different jobsites, each of them promising a better job to candidates and better candidates to employers. The Indian market for e-recruitment is still at least five years behind the West. This shows in the big numbers. According to industry estimates, the top four or five job portals account for only 1.5 to 2 per cent of total recruitments. Internationally, online recruitment is almost neck-to-neck with other recruiting channels. In the US, for instance, the online recruitment market already accounts for 29 per cent of total recruitment related advertising.

SERVICE DESIGN / SERVICE BLUEPRINT

A service blueprint is a graphical or visual representation of the process involved in providing a service. The purpose of service blueprint is to provide a clear and objective understanding of processes involved in the organization.

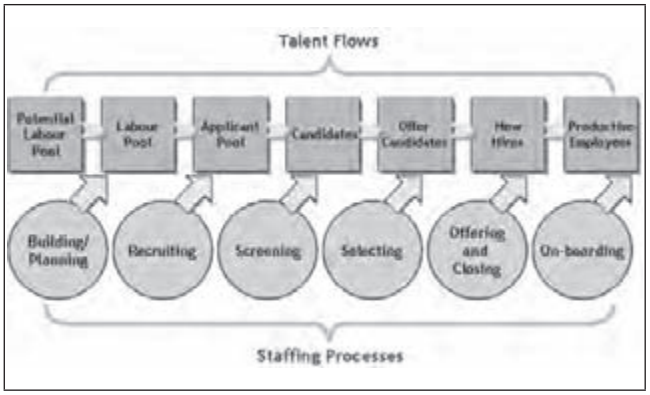
Figure 2 Service Design



TRENDS IN E-RECRUITMENT

The recruitment landscape both internationally and in India has changed significantly in recent years. Online recruitment has now become a significant part of the recruitment strategy for a wide range of organizations world-wide, in addition to becoming an increasingly popular method for job-seekers in searching and applying for jobs.

Figure 3 Typical processes involved in recruiting staff



Source: IES, 2005

Figure 3 illustrates the typical processes involved in recruiting staff. The Internet can be used to facilitate any or all of the main processes of: attraction (advertising/recruiting), selection and assessment (screening and testing), and on-boarding (offering and closing, induction). In addition, e-recruitment can be used, in parallel, to support applicant tracking and workflow systems.

There is growing evidence that organizations are using Internet technology and the World Wide Web as a platform for recruiting and testing candidates. The IES survey of 50 organizations using e-recruitment reported that the primary drivers behind the decisions to pursue e-recruitment were to:

- Improve corporate image and profile
- Reduce recruitment costs
- Reduce administrative burden
- Employ better tools for the recruitment team.
- Fifty-five per cent of respondents expected their organization to reduce its use of other recruitment methods in the future.

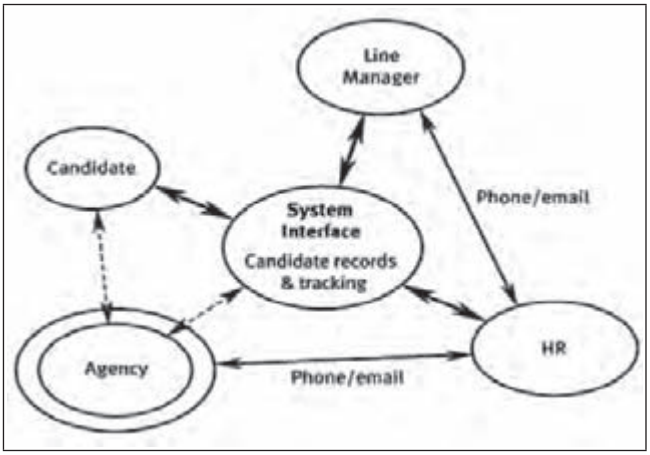
The key limiting factors to e-recruitment most frequently reported were:

- The cultural approach of the organization towards recruitment
- The lack of knowledge of e-recruitment within the HR community
- Internet usage by target candidates
- Commitment of senior management.

Issues raised as causing concern with e-recruitment included the quantity and quality of candidates applying using web-based tools (e.g. organizations being inundated with CVs attached by email, many of whom were not suitable for the post), the relevance of short listing criteria (e.g. the validity and legality of searching by keywords), confidentiality and data protection, and ensuring diversity of applicants.

The trends in e-recruitment use suggest a changing landscape whereby in future the candidate is connected to the central system and there is involvement of the line manager in the process (see figure 4). In addition to the reported benefits such as cost efficiencies, the role of HR in this model is viewed as more of a facilitative role, in theory allowing time for recruiters to become involved in the strategic issues within resourcing.

Figure 4 E-recruitment landscape (*Source: IES)*



INDUSTRY ANALYSIS
PORTER'S 5 FORCES ANALYSIS

How does the company stack up on Porter's 5 force model?

A) Bargaining Power Of Suppliers: Low

Portals are "virtual brokers" and are in a service business. Branding and eye-balls are the keys to succeed. Suppliers are website designers who do not add much value to the overall scheme of things. Hence, the bargaining power of suppliers is low.

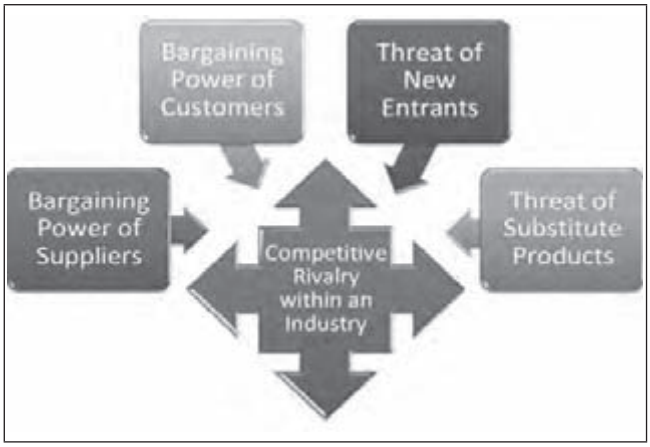
B) Bargaining Power Of Customers: High

A feature of the online portal business is that customers register with multiple portals in order to maximize the chance of finding a taker. Thus, portals are always on their toes to woo customers and retain them by offering low prices and enhanced services.

C) Threat Of Substitutes: Medium

Portals' value proposition in terms of speed and cost is enormous compared to that offered by traditional brokers. But of late, social networking sites like "Linkedin" warehouse almost similar data and are gaining popularity. Any surge in such networks would act as a challenge to online portals. However, this is a long shot and there is no major threat in the vicinity.

Figure 5 Porter's Five Force Model



D) Threat Of Competition: High

Portals in India have gained inroads only into a few segments like recruitment and matrimony. This narrow business scope results in a cut-throat competition amongst portals that target the same customer base. Hence, portals slash customer rates, offer specialized services and organize offline events etc to keep their business ticking.

E) Barriers To Entry: Medium

Portals are an 'easy to start' business. Designing a website is not expensive. Overheads are minimal since the business is run over the internet. However, gaining scale is challenging. Aspirants have to either venture into a new area or have to build a niche for themselves in existing segments, both uphill tasks.

Figure 6 PESTLE ANALYSIS

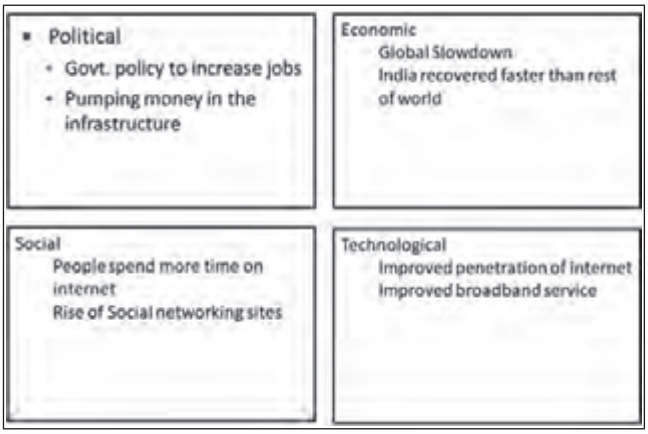


Table 2 PEST Factors

Factors	Time Frame	Type	Impact	Relative Importance
Political				
Trading Policies	2-3 years	High	Positive/ Increasing	Important
Funding, Grants & Initiatives	2 years	Medium	Positive/ Increasing	Important
International Events	1 year	Medium	Positive/ Increasing	Not important
Inter country work environment	3 & more years	Medium	Mixed/ Mixed	Important
Government Leadership	3 & more years	Medium	Positive/ Increasing	Important

Factors	Time Frame	Type	Impact	Relative Importance
Economic				
Cost Optimization	1 year	High	Positive/ Increasing	Important
Gaining occasional candidates	1 year	Low	Mixed/ Mixed	Not important
Building a Talent pool of Candidates	2-3 years	High	Positive/ Increasing	Critical
Reduced administration	1 year	High	Positive/ Increasing	Important
Pre filtering candidates	1 year	Medium	Positive/ Increasing	Important
Social				
Consumer Attitudes & Behavior	2-3 years	High	Mixed/ Mixed	Critical
Media views	1 year	Medium	Mixed/ Mixed	Important
Brand company & technology image	3 & more years	High	Positive/ Increasing	Critical
Advertising & Publicity	1 year	Medium	Mixed/ Mixed	Important
Trends	2-3 years	Medium	Mixed/ Mixed	Critical
Technological				
Competing Technologies	1 year	High	Positive/ Increasing	Important
Innovation Potential	2-3 years	High	Positive/ Increasing	Critical
User Communications	1 year	Medium	Positive/ Increasing	Critical
Maturity Of Technology	3 & more years	Medium	Negative/ decreasing	Unknown

SERVQUAL MODEL:

THE FIVE KEY SERVICE DIMENSIONS

1. Tangibles: The appearance of physical facilities, equipment, personnel and information material.

2. Reliability: The ability to perform the service accurately and dependably.

3. Responsiveness: The willingness to help customers and provide a prompt service.

4. Assurance: a combination of the following

   - Competence: having the requisite skills and knowledge.
   - Courtesy: politeness, respect, consideration and friendliness of contact staff.
   - Credibility: trustworthiness, believability and honesty of staff.
   - Security: freedom from danger, risk or doubt.

5. Empathy: a combination of the following:

   - Access (physical and social): approachability and ease of contact.
   - Communication: keeping customers informed in a language they understand and really listening to them.
   - Understanding the customer: making the effort to get to know customers and their specific needs.

Gap1: Customers' expectations versus management perceptions: The customers who in this case are the candidates to be sourced and the clients have certain expectations. The management needs to do a detailed study to know the customer expectations and perceive them properly. The expectation of the client is to get a candidate that is best fit for the JD provided by them. After study it was revealed that many times the sourced candidates do not turn up as their expectations were not fulfilled. Sometimes, it happens that the sourced candidate is unable to fulfil the expectations of the organization.

Gap2: Management perceptions versus service specifications: It is very important to set goals or targets and set a benchmark. This will bridge the gap and improve the service quality.

Gap3: Service specifications versus service delivery: as a result of role ambiguity and conflict, poor employee-job fit and poor technology-job fit, inappropriate supervisory control systems, lack of perceived control and lack of teamwork. The service delivery should be done in time so as to maintain the relationship with the client. The candidate should be sourced with a profile that matches the resume and skill set possessed him/ her.

Gap4: Service delivery versus external communication: There should be communication maintained between client and the candidate so that there is no gap of knowledge between the organization and customer. It was observed in one case that the client approached the candidate directly thus causing failure of business. This was due to the communication gap.

Gap5: The discrepancy between customer expectations and their perceptions of the service delivered: as a result of the influences exerted from the customer side and the shortfalls (gaps) on the part of the service provider. In this case, customer expectations are influenced by the word of mouth recommendation and past service experiences.

Gap6: The discrepancy between customer expectations and employees' perceptions: as a result of the differences in the understanding of customer expectations by front-line service providers.

Gap7: The discrepancy between employee's perceptions and management perceptions: as a result of the differences in the understanding of customer expectations between managers and service providers.

Figure 7 SERVQUAL MODEL

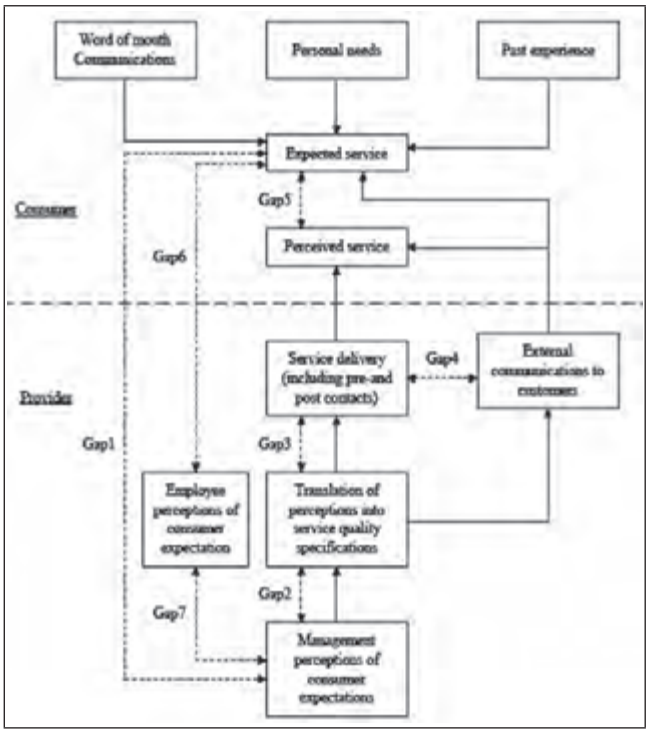
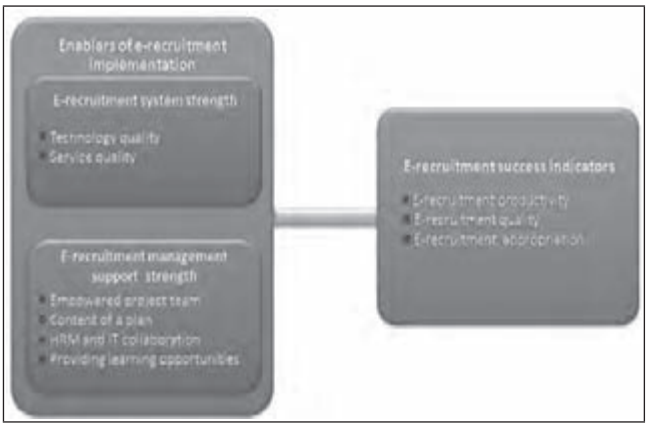


Figure 8 Enablers of E-Recruitment Implementation



E-RECRUITMENT IN THE INDIAN CONTEXT

Online recruitment is an important part of the recruitment strategy for a large majority of the Indian organizations. A significant proportion of Indian organizations are using the Internet to facilitate the recruitment process in some way, but many are using e-enabled processes alongside traditional methods rather than relying solely on e-recruitment.

The most significant progress has been made in using online methodologies at the front end of the recruitment process, in terms of advertising posts and receiving application forms. Increasing numbers of Indian organizations are also using Internet-based technology to track applications and communicate with and manage relationships with applicants.

The use of online tools for screening and assessing candidates is less prevalent among Indian organizations, but there is evidence that this practice is set to grow in the future, and that this facility will become increasingly valuable to organizations as greater use of online advertising attracts larger numbers of applications.

FAMOUS SITES IN INDIA

NAUKRI Since its inception in the year 1997, Naukri has earned a good name among the job seekers. It is regarded as one of the best job sites in India. The group operates across three verticals, namely, real estate, jobs and matrimony.

MONSTER INDIA Like Naukri, Monster India is also one of the top job sites in India. The main objective of this site is to enable the job seekers find out about a new career avenue, and discover the job opportunities that exactly match your profile.

TIMES JOBS The site contains all types of jobs and helps an individual to find out the job of his or her choice relevant to his or her area of study.

NAUKRI HUB Naukri Hub is regarded as one of the best job sites in India. Naukri Hub is a popular web portal committed towards guiding millions of job aspirants to find the correct way. The website believes that there is no shortcut to quality and always inspire people to set their dreams sky high. The way Naukri Hub executes all the relevant and best sorted job information, places it at a bench mark position. The site indeed leaves a mark to tremendous teamwork, provides an innovative approach, and leads to an excellently well-built customer relationship.

CLICKJOBS ClickJobs is a career site which gives you the option of keeping your profile in the site database. The site allows you to keep some of your information confidential if you desire to do so. If a potential employer is interested to view your full profile, you will be directly contacted via email and will be given the name of the potential employer.

SHINE This site provides information on the job openings in various sectors and companies. Also it gives details on consultants that can help in getting a good job

Figure 9 Popularity *(Source: Google Trends.com)*

Figure 10 Daily Traffic Trend *(Source: Alexa.com)*

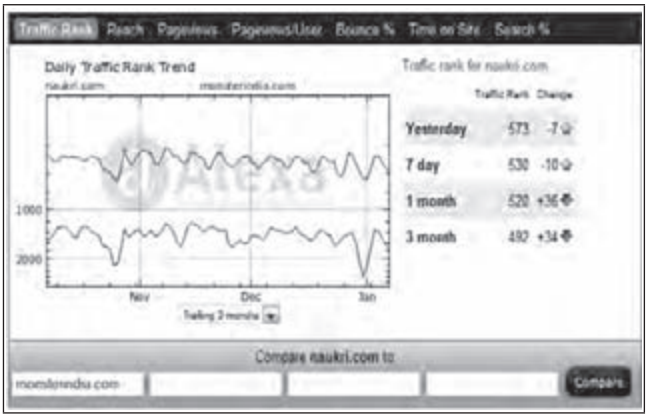


Figure 11 Daily Page views per User
(Source: Alexa.com)

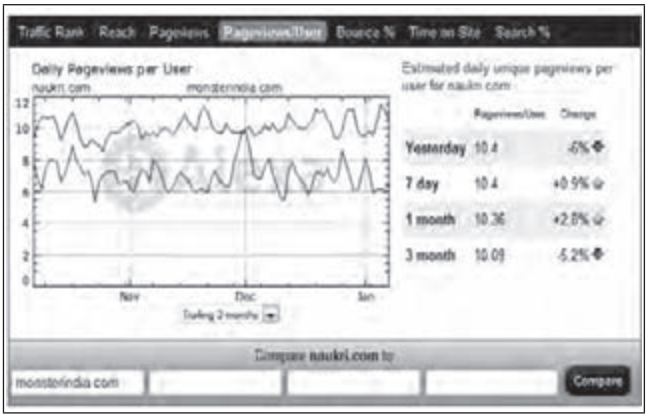
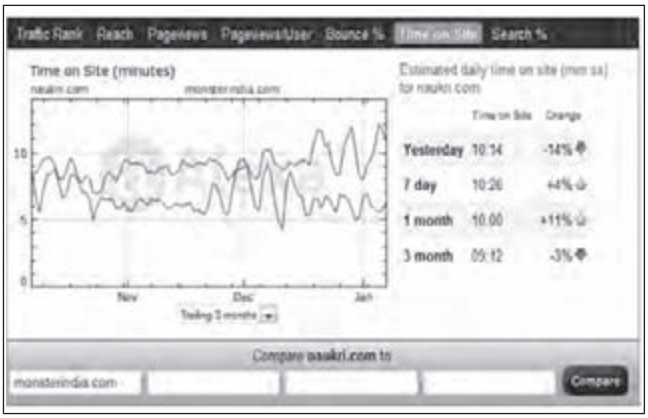


Figure 12 Time Spent on Site (*Source: Alexa.com*)



Naukri.com, a pioneering online recruitment agency in Indian, is faced with the threat of competition from Monsterindia as it took over Jobsahead as a part of its strategy for growth. A SWOT analysis of the company reveals the following:

Online and offline model: On a stand-alone basis, the online system must have a large number of users and corporate clients to survive. Only a few players have that model. So, naukri.com should move towards a more mature model where offline activities complement the online presence. Recruitment essentially includes activities like resume search, profile matching, screening of applications, short listing of candidates, counseling, client-servicing, and replacement. While resume searching and profile matching are done online through a jobsite, the remaining activities can be done off line through a head-hunting firm. Therefore, there is a need for good custom support services through offline presence for an online model to survive and prosper. There are other avenues which the company could explore for increasing the traffic and market share such as:

- Organizing job fairs in different metros
- Voice- assisted sales and registration over the phone
- Expanding to other Asian markets.

Presently, there is a boom in the job market which has also led to online recruitment growing at a fast pace. With the emergence of newer companies which are emerging to become stronger, there is increasing competition. A company which offers greater value for its clients in terms of ease of use reach, and satisfaction will finally emerge the winner.

WHY IS E-RECRUITMENT NECESSARY?

CURRENT WAR FOR TALENT The current global skills shortage and ageing population has been well documented and organizations will look to technology to play an increasing role in successful recruitment strategies. Online applicant tracking systems aid job posting, candidate screening and timely communication. As the ad response dwindles, the challenge will be to use the online system effectively as a talent pool.

INCREASING REACH OF THE INTERNET - MANAGE VOLUME The use of the Internet yields far greater number of applications for every job vacancy promoted, simply due to the decreased cost, increased reach and ease of application created by the Internet job boards and online forms. It is no surprise then that the Internet has become the source of choice for job seekers.

TALENT WAREHOUSING Internet connectivity provides an unprecedented capability to build a database of candidates from which to search for future positions. Companies use the e-recruitment system as a Talent Relationship Management tool to encourage job seekers back to the site to view new positions as they become available and update their information. This ensures companies search on recent relevant data and that over time the main source of candidates can come from our own database.

IMPROVES CANDIDATE CARE Companies recognize the value of using its website to source candidates, and this system will assist in the timely management of the applications.

CREATES A CENTRAL HUB FOR ALL RECRUITMENT E-recruitment allows the establishment of one 'easy to access' portal where the job seeker and recruiter can be connected and communicate with each other with the benefit of automation, real time data and reduced advertising spend.

STREAMLINED PROCESSES - REDUCE COST AND TIME PER HIRE Workflow based e-recruitment solutions provide the ability to significantly streamline HR and recruitment processes through automation of communication and engagement of relevant stakeholders at each step of the recruitment process. This has been proven to significantly reduce time and cost per hire.

ADVANCED REPORTING With increasing pressure being brought to bear on HR practitioners to find and select high quality candidates faster and deliver measurable benefit to businesses it is imperative to provide high visibility of process efficiency and a lower cost base - particularly in a world where it is increasingly difficult to find those candidates!

Advanced reporting includes the ability to measure against key metrics and performance indicators and much more all in real time via the web e.g. Where

candidates are coming from (which advertising media), How many candidates are applying?, Candidate data such as location, qualifications, skills, Time to evaluate candidates through selection process, Number of Vacancies by division or portfolio, school or business unit etc, Time to hire, Cost per hire, Resource allocation.

BRANDING OPPORTUNITY FOR EMPLOYERS Employers can use their job ads to project a consistent brand and company image/values to prospective job seekers. With the heat on for top talent, candidates can be very particular about whom they work for and these company descriptions often serve as a basis for their application decisions.

SOPHISTICATED MANAGEMENT TOOLS The entire recruitment process is managed from one location which allows the employer to post vacancies, receive CVs, screen, prioritize and contact candidates individually or collectively and track all activities from the confines of a private and highly functional employer workplace. Job seekers similarly can track the progress of their application at every stage of the hiring process from their own functional workspace. This allows for an enhanced user experience for both employer and job seeker.

ALLOWS FOR CONFIDENTIALITY Both employers and job seekers can elect to maintain their confidentiality. Employers can elect to search the databases without posting a job if the vacancy is sensitive in nature, or they can post a vacancy while keeping the company name confidential. Similarly, candidates can post their CVs online while keeping their names and present employer's name confidential.

ALLOWS FOR PROACTIVITY The employer/ recruiter is in full control of the hiring process with online recruitment, can contact candidates real-time and directly and does not require a middleman to sift through, filter, assess or select the required candidates. By being in the driving seat the employer gains valuable insight into the nature of the marketplace and the competitive landscape for the position. He is also able to ensure a superior match and a better fit for the long term.

ALLOWS FOR DATABASE BUILD-UP Employers can save high profile or particularly attractive CVs from an existing online search to build a priority database of pre-screened star talent for future use.

THE KEY LIMITING FACTORS TO E-RECRUITMENT

- The cultural approach of the organization towards recruitment
- The lack of knowledge of e-recruitment within the HR community
- Internet usage by target candidates
- Commitment of senior management
- The quantity and quality of candidates applying using web-based tools (e.g. organizations being inundated with CVs attached by email, many of whom were not suitable for the post)
- The relevance of short listing criteria (e.g. the validity and legality of searching by keywords)
- Confidentiality and data protection.

FACTORS AFFECTING THE ONLINE MARKET

- Cost of advertising in newspapers: Many employers have switched to online recruitment as it is cheaper and cost-effective. If the cost of advertising in newspapers reduces, it will hit the online recruitment business.
- Hiring plans of employers: If there is a reduction in hiring budgets, it will hurt the online recruitment business more, as compared to newspapers, as these portals are vertical (focused only on recruitment)
- Placement Consultants: Although, majority of the consultants use job sites as one of the media for sourcing profiles, mid/senior level candidates are better sourced through networking, paper advertisements and referrals. This is exactly what the top-notch consultants do. Since the online candidate database is available to anyone who subscribes to it, mid/senior level candidates are skeptical to register on job-sites.

- Vernacular Languages: Companies looking out for candidates from Tier II/III cities and interior belts advertise in the regional newspapers in the local language. Advertisements in local language can generate much better responses in these places. However, the job sites accept advertisements/ resumes in English language only.
- Client Satisfaction: Reduction in time and cost of recruiting
- Growth of Internet: Increase in market penetration will definitely increase the number of visitors on jobsites thus leading to growth of the e-recruitment market.
- R & D: Increased technological advancements combined with newer features being offered by jobsites could give e-recruitment a better edge over other modes.

CHALLENGES ASSOCIATED WITH E-RECRUITMENT

E-recruitment is no passing fad, but it is no panacea either. It has a number of disadvantages, particularly in the Indian context. In spite of its wider accessibility and speedy delivery, applications that match your requirements are often hard to find. Since applying online is so easy, there is a glut of unsuitable candidates who apply for every post. As one recruiter puts it, 'recruiting online offers cost and time-savings but requires more screening'.

Another drawback of e-recruitment is the disclosure of information. The candidates profile and company details are available to public. The applicants do not want their employer to know that they are looking for a change. Phone number, address information has led to many security problems. Again the companies do not want their competitors always to know the current scenario.

A traditional concern with e-recruitment is in relation to its acceptability to a broad range of applicants. This appears to be becoming much less of an issue, as more and more applicants are using the Internet as part of their job search process. In fact, there is significant evidence to suggest that the Internet is the preferred application method for a large majority of candidates. Nevertheless, many organizations involved in this research showed concern in relation to candidate access and perceptions, and are designing their online processes to be as candidate-friendly as possible, in addition to accepting applications, in some cases, by other methods. In spite of these drawbacks, the advantages of speed, flexibility and a user-friendly character have made e-recruitment a practical and popular hiring option.

MONITORING

Online recruitment may not be cost effective for all positions so it is important to review the use of technology along with the overall assessment of the effectiveness of the recruitment process.

Some tips:-

- Integrate with other recruitment methods so that all recruitment 'tools' work in harmony.
- Evaluate and monitor use - get feedback from applicants about how they found the process and take appropriate actions.
- Keep content fresh - don't display vacancies out of date vacancies. If you don't have any, say you don't have any.
- Avoid jargon and 'company speak' in advertisements.
- Invest the same time in preparing online copy as you would for printed.
- Decide a policy on how to deal with unsolicited applications.
- Provide contact telephone numbers in obvious places for those having technical problems.
- Ensure the site is accessible.
- Research into the most appropriate job board to host vacancies.
- Make it easy for search engines to find your website - think what keywords job hunters will use and how to improve your website's ranking.
- Realize your own limitations - think about partnership working to develop your e-recruitment.

RECOMMENDATIONS OF THE STUDY

The findings from the study indicate that the key recommendation to the HR specialist is based on the systematic approach of the organization towards e-recruitment. It has been found that there is a lack of knowledge with in the HR community. Therefore it is recommended that more emphasis should be laid on the training within HR to develop the capability to deliver e-recruitment, and also at the line manager level. Emphasis on integrating the e-recruitment practice sooner than later should be made so as to serve to move the recruiter up the value chain, allowing them to be far more strategic. The ease of recruitment would depend on their degree of involvement. It is desirable to plan employee recruitment strategy by an organization

THE FUTURE OF E-RECRUITMENT

Online recruitment has established itself as a significant part of the recruitment strategy and practices of a wide range of organizations operating in India. In an increasingly competitive recruitment market, it is critical that organizations maximize their use of the Internet in the recruitment process, or risk losing out on quality applicants as the Internet becomes the standard job search and application medium for job seekers.

There is a growth in the use of online systems to track and manage candidate applications, especially for larger organizations, where there will be significant benefits in terms of efficiency, cost, and capability to monitor and report on recruitment activities. It also identifies significant potential for relevant and objective online screening and assessment tools to add value in terms of matching the competencies and skills of the job applicant with the requirements of the organization in an efficient and cost-effective manner.

The findings would suggest that organizations need to examine and challenge their existing processes and strategy in an effort to identify the barriers to attracting and recruiting the best talent in a timely, customer-friendly and resource-efficient manner.

A number of key areas that organizations should consider to ensure successful implementation of an e-recruitment strategy, including:

- Building knowledge and understanding of the technology options available
- Ensuring candidate- and user-friendly interfaces on their systems
- Understanding Internet access and proficiency levels amongst target groups
- The importance of integrating online and offline systems.

TO CONCLUDE

Online recruitment covers a wide variety of activities. From a recruitment advertising and candidate sourcing point of view, success rests with choosing the most effective channel. In an ideal world you could use careers websites, job boards, CV databases, search engine marketing, and social media channels; but, being realistic, there is seldom enough time for that

Using the power of Internet to achieve HR goals not only increases productivity but also saves time and money to give a competitive advantage. The pluses are many: Posting jobs online can cost less than half as much as Sunday newspaper postings and far less than employment agency fees. Online ads can be longer, more descriptive, written any time of the day or night, and posted almost immediately. For employers, online recruiting allows far better targeting of candidates than does advertising in general newspapers, resulting in a greater percentage of qualified applicants. In addition, because 24/7 online job hunting is private and convenient, your company's Internet presence is more likely to draw in "passive job seekers" – high-quality candidates who may be curious to know what's out there but who have not launched all -out campaigns.

As online recruitment sites continue to multiply in numbers these 'value -added' services may well prove crucial to their long time survival. Although e -Recruitment addresses the initial phase of job hunting and applications the challenge is to go beyond the virtual value, and prove the value of the initial contact.

In summary, people will continue to be one of the most valuable assets for every organization. The benefits mentioned in the above study will improve

the accuracy of hiring and reduce hiring lead- time and cost, thereby increasing the overall competitiveness of the organization in today's marketplace.

Hence, it can be said that **E-recruitment is the *"Evolving face of recruitment."***

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Modelling Hybrid Single Model Assembly Line Balancing Problem

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Abstract

In this paper, the single model assembly line balancing problem is considered. In assembly line balancing, there are two prime objectives, viz. minimizing the number of workstations and minimizing the cycle time. Normally the first objective is considered to design an assembly line for a given cycle time, which is computed based on a given production volume per shift. If the second objective of minimizing the cycle time is also met along with the first objective, the extra production that can be realized through the reduced cycled time can act as a cushion in the event of any change in demand. Under such situation, the assembly line can be reconfigured for the reduced cycle time to have extra production.

In this paper, sequential models for the hybrid assembly line balancing problem is presented. First a model to minimize the number of workstations for a given cycle time is presented and then a model to minimize the cycle time for the minimum number of workstations identified through the first model is presented. These are illustrated using example problems.

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1. Introduction

In the assembly type system, the product will have a set of tasks which are to be processed as per the relationship defined in a precedence network. In the network, some of the tasks will be processed in serial order and some of them will be processed in parallel. The system to assemble an engine is an example of assembly type system.

The prime objective of simple assembly line balancing problem is to subdivide the work elements in the precedence network into a minimum number of workstations such that the balancing efficiency is maximized. Another objective is to design the assembly line such that the cycle time is minimized for a given number of workstations. Such exercises are more challenging, because these problems come under combinatorial category.

The inputs for the design of the single model assembly type system are as listed below.

- Precedence network of the tasks.
- Tasks times
- Cycle time or number of workstations.

The cycle time is the time between the consecutive releases of the assemblies at the end of the line or the total time allocated to each workstation in the assembly line.

The formula for the cycle time (CT) is as given below (Panneerselvam 2012).

$$CT = \frac{\text{Effective time available per period}}{\text{Production volume/ period}}$$

The cycle time and the number of workstations are mutually exclusive data, which mean that if the cycle time is given as an input, then the objective is to minimize the number workstations in the assembly line, which in turn will maximize the balancing efficiency of the assembly line; if the number of workstations is given as an input, then the objective is to minimize the cycle time, which in turn will also maximize the production volume of the product/ per period (minimizing the throughput time of the product in the assembly line) on incremental basis.

The formula to compute the balancing efficiency is given below (Panneerselvam 2012).

$$\text{Balancing efficiency} = \frac{\text{Sum of all tasks times}}{\text{Number of workstations x Cycle time}} \text{ x } 100$$

The assembly line balancing problem is classified into assembly line balancing problem I (ALBP I) and assembly line balancing problem II (ALBP II), which are presented below.

ALBP I: In this problem, the tasks in the given precedence network are divided into a number of workstations for a given cycle time subject to the following two conditions such that the balancing efficiency is maximized

- Non-violation of the precedence constraints among the tasks
- sum of the processing times of the tasks assigned to each workstation is less than or equal to the given cycle time

ALBP II: In this problem, the tasks in the given precedence network are divided into a given number of workstations without violation of the precedence constraints among the tasks such that the cycle time is minimized.

If the second objective of minimizing the cycle time is also met along with the first objective, the extra production that can be realized through the reduced cycled time can act as a cushion in the event of any change in demand. Under such situation, the assembly line can be reconfigured for the reduced cycle time to have extra production.

In this paper, a hybrid mathematical model is developed for ALBP I and ALBP II to minimize the number of workstations for a given cycle time and then to minimize the cycle time for the identified number of workstations.

2. Literature Review

This section presents the review of literatures of the single model assembly line balancing problem. Thangavelu and Shetty (1971) have shown that certain steps in Geoffrion's 0-1 integer programming algorithm can be simplified or eliminated to solve the simple assembly line balancing problem such that the number of stations is minimized for a given cycle time. Deckro and Sarangan Rangachari (1990) have developed a goal programming model for the simple assembly line balancing problem with the objective of minimizing the number of workstations by simultaneously considering various operational requirements such as zoning, sequencing, idle time, cycle time and costs. Panneerselvam and Oudaya Sankar (1993) have considered the single model assembly line balancing problem in which the objective is to minimize the number of workstations for a given cycle time. They have considered six heuristics of Dar-EL (1975)'s research and proposed six new heuristics. Through a carefully designed experiment, they concluded that three heuristics of Dar-EL(1975)'s contribution and all the six newly proposed heuristics by them are selected as the best set of heuristics to solve the problem.

Rubinnovitz and Levitin (1995) have considered the single model assembly line balancing problem with deterministic processing time. They developed a genetic algorithm and compared its results with that of the MUST algorithm suggested by Dar-EL and Rubinovitch (1979). Yeo Keun Kim et al. (1996) have developed genetic algorithm for simple assembly line balancing problem with various objectives, viz. (i) minimizing the number of workstations, (ii) minimizing the cycle time, (iii) maximizing the work load smoothness and (iv) maximizing work relatedness and multiple objective with (iii) and (iv)

Ponnambalam et al. (2000) have developed a multi-objective genetic algorithm for solving simple assembly line balancing problem for a given cycle time. The objectives include the number of workstations, line efficiency, and the smoothness index. They compared its performance with six existing heuristics.

Narayanan and Panneerselvam (2000) have developed a new efficient set of heuristics (NESHU) to design the mass production system in an effective manner. The objective of this work is to group the tasks with deterministic times into minimum number of workstations for a given cycle time, such that the balancing efficiency is maximized. In their approach, the initial solution is generated using a heuristic for assembly line balancing (HAL) and composite weight factor, and then it is improved using global search heuristic, which is similar to simulated annealing algorithm.

Sotskov et al. (2006) have considered the simple assembly line balancing problem in which the objective is to minimize the number of workstations for a given cycle time. The activities of the assembly line are divided into two subsets (Set 1 and Set 2), where the Set 1 consists of activities having deterministic task times and the Set 2 consists of activities having stochastic task times. The authors have studied the stability of the optimal solution with respect to the variations in the task times in Set 2. Scholl and Voβ (1996) proposed an indirect approach for tabu search that solves iteratively several single model assembly line balancing problem of type II in which the objective is to minimize the cycle time for a given number of workstations, with an increasing number of workstations until a solution that satisfies the target cycle time is found.

Supaporn Suw Annarongsri et al. (2007) have developed a hybrid tabu search method for the simple assembly line balncing problem with the objective of minimizing the number of workstations for a given cycle time. Lai and Liu (2009) have developed an evolutionary algorithm based on ant colony optimization technique for the simple assembly line balancing problem to minimize the cycle time (makespan) for a given number of workstations. Jie Gao et al. (2009) have considered the simple assembly line balancing problem with the objective of minimizing the cycle time, which is known as ALBP II problem. This study presents a robotic assembly line balancing in which the assembly tasks have to be assigned to workstations and each workstation needs to select one of the available robots to process the assigned tasks with the objective of minimizing the cycle time. An innovative genetic algorithm hybridized with local search is proposed for this problem. Din-Horng Yeh and Hsiu-Hsueh Kao (2009) have developed a bidirectional heuristic to group the tasks into a minimum number of workstations such that the balancing efficiency is maximized. Lu Jian-sha, Jiang Ling-ling and Li Xiu-lin (2009) have developed hybrid particle swarm optimization algorithm for assembly line balancing problem-2 in which the objective is to minimize the cycle time for a given number of workstations.

Jianfeng Yu and Yuehong Yin (2010)] have developed an adaptive genetic algorithm to determine the minimum number of workstations with workload balance between the workstations for a given cycle time. Seyed-Alagheband, Fatemi Ghomi and Zandieh (2010) have developed a simulated annealing algorithm to balance the assembly line of type II with sequence dependent setup times. Ozcan Kilincci (2010) has considered SALB-2 problem in which the objective is to minimize the variations in workloads among the workstations for a given number of workstations. The author has developed a Petrinet heuristic for this problem.

Burcin Cakir, Fulya Altiparmak and berna Dengiz (2011) have developed a hybrid simulated annealing algorithm for multi-objective optimization of a stochastic assembly line balancing problem. This aims to obtain Pareto optimal solution. Fathi, Jahan., Ariffin and Ismail (2011) have developed a new heuristic method based on CPM for simple assemble assembly line balancing problem. In this approach, the precedence constraints between the tasks and the cycle time are considered along with tasks times. Here, the objective is to minimize the number of workstations. Zacharia and Nearchou (2012) have considered the assembly line balancing problem of type 2 with fuzzy

job processing times. They developed a new multi-objective genetic algorithm for this problem.

Under single model assembly line balancing problem, authors have researched on the development of models, simple heuristics, genetic algorithm, global search heuristic, tabu search, hybrid tabu search, ant colony optimization algorithm, petrinet algorithm, CPM based method, particle swarm optimization algorithm and simulated annealing. In most of the cases involving comparisons of new approaches with existing approaches, the comparisons are not done using extensive statistical analysis, like design of experiments.

Though there are heuristics for ALBP I and ALBP II, when a new heuristic is developed, its solution accuracy can be assessed by comparing its solution with that obtained using mathematical model for small and moderate size problems.

So, in this paper, a hybrid model is presented to deal with ALBP I and ALBP II in stages.

3. Hybrid Assembly Line Balancing

The single model assembly line balancing problem consists of ALBP I and ALBP II. In literature, these two problems are dealt in isolation. Though the ALBP I is popular in reality, after having designed the line using the ALBP I, on can reduce the cycle time from the cycle time that has been assumed in ALBP I by rearranging the work elements without violating the precedence relationships among the workstations that are formed in ALBP I. Such problem is called hybrid assembly line balancing problem. This type of design will help organizations to reduce the throughput time from the cycle time that has been assumed in the ALBP I to the minimized cycle time that will be obtained in ALBP II. This in turn will enhance the production volume per shift in short run to meet any increased demand. As per this design, the assembly line will be configured using the result of ALBP I. Later, in the event of increased demand, the line may be reconfigured as per the results of the ALBP II.

In literature, there is a 0–1 programming model for ALBP I (Thangavelu and Shetty, 1971), which forms the model for the first stage of this paper with necessary corrections, because in the literature there are some mistakes. The objective of this model is to design the assembly line such that the number of workstations is minimized. For the second stage of this paper, a mathematical model is presented for ALBP II, which is a contribution in this paper. The objective of this model is to design the assembly line such that the cycle time is minimized for the number of workstations that is determined in the first stage.

These models are presented in the following sections with illustrations.

3.1 Model for Assembly Line Balancing Problem I (ALBP I) To Minimize the Number of Workstations

The assembly line balancing problem in which the objective is to minimize the total number of workstations is known as ALBP I. In this problem, the minimization of the number of workstations maximizes the balancing efficiency.

Zero-One Programming Model to Minimize the Number of Workstations

In this section, a 0-1 programming model to minimize the number of workstations is presented.

The notations which are used in this model are listed below.

Let,

N be the number of work elements

t_j be the time of the work element j, j = 1, 2, 3, …., N.

C be the cycle time

M be the maximum number of workstations, which can be assumed as the result of any heuristic, like RPW method.

Note: The result of any heuristic may be optimal or non-optimal.

M_0 be the minimum number of workstations.

$M_0 = \lceil (\Sigma t_j)/C \rceil$, rounded to next integer.

$X_{ij} = 1$, if the work element j is assigned to the workstation i,
= 0, otherwise,

for i =1, 2, 3, …, M and j = 1, 2, 3, …, N.

F be the set of work elements which have no succeeding work elements.

c_{ij} be the inflated times of the work elements in the workstations beyond the workstation M_0, which is given by the formula as given below.

$$c_{ij} = t_j [\Sigma_{k \in F} t_k + 1]^{(i - M0 - 1)}, \; i = M_0 + 1, \ldots, M$$

$$= 0, \text{ otherwise}$$

$R = \{ (p_1, q_1), (p_2, q_2), (p_3, q_3), \ldots\ldots, (p_n, q_n)\}$ be the set of arcs in the network. In the arc (p_i, q_i), the work element p_i precedes the work element q_i, i =1 ,2, 3, …., n.

n be the cardinality of the set R.

The model is given below.

$$\text{Minimize } Z = \sum_{i=1}^{M} \sum_{j=1}^{N} c_{ij} X_{ij}$$

Subject to

$$\sum_{j=1}^{N} t_j X_{ij} \le C, \; i = 1, 2, 3, \ldots\ldots, M \qquad \ldots\ldots\ldots [1]$$

$$\sum_{i=1}^{M} X_{ij} = 1, \; j = 1, 2, 3, \ldots\ldots, N \qquad \ldots\ldots\ldots [2]$$

$$X_{kq} \le \sum_{y=1}^{k} X_{yp}, \; k = 1, 2, 3, \ldots\ldots, M, \quad \text{where } (p,q) \in R \text{ and } R = \{ (p_1, q_1), (p_2, q_2), (p_3, q_3), \ldots\ldots, (p_n, q_n)\}$$

$\ldots\ldots\ldots [3]$

Note: If the cardinality of the set R is n, which means that there are n immediate precedence relationships, the total number of constraints of this type will be Mn.

where,

$X_{ij} = 0$ or 1, for i =1 ,2 3, ….., M and j = 1, 2, 3, …., N.

The objective function consists of the terms with the inflated times of the work elements in the workstations beyond the minimum number of workstations [M_0]. These terms will give the required effect to assign the work elements to the earlier workstations and in turn will minimize the number of workstations.

The constraints in the Set 1 ensure that the total time of the work elements assigned to each workstation is limited to the cycle time (C). The constraints in the Set 2 ensure that each work element is assigned to only one workstation. The constraints in the Set 3 ensure the precedence relationships among the work elements in the network.

In the model, the total number of variables is MN and the total number of constraints is M + N + M n

An improved model of the earlier 0-1 programming model mainly to reduce the number of constraints in the Set 3 is given below.

$$\text{Minimize } Z = \sum_{i=1}^{M} \sum_{j=1}^{N} c_{ij} X_{ij}$$

Subject to

$$\sum_{j=1}^{N} t_j X_{ij} \le C, \; i = 1, 2, 3, \ldots\ldots, M \qquad \ldots\ldots\ldots [1]$$

$$\sum_{i=1}^{M} X_{ij} = 1, \; j = 1, 2, 3, \ldots\ldots, N \qquad \ldots\ldots\ldots [2]$$

$$\sum_{i=1}^{M} (M - i + 1)(X_{ip} - X_{iq}) \ge 0, \text{ where } (p,q) \in R \text{ and } R = \{ (p_1, q_1), (p_2, q_2), (p_3, q_3), \ldots\ldots, (p_n, q_n)\}$$

$\ldots\ldots\ldots [3']$

where,

X_{ij} = 0 or 1, for i =1 ,2 3, ….., M and j = 1, 2, 3, …., N.

In this model, as stated in the previous model, the objective function consists of the terms with the inflated times of the work elements in the workstations beyond the minimum number of workstations [M_0]. These terms will give the required effect to assign the work elements to the earlier workstations and in turn will minimize the number of workstations.

The constraints in the Set 1 ensure that the total time of the work elements assigned to each workstation is limited to the cycle time (C). The constraints in the Set 2 ensure that each work element is assigned to only one workstation. The constraints in the Set 3' ensure the precedence relationships among the work elements in the network. In the model, the total number of variables is MN and the total number of constraints is M + N + n. There is a reduction of Mn – n constraints in this model when compared to the earlier model.

Example

The precedence network of eight work elements and their times (in minutes) are shown in Fig.1. The desired cycle time is 15 minutes. The number of workstations formed using Rank Positional Weight method (Panneerselvam 2012) for this problem is 4, which is treated as the maximum number of workstations.

A 0-1 programming model to allocate the work elements to workstations such that the number of workstations is minimized is presented and its results are also summarized.

The total number of work elements, N = 8

Given cycle time, C = 15 minutes

Maximum number of workstations as per RPW method [M] = 4

Minimum number of workstations,

$M_0 = \lceil (\Sigma t_j)/C \rceil = \lceil 45/15 \rceil = 3$

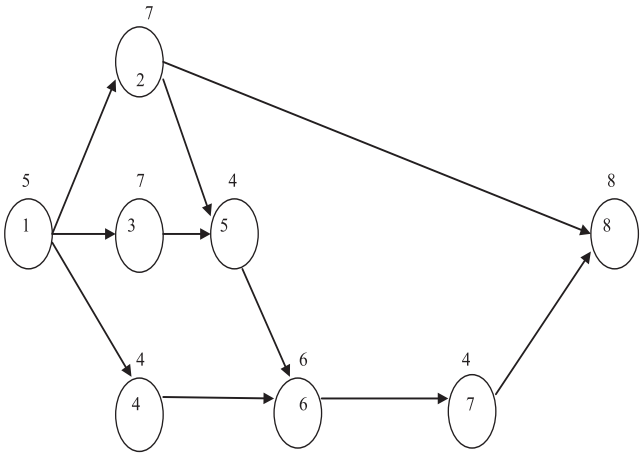

Fig.1 Precedence network along with task times

The inflated times of work elements in the workstations beyond the minimum number of workstations using the following formula are summarized in Table 1.

$$C_{ij} = t_j [\sum_{k \in F} t_k + 1]^{(i - M0 - 1)}, \; i = M_0 + 1, \ldots, M$$

= 0, otherwise

where, F is the set of work elements which have no succeeding work elements

In this example, the work element 8 is not having any succeeding work elements. The time of this work element is 8 minutes.

Table 1 Inflated Times of Work Elements in Workstation 4

Work element (j)	Inflated time in Workstation 4 [c_{4j})
1	$5x[(8) + 1]^{(4-3-1)} = 5$
2	$7x[(8) + 1]^{(4-3-1)} = 7$
3	$7x[(8) + 1]^{(4-3-1)} = 7$
4	$4x[(8) + 1]^{(4-3-1)} = 4$
5	$4x[(8) + 1]^{(4-3-1)} = 4$
6	$6x[(8) + 1]^{(4-3-1)} = 6$
7	$4x[(8) + 1]^{(4-3-1)} = 4$
8	$8x[(8) + 1]^{(4-3-1)} = 8$

The 0-1 programming model of the problem is given below.

Let X_{ij} = 1, if the work element j is assigned to the workstation i,
= 0, otherwise.

for i =1, 2, 3, 4 and j = 1, 2, 3, 4, 5, 6, 7, 8

Minimize $Z = 5X_{41} + 7X_{42} + 7X_{43} + 4X_{44} + 4X_{45} + 6X_{46} + 4X_{47} + 8X_{48}$

Subject to

$$5X_{11} + 7X_{12} + 7X_{13} + 4X_{14} + 4X_{15} + 6X_{16} + 4X_{17} + 8X_{18} \le 15$$
$$5X_{21} + 7X_{22} + 7X_{23} + 4X_{24} + 4X_{25} + 6X_{26} + 4X_{27} + 8X_{28} \le 15$$
$$5X_{31} + 7X_{32} + 7X_{33} + 4X_{34} + 4X_{35} + 6X_{36} + 4X_{37} + 8X_{38} \le 15$$
$$5X_{41} + 7X_{42} + 7X_{43} + 4X_{44} + 4X_{45} + 6X_{46} + 4X_{47} + 8X_{48} \le 15$$
$$X_{11} + X_{21} + X_{31} + X_{41} = 1$$
$$X_{12} + X_{22} + X_{32} + X_{42} = 1$$
$$X_{13} + X_{23} + X_{33} + X_{43} = 1$$
$$X_{14} + X_{24} + X_{34} + X_{44} = 1$$
$$X_{15} + X_{25} + X_{35} + X_{45} = 1$$
$$X_{16} + X_{26} + X_{36} + X_{46} = 1$$
$$X_{17} + X_{27} + X_{37} + X_{47} = 1$$
$$X_{18} + X_{28} + X_{38} + X_{48} = 1$$
$$4(X_{11} - X_{12}) + 3(X_{21} - X_{22}) + 2(X_{31} - X_{32}) + (X_{41} - X_{42}) \ge 0$$
$$4(X_{11} - X_{13}) + 3(X_{21} - X_{23}) + 2(X_{31} - X_{33}) + (X_{41} - X_{43}) \ge 0$$
$$4(X_{11} - X_{14}) + 3(X_{21} - X_{24}) + 2(X_{31} - X_{34}) + (X_{41} - X_{44}) \ge 0$$
$$4(X_{12} - X_{15}) + 3(X_{22} - X_{25}) + 2(X_{32} - X_{35}) + (X_{42} - X_{45}) \ge 0$$
$$4(X_{12} - X_{18}) + 3(X_{22} - X_{28}) + 2(X_{32} - X_{38}) + (X_{42} - X_{48}) \ge 0$$
$$4(X_{13} - X_{15}) + 3(X_{23} - X_{25}) + 2(X_{33} - X_{35}) + (X_{43} - X_{45}) \ge 0$$
$$4(X_{14} - X_{16}) + 3(X_{24} - X_{26}) + 2(X_{34} - X_{36}) + (X_{44} - X_{46}) \ge 0$$
$$4(X_{15} - X_{16}) + 3(X_{25} - X_{26}) + 2(X_{35} - X_{36}) + (X_{45} - X_{46}) \ge 0$$
$$4(X_{16} - X_{17}) + 3(X_{26} - X_{27}) + 2(X_{36} - X_{37}) + (X_{46} - X_{47}) \ge 0$$
$$4(X_{17} - X_{18}) + 3(X_{27} - X_{28}) + 2(X_{37} - X_{38}) + (X_{47} - X_{48}) \ge 0$$

where,

X_{ij} = 0 or 1, for i = 1, 2, 3, 4 & j = 1, 2, 3, ,4, 5, 6, 7, 8.

Results: The results of this model using STORM software are given below.

$X_{11} = X_{14} = X_{22} = X_{23} = X_{35} = X_{36} = X_{37} = X_{48} = 1$ & all other variables are 0.

The details of the allocation of work elements to different workstations based on the above results are shown below..

Details of Workstations

Workstation	Assigned work elements	Total workstation time	Idle time
1	1, 4	9	6
2	2, 3	14	1
3	5, 6, 7	14	1
4	8	8	7
Balancing efficiency		[45/(4x15)]x100 = 75%	

Note: The number workstations formed using RPW method is 4 and that formed using the 0-1 programming model is also 4. This implies that the RPW method gives the optimal solution for this problem.

3.2 Model for Assembly Line Balancing Problem II (ALBP II) to Minimize Cycle Time

In contrasts to the model given for ALBP I, the assembly line balancing problem II (ALBP II) aims to minimize the cycle time.

Let,

M be the maximum number of workstations, which can be assumed as the result of any heuristic, like RPW method or any other intuitive method (Note: The result of any heuristic may be optimal or non-optimal).

T_i be the total time of the work elements assigned to the workstation i, i =1 , 2,3 …, M.

$C = \text{Max}\{T_i\}$, i =1, 2, 3, …., M

The objective of the ALBP II is to minimize the value of C.

The other notations used in this model are presented below.

N be the number of work elements

t_j be the time of the work element j, j = 1, 2, 3, …., N.

M_0 be the minimum number of workstations.

$M_0 = \lceil (\Sigma t_j)/C \rceil$, rounded to next integer.

X_{ij} = 1, if the work element j is assigned to the workstation i,
= 0, otherwise,

for i =1, 2, 3, …, M and j = 1, 2, 3, …, N.

F be the set of work elements which have no succeeding work elements.

R = { (p_1, q_1), (p_2, q_2), (p_3, q_3), ……., (p_n, q_n)} be the set of arcs in the network. In the arc (p_i, q_i), the work element p_i precedes the work element q_i, i =1 ,2, 3, …., n.

n be the cardinality of the set R.

The model to minimize the maximum of the total time of the work elements assigned to different stations is given below.

$$\text{Minimize } Z = \underset{i=1, 2, ..M}{\text{Max}} \left\{ \sum_{j=1}^{N} t_j X_{ij} \right\}$$

Subject to

$$\sum_{i=1}^{M} X_{ij} = 1, \quad j = 1, 2, 3, ..., N \qquad \text{……. [1]}$$

$$\sum_{i=1}^{M} (M - i + 1)(X_{ip} - X_{iq}) \geq 0, \text{ where } (p,q) \in R \text{ and } R = \{ (p_1, q_1), (p_2, q_2), (p_3, q_3), ……., (p_n, q_n)\}$$

…….. [2]

where,

X_{ij} = 0 or 1, for i =1 ,2 3, ….., M and j = 1, 2, 3, …., N.

In this model, the objective function minimizes the maximum of the total workstation times. The constraints in the Set 1 ensure that each work element is assigned to only one workstation. The constraints in the Set 2 ensure the precedence relationships among the work elements in the network.

Since, the objective function is in descriptive form, this model cannot be used to solve problems. Hence, the objective function is to be converted into a workable form, which is achieved using the conversion shown below.

Let C be the minimized cycle time. For each workstation, i = 1, 2, 3, …, M, C is made greater than or equal to the total time of the work elements assigned to that station and treated as a constraint.

$$\text{i.e. } C \geq \sum_{j=1}^{N} t_j X_{ij}, \; i = 1, 2, 3, …., M \qquad \text{…… [3]}$$

Now, the objective function will have only one term, C which is the minimized value of the maximum of the total times of the work elements assigned to different stations.

The model after including this conversion of the objective function is presented below.

Minimize Z = C

Subject to

$$\sum_{i=1}^{M} X_{ij} = 1, \quad j = 1, 2, 3, ..., N \qquad \text{…….[1]}$$

$$\sum_{i=1}^{M} (M - i + 1)(X_{ip} - X_{iq}) \geq 0, \text{ where } (p,q) \in R \text{ and } R = \{ (p_1, q_1), (p_2, q_2), (p_3, q_3), ……., (p_n, q_n)\}$$

…….. [2]

$$C \geq \sum_{j=1}^{N} t_j X_{ij}, \; i = 1, 2,3, ..., M \qquad \text{…….. [3]}$$

where,

X_{ij} = 0 or 1, for i =1 ,2 3, ….., M and j = 1, 2, 3, …., N & C ≥ 0

In this model, the objective function minimizes the maximum of the total workstation times (C). The constraints in the Set 1 ensure that each work element

is assigned to only one workstation. The constraints in the Set 2 ensure the precedence relationships among the work elements in the network. The constraints in the Set 3 ensure that maximum of the total workstation times [Max(T_i), I =1, 2, 3, …., M] is updated in the variable C.

As stated earlier, the model for the ALBP I gives the result of four workstations which results with the balancing efficiently of 75%.

The model for ALBP II aims to minimize the maximum of the workstation times, which is known as the minimized cycle time.

The model of the example problem given earlier applied to this ALBP II is presented below.

Minimize Z = C

Subject to

$$X_{11} + X_{21} + X_{31} + X_{41} = 1$$
$$X_{12} + X_{22} + X_{32} + X_{42} = 1$$
$$X_{13} + X_{23} + X_{33} + X_{43} = 1$$
$$X_{14} + X_{24} + X_{34} + X_{44} = 1$$
$$X_{15} + X_{25} + X_{35} + X_{45} = 1$$
$$X_{16} + X_{26} + X_{36} + X_{46} = 1$$
$$X_{17} + X_{27} + X_{37} + X_{47} = 1$$
$$X_{18} + X_{28} + X_{38} + X_{48} = 1$$
$$4(X_{11} - X_{12}) + 3(X_{21} - X_{22}) + 2(X_{31} - X_{32}) + (X_{41} - X_{42}) \geq 0$$
$$4(X_{11} - X_{13}) + 3(X_{21} - X_{23}) + 2(X_{31} - X_{33}) + (X_{41} - X_{43}) \geq 0$$
$$4(X_{11} - X_{14}) + 3(X_{21} - X_{24}) + 2(X_{31} - X_{34}) + (X_{41} - X_{44}) \geq 0$$
$$4(X_{12} - X_{15}) + 3(X_{22} - X_{25}) + 2(X_{32} - X_{35}) + (X_{42} - X_{45}) \geq 0$$
$$4(X_{12} - X_{18}) + 3(X_{22} - X_{28}) + 2(X_{32} - X_{38}) + (X_{42} - X_{48}) \geq 0$$
$$4(X_{13} - X_{15}) + 3(X_{23} - X_{25}) + 2(X_{33} - X_{35}) + (X_{43} - X_{45}) \geq 0$$
$$4(X_{14} - X_{16}) + 3(X_{24} - X_{26}) + 2(X_{34} - X_{36}) + (X_{44} - X_{46}) \geq 0$$
$$4(X_{15} - X_{16}) + 3(X_{25} - X_{26}) + 2(X_{35} - X_{36}) + (X_{45} - X_{46}) \geq 0$$
$$4(X_{16} - X_{17}) + 3(X_{26} - X_{27}) + 2(X_{36} - X_{37}) + (X_{46} - X_{47}) \geq 0$$
$$4(X_{17} - X_{18}) + 3(X_{27} - X_{28}) + 2(X_{37} - X_{38}) + (X_{47} - X_{48}) \geq 0$$
$$C - 5X_{11} - 7X_{12} - 7X_{13} - 4X_{14} - 4X_{15} - 6X_{16} - 4X_{17} - 8X_{18} \geq 0$$
$$C - 5X_{21} - 7X_{22} - 7X_{23} - 4X_{24} - 4X_{25} - 6X_{26} - 4X_{27} - 8X_{28} \geq 0$$
$$C - 5X_{31} - 7X_{32} - 7X_{33} - 4X_{34} - 4X_{35} - 6X_{36} - 4X_{37} - 8X_{38} \geq 0$$
$$C - 5X_{41} - 7X_{42} - 7X_{43} - 4X_{44} - 4X_{45} - 6X_{46} - 4X_{47} - 8X_{48} \geq 0$$

where,

X_{ij} = 0 or 1, for i = 1, 2, 3, 4 & j = 1, 2, 3, ,4, 5, 6, 7, 8 & C ≥ 0

Results: The results of this model using STORM software are given below.

$X_{11} = X_{12} = X_{23} = X_{24} = X_{35} = X_{36} = X_{47} = X_{48} = 1$ & all other variables are 0.

The details of the allocation of work elements to different workstations based on the above results are shown below.

Details of Workstations

Workstation	Assigned work elements	Total workstation time	Idle time
1	1, 2	12	0
2	3, 4	11	1
3	5, 6	10	2
4	7, 8	12	0
Balancing efficiency		[45/(4x12)]x100 = 93.75%	

Using the model of ALBP I, the assembly line is designed with four workstations for the given cycle time of 15 minutes. Using the model of ALBP II, for the given number of workstations of 4 (output of ALBP I), the minimized cycle time is 12 minutes, which is less than the cycle time used in ALBP I. This result will help the organization to increase the production on necessity with the same number of workstations.

4. Conclusion

The assembly line balancing problem plays a vital role in mass production system. Though there are many heuristics for the ALBP I as well as for the ALBP II, one has to have a mathematical model for these problems to check the solution accuracy of these heuristics. In this paper, first a 0-1 programming model is presented to minimize the number of workstations for a given cycle time. Then, a 0-1 programming model is presented to minimize the cycle time for the number of workstations determined in the first model. Though the first model in which the objective is to

minimize the number of workstations is popular, the results of the second model will be useful to enhance the production capacity in case of increased demand due to unforeseen reason to the extent permitted by the difference between the cycle time used in the first model and the cycle time obtained in the second model.

Further, at the time of developing any new heuristic, its solution may be compared with the optimal solution of the corresponding model for small and moderate size problems.

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Analysis of Enablers to Implement Green Supply Chain Management of Indian Automobile Industry

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ABSTRACT: *With increase in environmental concerns during the past few years, a consensus is growing that environmental pollution issues accompanying industrial development should be addressed together with supply chain management, thereby contributing to Green Supply Chain Management (GSCM). GSCM is new concept and appearing in recent literatures. Fifteen enablers to implement GSCM relevant to Indian automobile industry have been identified from literature review through extensive discussions with senior and middle level SC professionals. Questionnaire based survey has been used to indicate the significance of fifteen Enablers. A total of 79 valid responses of Indian automobile industry were received on a five point Likert scale ranging from unimportant to most important. Statistical analysis was used to establish the reliability and validity of the questionnaire. Factor analysis identified two components which covers 90.472% of total variance. This paper may play an important role in promoting green supply chains in Indian automobile industry.*

Keywords: *Supply Chain Management (SCM), Green Supply Chain Management (GSCM), Enablers to implement GSCM, Indian Automobile Industry, Factor Analysis*

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1. Introduction

Since last two decades the competition in different organizations intensified and market become, so did the challenges associated with getting a product and service to the right place at the right time at the lowest cost. Organizations began to realize that it is not enough to efficiencies within an organization, but their whole supply chain has to be made competitive. The understanding and practicing become an essential prerequisite for staying competitive in the global race and for enhancing profitably (Jackson and Alvarez 1992; Upasani 2012).

In past few years, the significant economic growth has been seen in India based on the rapid development of new technologies and broad international trade opportunities. Environmental problems associated with waste and emissions produced from various supply chain activities have forced organizations, facing competitive, regulatory and community pressures, to move towards greening their supply chains.

Supply chain management (SCM) is a set of approaches utilized to efficiently integrate suppliers, manufacturers, warehouses, and stores, so that a quality product is produced and distributed in right quantities, to the right locations, at the right time and at minimum cost (McLaren, Head and Yuan 2004; Mishra 2012). Green Supply Chain Management is adding 'green' component to Supply Chain Management, including operations, green design, green manufacturing, reverse logistics and waste management (Srivastva 2007).

1.1 Organization of the paper

Literature Review has been carried out in section 2. Enablers to implement GSCM in Indian automobile industry have been identified and described in section

3. Methodology has been explored in section 4. In the last sections, the results and discussions of this research are presented, followed by limitations and scope for future research and conclusions.

2. Review of Literature

Various researchers worked on issues related to GSCM. The research work done by various researchers may be highlighted in chronological order as follows-

Hosseini (2007) discussed factors and a conceptual model in the adoption and maintenance of green management system. Sarkis, Hasan and Shankar (2007) developed a structured model of environmentally conscious manufacturing barriers. Yu (2007) studied factors three factors named technology, organization and environment influencing the adoption of green supply chain practices for the logistics industry in Taiwan.

Walker, De Sisto and Mc Brian (2008) identified barriers to environment supply chain management practices. They divided barriers in to two types- internal barriers and external barriers. Yu and Hui (2008) examined six factors influencing adoption of green innovations for logistics service providers. Zhu, Sarkis and Lai (2008a) surveyed to evaluate their perceived GSCM practices and relate them to close the supply chain loop with manufacturers in four typical Chinese industries. Zhu, Sarkis and Lai (2008b) formulated a measurement model for GSCM practices implementation among the manufacturers.

Mudgal, Shankar, Talib and Raj (2009) explained ISM based model for greening the supply chain in Indian manufacturing industries. Yu and Hu (2009) developed green supply chain model and analyzed different factors affecting all the aspects of the products. They suggested that optimization the procurement on the raw materials and product distribution would optimize the GSCM. Wu and Hang (2009) suggested Implementation of GSCM in IT industry of Taiwan. They explored the relationships between knowledge transfer and green management performance.

Faisal (2010) presented an approach to effectively adopt sustainable practices in a supply chain by understanding the contextual relationships between various enablers that would help to transform a supply chain into a sustainable manufacturing. Hu and Hsu (2010) identified critical success factors for implementing GSCM in electrical and electronic industries in Taiwan. They identified twenty critical factors dividing into four dimensions i.e. supplier management, product recycling, organization involvement and lifecycle management. Mudgal, Shankar, Talib and Raj (2010) proposed ISM based model for the barriers of green supply chain Practices in Indian manufacturing industries. Shang, Lu and Li (2010) investigated crucial GSCM capability dimensions and firm performance based on electronics-related manufacturing firms in Taiwan. Factor analysis was conducted to reduce the identified GSCM attributes into six critical GSCM factors. The six GSCM factors were labeled as green manufacturing and packaging, environmental participation, green marketing, green supplier, green stock and green eco-design. The results suggested that firms with a better GSCM capability attain a higher firm performance in the electronics industry. Woofi and Zailani (2010) investigated barriers to implement Green Supply Chain initiatives in SMEs of Malaysia. They discussed Lack of eco-design, Lack of green purchasing, Lack of reverse logistics, Attitudinal and Perceptions barriers, Information related barriers, Technical barriers and Resource barriers.

Diabat and Govidan (2011) suggested that GSCM as an important organizational philosophy to reduce environmental risks. Eltayeb, Zailani and Ramayah (2011) assessed the actual environmental, economic and intangible outcomes resulting from the adoption of green supply chain initiatives. Luthra, Kumar, Kumar and Haleem (2011) developed ISM based model of barriers to implement GSCM in Indian automobile industry. Brave and Muduli, (2011) discussed challenges to implement Environmental Management System (EMS) in Indian mining industry. They identified ten barriers to implement EMS from literature survey and expert opinions.

Luthra, Garg, Kumar and Haleem (2012) developed ISM based hypothetical model of factors important to

implement GSCM in Indian manufacturing industry based upon literature review and experts' opinions. Nimawat and Namdev (2012) provided an overview of GCM practices in India and discussed four major activities of GSCM like green purchasing, green manufacturing, green marketing and reverse logistics.

3. Identification of Enablers to Implement GSCM in Indian Automobile Industry

The Automobile industry in India is one of the largest in the world and one of the fastest growing globally. A growth rate of 18% per annum has been observed (Choudhary and Seth 2011). India manufactures over 11 million vehicles (including 2 wheeled and 4 wheeled) and exports about 1.5 million every year. In 2009, India emerged as Asia's fourth largest exporter of passenger cars, behind Japan, South Korea and Thailand (Subrahmanian and Kumar 2011).

Fifteen important enablers to implement GSCM practices in Indian automobile industry have been identified. These enablers have been identified through extensive literature review, discussions with senior and middle level engineers/ managers. Enablers to implement GSCM in Indian automobile industry as reported in literature are briefly explained in Table 1:

Table 1: Enablers to Implement GSCM in Indian Automobile Industry as reported in Literature

S. N.	Enablers to Implement GSCM	Brief Description	Researchers
1	Information Technology (IT) Enablement	An efficient information technological system is necessary for effective communication and supporting the GSCM.	Jharkharia and Shankar (2005); Ravi and Shankar (2005); Sarkis et. al. (2007); Yu (2007); Yu and Hui, (2008); Luthra et. al. (2011)
2	Technology Advancement and Organization Adoption	Technology advancement and organization adoption is advancements in machinery and equipments to improve the products and services to increase the environmental performance to achieve GSCM.	Gant (1996); Digalwar and Metri (2004); Yu (2007); Yu and Hui, (2008); Mudgal et. al. (2009)
3	Organization Encouragement	Organization Encouragement is to motivate the employees by providing incentives or other benefits to achieve efficient GSCM.	Sarkis et. al. (2007); Yu (2007); Hsu and Hu (2008); Singh and Kant (2008); Yu and Hui (2008); Luthra et. al. (2011)
4	Quality of Human Resources	Quality of human resources means well qualified and professionals to implement effective green practices.	Ravi and Shankar (2005); Sarkis et. al. (2007); Yu (2007); Yu and Hui (2008); Luthra et. al. (2011)
5	Government Support systems	Government sets the environmental regulations for industry. Government support system means industry friendly governmental policies to promote GSCM.	Scupola (2003); Yu (2007); Yu and Hui (2008); Mudgal et. al. (2009); Mudgal et. al. (2010); Luthra et. al. (2011)
6	Innovative Green Practices	Innovative Green Practices means use of those practices, which are not/ less harmful to the environment e.g. Green Design, Green Manufacturing etc.	Yu (2007); Zhu et. al. (2007a, b); Hsu and Hu (2008); Mudgal et. al. (2009); Hsu and Hu (2010); Mudgal et. al. (2010); Luthra et. al. (2011)
7	Top Management Commitment	Top management commitment is a dedication to empower people to change, the progress to ensure core manufacturing strategies and business strategies.	Hamel and Prahalad (1989); Digalwar and Metri (2004); Ravi and Shankar (2005); Yu (2007Yu and Hui (2008); Singh and Kant (2008); Yu and Hui (2008); Mudgal et. al. (2009); Luthra et. al. (2011)
8	International Environment Agreements	An international environment agreements means green practices should be promoted at international platforms e.g. SAARC, WHO etc.	Chien and Shih (2007); Yu (2007); chien and Shih (2008); Yu and Hui (2008); Luthra et. al. (2011)

S. N.	Enablers to Implement GSCM	Brief Description	Researchers
9	Supplier Motivation	Involvement of the suppliers in design process and technology affects overall performance of whole chain.	Digalwar and Metri (2004); Ravi and Shankar, (2005); Sarkar and Mohapatra (2006)
10	Awareness Level of customers	Customer's awareness means if customer wants green products; the company has to change technology for innovative Green Products.	Lamming and Hamapson (1996); Yu (2007); Yu and Hui (2008); Zhu et. al. (2008 a, b); Mudgal et. al. (2009); Mudgal et. al. (2010); Toke et. al. (2010); Luthra et. al. (2011)
11	Environment Literacy among Supply Chain Distribution Networks	Environment literacy is the understanding of environmental issues to implement GSCM.	Revell, and Rutherfoord (2003); Mudgal et. al. (2009); Mudgal et. al. (2010)
12	Supportive Company Policies towards GSCM	Supportive Company policies means policies that encourage or motivate to implement GSCM	Mudgal et. al. (2009); Mudgal et. al. (2010); Yan (2011)
13	Economic Interests	Economic interests means lowering costs by reducing waste and reducing environmental compliance costs	Lamming and Hamapson (1996); Stevels (2002); Duber-Smith (2005); Zhu and Sarkis (2006); Mudgal et. al. (2009); Luthra et. al. (2011)
14	Competitiveness	Competitiveness is supremacy, standing out from others	Chen et. al. (2006); Mudgal (2009)
15	Proper Strategic Panning	Strategic planning gives the course of action for implementation of GSCM.	Hsu and Hu (2008); Simpson and Samson (2008); Mudgal et. al. (2010)

4. Methodology

Questionnaire based survey to rank these enablers and factor analysis have been used to achieve the objectives of this research work. These methodologies and their results are discussed in the following sections.

4.1 Data Collection

In the present survey, the respondents were asked to indicate the significance of 15 listed enablers on a five-point Likert scale. The questionnaire was mailed to concerned persons of Indian automobile industry. 289 questionnaires were sent. After several reminder emails in addition to some telephonic calls, 87 completed questionnaires were received. Eight questionnaires were incomplete and were discarded. So, only 79 questionnaires were analyzed. This gives an overall response rate of 27.33%. Malhotra and Grover (1998) have suggested a response rate of 20% for positive assessment of the surveys. This implies that the sample proportion of response rate of this study is acceptable. On the basis of responses, data of responding companies has been shown in Table 2 and enablers to implement GSCM in Indian automobile industry have been presented in the decreasing order of their significance in Table 3.

Table 2: Data of Responding Companies

S. N.	Description of Data	Range/Type	Percentage of Companies
1.	Respondent Profile	Sr. Level Managers Middle Level Managers Lower Middle Managers/ Engineers	15.1 58.0 27.9
2.	Work Experience	Less than 5 Years 5 to 10 Years 10 to 15 Years 15 to 20 Years Greater than 20 Years	20.3 30.4 22.8 17.7 8.8
3.	Size of Company	Less than 50 Employees 50-249 Employees Greater than 250 Employees	12.7 19.0 68.7
4.	Type of Company	Original Equipment Manufacturer Supplier	53.2 46.8
5.	No. of Suppliers	Less than 5 6 to 10 11 to 20 Greater than 20	7.6 10.1 16.5 65.8
6.	Environmental Management System	Yes No In progress	97.5 0.00 2.5

Table 3: Survey results of Enablers Important to Implement GSCM in Indian Automobile Industry as reported in Literature

S. N.	Enablers To Implement GSCM	Mean	Standard Deviation	Rank
1	International Environment Agreements	4.86	0.416	1st
2	Government Support Systems	4.78	0.498	2nd
3	Top Management Commitment	4.73	0.548	3rd
4	Proper Strategic Planning	4.68	0.611	4th
5	Supportive Company Policies towards GSCM	4.57	0.710	5th
6	Technology Advancement and Adoption	4.52	0.749	6th
7	IT Enablement	4.43	0.779	7th
8	Innovative Green Practices	4.28	0.783	8th
9	Environment Literacy among Supply Chain Distribution Networks	4.18	0813	9th
10	Supplier Motivation	4.07	0.829	10th
11	Organization Encouragement	3.97	0.832	11th
12	Awareness Level of Customers	3.94	0.837	12th
13	Economic Interests	3.78	0.842	13th
14	Competitiveness	3.72	0.846	14th
15	Quality of Human Resources	3.71	0.850	15th

International Environment Agreements" has been observed highest mean, lowest standard deviation and "Quality of Human Resources" lowest mean, highest standard deviation has been observed in Table 3.

4.2 Factor Analysis

Collected data were analyzed using statistical software – SPSS Version 17.0. Both factor analysis and reliability testing were carried out on the enablers to implement GSCM practices in Indian automobile industry. Factor analysis was utilized to extract factors based upon the principal components analysis with varimax rotation. Bartlett's test of sphericity and the Kaiser- Meyer-Olkin (KMO) measure of sampling adequacy were employed to test the appropriateness of the data for factor analysis (Kaiser 1974). The test results of KMO show that the compared value is 0.909, significantly exceeding the suggested minimum standard of 0.5 required for conducting factor analysis (Hair et al. 2009). Based on the above tests, it is evident that all factors are suitable for applying factor analysis. The authors performed factor analysis to extract factors in accordance with the eigen values of discontinuity greater than 1 and factor loading exceeding 0.6 was principle in choosing factors (Hsu and Hu 2010). In our case, all enablers have factor loading greater than 0.6. Reliability concerns the extent to which an experience, test or any measuring procedure yields the same results on repeated trials (Carmines and Zeller 1979). The reliability of the factors needs to be determined to support any measures of validity that may be employed (Nunnally 1978). Generally, Cronbach's alpha value exceeding 0.7 is considered to have high internal consistency of scale (Nunnally 1978). In our study, Cronbach's alpha values in our study are greater than 0.974, revealing the high internal consistency. Table 3 explains results of enablers to implement GSCM in Indian automobile industry by using factor analysis. Two components have been extracted, which covers 90.472% of total variance. Members of supply chain (Organization Involvement, Suppliers and Customer etc.) as well non members of supply chain (International Environment Agreements and Government Support Systems) will play important role in greening the Indian automobile supply chain.

Table 4: Factor Analysis result of enablers to implement GSCM in Indian automobile industry

Kaiser-Meyer-Olkin Measure of Sampling Adequacy = 0.909

Bartlett's Test of Sphericity: Approx. Chi-Square= 2371.563; df=105; Sign. =.000

Overall Cronbach's α for enablers to implement GSCM in Indian automobile industry = 0.974

Enablers to implement GSCM in Indian automobile industry	Component Loading	
	Component 1	Component 2
Competitiveness	.952	
Quality of Human Resources	.951	
Economic Interests	.943	
Awareness Level of Customers	.899	
Organization Encouragement	.883	
Supplier Motivation	.835	
Environment Literacy among Supply Chain Distribution Networks	.784	
Innovative Green Practices	.692	

Enablers to implement GSCM in Indian automobile industry	Component Loading	
	Component 1	Component 2
Government Support Systems		.927
Top Management Commitment		.917
Proper Strategic Planning		.903
International Environment Agreements		.870
Supportive Company Policies towards GSCM		.852
Technology Advancement and Adoption		.820
IT Enablement		.749
Eigen Values	**7.047**	**6.524**
Variance Explained (% age)	**46.978**	**43.494**
Cumulative Variance (% age)	**46.978**	**90.472**
Cronbach's α	**0.982**	**0.966**

Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization; Rotation converged in 3 iterations

5. Results and Disscusions

Fifteen enablers have been identified from the literature review, the experts' opinion (Academia and Industry) and questionnaire based survey. The objective of the research is to validation of enablers to implement GSCM in Indian automobile industry. Table 3 shows the rated levels of GSCM practices for each of the enabler to implement GSCM in the Indian automobile industry. International environment agreements have highest rating (4.86). Green practices should be promoted at international platforms like SAARC, WTO, WHO, CWO etc. effectively. International environment agreements may support Indian government to take initiatives towards green practices. ISO14001:2004 (Environment management system) and ISO26000:2010(Guidance on social responsibility) should be promoted by Indian government. In last few years, many important steps have been taken to promote green practices by Indian Government. In 11th five year plan (2007-2012) environment and social responsibility is given special importance. Indian government may announce some extra tax benefits or other benefits to the organizations following green practices. Implementation of government supportive policies towards green practices will lead to more committed top management towards GSCM. Top management commitment is required to encourage implement current technological advancements relevant to green practices. IT enablement will also help in fast and effective communication among members of supply chain to achieve competent SCM. IT enablement will reduce a lot of paper work which will further reduce the need of cutting trees. Well aware and good quality of human resources should be hired. Initially, top management may find it more costly, ultimately it is going to help in implementing effective green practices. Technology advancement adoption, Organization encouragement, Quality of human resources, Supportive company policies towards GSCM and proper strategic planning will create environment literacy among supply chain distribution network, which will further increase supplier motivation towards GSCM. Supplier motivation and organization involvement will lead to better implementation of innovative green practices in supply chain of Indian automobile industry. Innovative green practices involve hazardous solid waste disposal, energy conservation, reusing and recycling materials. Regular training programs may be conducted to create awareness about green practices which will further help in organizations adoption and encouragement. Government and Industry should take initiatives to make the customers aware about green products and how they are helpful to them. Special ad- campaigns and welfare programs by government departments like welfare ministry should be made to increase awareness level of customers. Aware customers about green products would like to purchase green products, which will increase organization's reputation and sales volumes. Organizations implementing green practices can compete and export their products in world market. Organizations using improved environmental performance may lower their costs by reducing waste, also reducing their environmental compliance costs and lessening the threats of civil and criminal liability by preventing pollution (Luthra, Kumar, Kumar and Haleem 2011).

6. Conclusions

In this research study, an attempt has been made to identify the major enablers that facilitate successful implementation of GSCM practices in Indian automobile industry. Overall findings of this paper suggest that there is growing awareness about green issues in India and automobile industry is under pressure to ensure a more environmentally friendly supply chain. While some of them have already taken lead in this direction, others are also gearing up to deal with the problem. An organization may be benefited in analyzing which enablers they have to improve upon to implement GSCM in Indian automobile industry. This paper will help Indian automobile industry to prepare well for implementation of GSCM

7. Limitations and Scope for Future Research

In the present paper, fifteen enablers to implement GSCM in Indian automobile industry are identified but in future, more number of enablers to implement GSCM in Indian automobile industry may emerge. Some enablers may be included for other industry in India or any other country. Further, Analytical Hierarchy Process (AHP) and Analytical Network Process (ANP) techniques may also be used to determine strength of relationships among these enablers considered in our study. Interpretive Ranking Process (IRP) may be used to rank enablers to implement GSCM in Indian automobile industry.

Acknowledgments

The authors would like to thank Dr. Sanjay Kumar, Professor, Department of Mechanical Engineering, Bhagwan ParshuRam College of Engineering, Gohana-131301, Haryana (India) for the technical advice. Additional thanks go to Consulting Group members of Indian automobile industry and academicians for sharing their knowledge.

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A Study on Capital Budgeting Decision at Bharat Heavy Electricals Limited (BHEL) Power Sector – Southern Region (PSSR), Chennai

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Ramya G **

Abstract

Capital budgeting Decision is one of the most important decisions faced by a financial Manager since it involves large investments and benefits are realized only in the future.

BHEL is one among the Navaratnas of Government of India and a continuously growing organization.

The objectives of the study is to analyse the process use for capital budgeting decision done in BHEL in which the proposal are analyzed in terms of Payback period, Accounting rate of return, Internal rate of return, Net Present value and Profitability Index. The acceptance rules for the proposal are decided by the management of the organization. In this study, the decision to buy or not to buy a crane is taken on the above parameters.

Capital Budgeting Decision refers to the process we use to make decision concerning investment in the long term assets of the firm. The general idea is that the capital or long term funds raised by the firms are used to invest in assets that will enable the firm to generate revenue for several years in the future.

Key words: *Capital Budgeting, Payback Period, Net Present Value , Internal Rate of Return, Profitability Index.*

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1. Introduction

BHEL is the largest engineering and manufacturing enterprise in India and it was incorporated in the year 1964. It is one of the leading international companies in the field of power equipment manufacture and engaged in power generation, transmission, industry (transportation, renewable energy etc) and Overseas Business**. BHEL is a ISO 9000, ISO 9001-2000, ISO 14001 and also OHSAS-18001** certified. BHEL has over the years established its references in 68 countries of the world spanning across all the six-inhabited continents. In 1991-92, it has divested a part of its equity shares to public and financial institutions. At present the government of India holds a stake of 67.72% in the total equity capital of the company. In India alone BHEL have 14 manufacturing units, four power sector regional offices, eight service centres and 15 business offices. BHEL manufactures over 180 products under 30 major product groups and enable to provide high level of quality & reliability of its products at prompt time.

In Power generation segment, BHEL is the largest manufacturer in India supplying wide range of products & systems for thermal, nuclear, gas and hydro-based utility and captive power plants.

BHEL has proven turnkey capabilities for executing power projects from concept-to-commissioning. BHEL supplied utility power generating sets have crossed the landmark of 100000 MW and continue to maintain the record of nearly two-third of the overall installed capacity and around three-four them of the power generated in India.

Capital budgeting is concerned with designing and carrying through a systematic investment program.

According to **Charles T. Horngren**, "Capital budgeting is a long-term planning for making and financing proposed capital outlays."

Thus, the **capital budgeting** decision may be defined as the firm's decision to invest its current funds most efficiently in long-term activities in anticipation of an expected flow of future benefits over a series of years. Such decisions may consist of addition, disposition, modification, mechanization or replacement of any fixed assets.

Capital budgeting is the process by which firms determine how to invest their capital. It also includes the decision to invest in new projects, reassess the amount of capital already invested in existing project, allocate and ration capital across divisions, and acquire other firms. In essence, the capital budgeting process defines the set and size of a firm's real assets, which in turn generate the cash flows that ultimately determine its profitability, value and viability.

1.1 SCOPE OF CAPITAL BUDGETING DECISIONS

a) **Mechanization of a process** - In order to reduce costs, a firm may intend to mechanize its existing production process by installing machine. The future cash inflows on this investment are the savings resulting from the lower operating costs. The firm would be interested in analyzing whether it's worth to install the machine.

b) **Expansion decision** - Every company want to expand its existing business. In order to increase the scale of production. The company may think of acquiring new machinery, addition of building, merger or takeover of another business etc. This all would require additional investment which should be evaluated in terms of future expected earnings.

c) **Replacement decision** - A company may contemplate to replace an existing machine with a latest model. The use of new and latest model of machinery may be possible to bring down operating costs and increase the production. Such replacement decision will take with help of capital budgeting.

d) **Choice of equipment** - A company needs an equipment to perform a certain process. Now a choice can be made between semi-automatics or fully-automatic machine. Capital budgeting process helps a lot in such selections.

e) **Product or process innovation** - The introduction of new product or a new process will be involve heavy expenditure and will earn profits also in the future. So, a study of capital budgeting will be very useful and the ultimate decision will depend upon the profitability of the product or process.

CAPITAL BUDGETING - DISTINCTIVE FEATURES:-

a) It involves exchange of current funds for the benefits to be achieved in future.

b) Future benefits are expected to be realized over a series of years.

c) There is relatively high degree of risk and may involve substantial outlay.

d) They have long-term and significant effect on profitability of the concern.

TYPES OF CAPITAL BUDGETING DECISIONS:

a) **Accept-reject decisions**:

This is a fundamental decision capital budgeting. If the project is accepted - the firm invests in it. If the proposal is rejected- the firm does not invest in it.

b) **Mutually exclusive projects decision**:

These are projects which compete with other projects in such a way that the acceptance of one will exclude the acceptance of other projects. The alternatives are mutually exclusive and only one may be chosen. Mutually exclusive investment decisions acquired significance when more than one proposal is acceptable under accept-reject criterion.

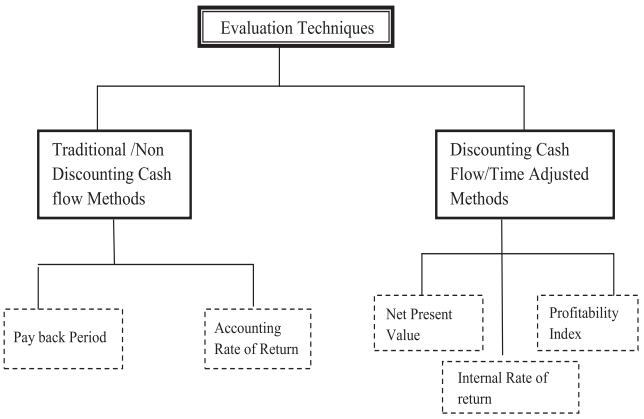
c) Capital rationing decisions:

Capital rationing refers to situation in which the firm has more acceptable investments requiring greater amount of finance then is available with the firm. It is concerned with selection of group of investment proposals actable under accept-reject criterion under financial constraints.

EVALUATION TECHNIQUES OF CAPITAL BUDGETING

The methods of appraising capital expenditure proposals can be classified into two broad categories as shown in figure below:

Figure 1 showing techniques of Capital Budgeting



FACTORS INFLUENCING CAPITAL BUDGETING DECISION:

There are many factors financial as well as non financial which influence the capital expenditure decisions and the profitability of the proposal yet, there are many other factors which have to be taken into consideration while taking a capital expenditure decisions. They are

a) URGENCY: Sometime an investment is to be made due to urgency for the survival of the firm or to avoid heavy losses. In such circumstances, proper evaluation of the proposal cannot be made though profitability tests

b) DEGREE OF UNCERTAINTY:

Profitability is directly related to risk, higher the profits, greater is the risk or uncertainty.

c) INTANGIBLE FACTORS:

Sometimes, a capital expenditure has to be made due to certain emotional and intangible factors such as safety and welfare of the workers, prestigious projects, social welfare, goodwill of the firm etc.

d) LEGAL FACTORS:

An investment which is required by the provisions of law is solely influenced by this factor and although the project may not be profitable yet the investment has to be made.

e) FUTURE EARNINGS:

A project may not be profitable as compared to another today, but is may promise better future earnings. In such cases it may be preferred to increase earnings.

1.2 OBJECTIVES OF THE STUDY

a) To study the procedure followed in BHEL-PSSR (Power Sector Southern Region) for **Capital Budgeting Decisions**

b) To study the project proposal followed in **BHEL** for Crane purchase and their acceptance and rejection for the concerned project.

1.3 RESEARCH METHODOLOGY

This study of capital budgeting decision use both analytical research and descriptive research.

1.4 SOURCES OF DATA

SECONDARY DATA:

The study is mainly based on secondary data which was collected from

a) Annual reports for the year 2006-07,2007-08,2008-09,2009-10,2010-11.

b) Journals of BHEL

c) Official website of the company

1.5 FINANCIAL TOOLS USED

The financial tools used in analyzing the **Capital Budgeting Decision** in **Bharat**

Heavy Electrical Limited (PSSR), Chennai were

a) Payback Period

b) Average Rate of Return

c) Internal Rate of Return

d) Net Present Value

e) Profitability Index

2. Review Of Literature

In the 1970's the studies like those of Petty et al (1975), observed an inclination towards the use of Discounted Cash Flow method especially IRR method.

A trend towards incorporation of risk was also indicated by these studies. During this time that certain studies focused specifically on the risk aspect of capital budgeting. However the studies of 1980's like those of Pandey (1989) found that Payback Period Method was most popular followed by IRR Method.

Beginning from the early 1990s, U. Rao Cherukuri (1991) in the case of large U.S. companies concluded that IRR was the most preferred choice followed by the NPV method. They found that evaluators used multiple evaluation methods. The most widely accepted discount rate was 'weighted average cost of capital' (78%) and for measuring risk 'sensitivity analysis' (80%). Similar results were found by Bierman (1993) in a survey of 74 Fortune 100 firms.

Babu and Sharma (1995) observed that discounted cash flows (DCF) methods were applied by as many as 75 percent of the respondent companies. Sensitivity analysis and adjustment of discount rate methods were found popular for handling risk.

Similarly Dhanker's (1995) study revealed that 16 percent companies used DCF techniques and 33 percent traditional methods like Payback and Accounting Rate of Return (ARR). Further, 51 percent of companies incorporated risk by adjusting the discount rate and 45 percent used Capital Asset Pricing Model (CAPM). The studies of Jog and Srivastava (1995) and Pike, Richard (1996) supported this and found that payback period method was the most preferred method in companies of Canada and the United Kingdom.

Cherukuri (1996) selected top 300 non-government companies and compared their capital budgeting practices with those of Hong Kong, Malaysia and Singapore. The study revealed that 51 percent of the respondent companies used IRR, 30 percent used NPV and 38 percent and 19 percent respondents used respectively the payback period and ARR methods. About 90 percent of respondent firms used shortening the payback period and 59 percent used sensitivity analysis for incorporating risk.

Chadwell-Hatfield et al, (1997) found that more than 70 percent preferred high IRR and 84 percent NPV as one of the methods in appraising projects. Nearly two thirds of the firms believe that acceptable project should have shorter payback period in addition to either high IRR or NPV.

Stanley Block (1997) studied the small business firms for evaluating capital budgeting techniques used by them in 1990's and found that payback period (42.7%) was most popular method, followed by ARR (22.4%). However, it was noticed that the small business owners have increased their sophistication as over 27 percent used discounted cash flow as the primary method of analysis. For inclusions of risk consideration, higher required returns either in form of increasing the cut-off rate or shortening the minimum payback period was preferred by 46.3 percent of the firms.

Jain and Kumar (1998) in a study of 96 non government companies listed on Bombay Stock Exchange in India and 5 companies of South East Asia observed that the most preferred method was Payback Period Method (80% companies) followed by NPV and IRR. For incorporation of risk companies' preferred sensitivity analysis followed by higher cut off rate and shorter payback period.

However Kester and Chang's (1999) survey of 226 CEOs from Australia, Hong Kong, Indonesia, Malaysia, Philippines, and Singapore, found that DCF techniques such as NPV/IRR are the most important techniques for project appraisal and sensitivity analysis and scenario analysis for project risk assessment in all these countries. The beginning of 2000 was marked by certain ground–breaking landmark studies in the area of capital budgeting.

Bums and Walker (1997) included two questions on the frequency and kinds of strategic options in the context of discovering reasons for accepting a negative NPV project. They found a relatively infrequent use of such options, and mostly for reasons of maintaining market share or allowing for operating and managerial flexibility.

Graham and Harvey's (2001) survey of 392 CFOs revealed that the firms which are large, with high debt ratios, having CEOs with MBA are significantly more likely to use DCF techniques like NPV and IRR than their counterparts. Similarly large firms are more likely to use risk-adjusted discount rate while small firms prefer Monte Carlo simulation for risk adjustment.

Similar results were observed by Ryan and Ryan (2002) in a study of Fortune 1000 companies. He observed NPV was most popular technique followed closely by IRR. Additionally, firms with larger capital budgets tend to prefer NPV and IRR. Popular supplemental methods used along with NPV and IRR included sensitivity analysis, scenario analysis, inflation adjusted cash flows, economic value added, and incremental IRR.

Over these years certain noteworthy studies in India were also conducted. In a study of Indian corporate finance practices by Anand (2002), NPV criterion was observed to be a widely used capital budgeting technique followed by IRR. For incorporation of risk, risk adjusted discount rate; sensitivity analysis and scenario analysis were also widely preferred techniques for project risk analysis. However, the use of decision tree analysis and Monte Carlo techniques was limited.

3. Data Analysis

Capital budgeting decision at BHEL- PSSR for Crane purchases in various location of southern region was suggested based on the different methods.

There are five ongoing projects on Capital Budgeting decision of BHEL-Crane purchases in various locations are as follows

PROJECT 1:

Cost of investment is Rs.5125 Lacs. Crane Capacity is 600MT. Place is Bellary.

The profit before depreciation and tax (PBDT) projected for next 10 years are as follows.

(Rs. in lacs)

PBDT	1020	1520	1520	1620	1720	1520	1650	1520	1210	1310

PROJECT 2:

Cost of investment is Rs.10250 Lacs. Crane Capacity is 600MT. Place is Tuticorin.

The profit before depreciation and tax (PBDT) projected for next 10 years are as follows:

(Rs. in lacs)

PBDT	3060	4560	4560	4860	5160	4560	4950	4560	3630	3930

PROJECT 3:

Cost of investment is Rs.4125 Lacs. Crane Capacity is 350MT. Place is North Chennai.

The profit before depreciation and tax (PBDT) projected for next 10 years are as follows.

(Rs. in lacs)

PBDT	306	456	456	486	516	456	495	456	363	393

PROJECT 4:

Cost of investment is Rs.8125 Lacs. Crane Capacity is 800MT. Place is Neyveli.

The profit before depreciation and tax (PBDT) projected for next 10 years are as follows.

(Rs. in lacs)

PBDT	1122	1672	1672	1782	1892	1672	1815	1672	1331	1441

PROJECT 5:

Cost of investment is Rs.1920 Lacs. Crane Capacity is 150MT. Place is Kalpakkam.

The profit before depreciation and tax (PBDT) projected for next 10 years are as follows.

(Rs. In Lacs)

PBDT	91.8	136.8	136.8	145.8	154.8	136.8	148.8	136.8	108.9	117.9

Table 1 a
Investment across projects

(Rs. in lacs)

Project	1	2	3	4	5
Cost of investment	5125	10250	4125	8125	1920

Table 1 b
Expected Profits across Projects

(Rs. in lacs)

PBDT	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Total
Project1	1020	1520	1520	1620	1720	1520	1650	1520	1210	1310	14610
Project2	3060	4560	4560	4860	5160	4560	4950	4560	3630	3930	43830
Project3	306	456	456	486	516	456	495	456	363	393	4383
Project4	1122	1672	1672	1782	1892	1672	1815	1672	1331	1441	16071
Project5	91.8	136.8	136.8	145.8	154.8	136.8	148.8	136.8	108.9	117.9	1315.2

Depreciation as per the profit and loss account - 15% (Straight Line Method)

Depreciation as per the income tax act: 1st year 35%; 2nd year onward 15% (Written down value)

Tax Rate 33%

Present value factor 13%

Techniques Used

a) Payback Method

b) Average rate of return (or) Accounting rate of return

c) Net Present Value

d) Internal rate of return

e) Profitability Index

The five projects of BHEL-PSSR are analyzed using the different Capital Budgeting Techniques to arrive at a decision whether to purchase a Crane or not.

Table 2a
Cash Flows after Tax for Project 1

Years	PBDT	Less depreciation as per income tax	PBT	Less Tax 33%	PAT	ADD Depreciation	CFAT	CCFAT
1	1020	1794	-774	-255	-519	1794	1275	1275
2	1520	500	1020	337	683	500	1183	2458
3	1520	425	1095	361	734	425	1159	3617
4	1620	361	1259	415	844	361	1205	4822
5	1720	307	1413	466	947	307	1254	6076
6	1520	261	1259	415	844	261	1105	7181
7	1650	222	1428	471	957	222	1179	8360
8	1520	188	1332	439	893	188	1081	9441
9	1210	160	1050	346	704	160	864	10305
10	1310	136	1174	387	787	136	923	11228
Total	**14610**	**4354**	**10256**	**3382**	**6874**	**4354**	**11228**	

Table 2 b
Present Values @13% and 20% for Project 1

Years	CFAT	PV@13%	Total PV	PV@20%	Total PV
1	1275	0.885	1129	0.833	1062
2	1183	0.783	926	0.694	821
3	1159	0.693	803	0.579	671
4	1205	0.613	739	0.482	581
5	1254	0.543	681	0.402	504
6	1105	0.480	530	0.335	370
7	1179	0.425	501	0.279	329
8	1081	0.376	406	0.233	252
9	864	0.333	288	0.194	168
10	923	0.295	272	0.162	150
Total			**6275**		**4907**

Present value cash inflow = Rs. 6275 Lacs

Present value cash outflow= Rs.5125 Lacs

PAY BACK PERIOD METHOD

$$\text{Base period} + \frac{\text{Investment - CCFAT}}{\text{Next CFAT}}$$

$$= 4 + \frac{5125 - 4822}{1254}$$

$$= 4 + 0.24 = 4.24 \text{ years}$$

AVERAGE RATE OF RETURN

$$\text{ARR} = \frac{\text{Average annual profit after taxes}}{\text{Average Investment over the life of the project}} * 100$$

Average cash inflow=11228/10 = 1123

Average Investment = 5125/2 = 2563

=1123/2563 *100 = 44%

NET PRESENT VALUE METHOD

Net present value = cash inflow-cash outflow

= 6275 - 5125

NPV @ 13% = Rs. 1150 Lacs

INTERNAL RATE OF RETURN (IRR)

$$\text{IRR} = \text{Lower rate} + \frac{\text{Inflows at lower rate-investment}}{\text{Inflows at lower rate-Inflow at higher rate}} * (\text{Higher Rate} - \text{Lower Rate})$$

$$= 13 + \frac{6275-5125}{6275-4098} *(20-13) = 13 + 5.88 = 19\%$$

PROFITABILITY INDEX

P.I = Total present value of cash inflow/ Total Investment

= 6275/5125 = 1.22 Times

INTERPRETATION

a) The discounted PBP is 4.24 years. The investment will recover in 4 years and 2 months.

b) NPV is positive for the proposal.

c) The internal rate of return 19%.

d) The profitability index is 1.22 times > 1

e) Average rate of return is 44%.

f) BHEL can buy the crane for the project at Bellary, since all the Capital Budgeting techniques are positive and generating high returns.

Table 3a
Cash Flows after Tax for Project 2

Years	PBDT	Less depreciation as per income tax	PBT	Less Tax 33%	PAT	ADD Depreciation	CFAT	CCFAT
1	3060	3588	-528	-174	-354	3588	3234	3234
2	4560	999	3561	1175	2386	999	3385	6619
3	4560	850	3710	1224	2486	850	3336	9955
4	4860	722	4138	1366	2772	722	3494	13449
5	5160	614	4546	1500	3046	614	3660	17109
6	4560	522	4038	1333	2705	522	3227	20336
7	4950	443	4507	1487	3020	443	3463	23799
8	4560	377	4183	1380	2803	377	3180	26979
9	3630	320	3310	1092	2218	320	2538	29517
10	3930	272	3658	1207	2451	272	2723	32240
Total	**43830**	**8707**	**35123**	**11590**	**23533**	**8707**	**32240**	

Table 3 b
Present Values @13% and 20% for Project 2

Years	CFAT	PV@13%	Total PV	PV@20%	Total PV
1	3234	0.885	2862	0.833	2694
2	3385	0.783	2651	0.694	2349
3	3336	0.693	2311	0.579	1932
4	3494	0.613	2142	0.482	1684
5	3660	0.543	1986	0.402	1471
6	3227	0.480	1549	0.335	1081
7	3463	0.425	1472	0.279	966
8	3180	0.376	1196	0.233	741
9	2538	0.333	845	0.194	492
10	2723	0.295	803	0.162	441
Total			**17817**		**13851**

Present value cash inflow = Rs. 17817 Lacs Present value cash outflow= Rs.10250 Lacs

PAY BACK PERIOD METHOD

$$\text{Base period} + \frac{\text{Investment - CCFAT}}{\text{Next CFAT}}$$

$$= 3 + \frac{10250 - 9955}{3494}$$

= 3 + 0.08 = 3.08 years

AVERAGE RATE OF RETURN

$$\text{ARR} = \frac{\text{Average annual profit after taxes}}{\text{Average Investment over the life of the project}} * 100$$

Average cash inflow=32240/10 = 3224

Average Investment = 10250/2 = 5125

= 3224/5125 *100

= 63%

NET PRESENT VALUE METHOD

Net present value= cash inflow-cash outflow

= 17817 - 10250

NPV @ 13% = Rs. 7567 Lacs

INTERNAL RATE OF RETURN (IRR)

$$\text{IRR} = \text{Lower rate} + \frac{\text{Inflows at lower rate-investment}}{\text{Inflows at lower rate-Inflow at higher rate}} * (\text{HR-LR})$$

$$= 13 + \frac{17817 - 10250}{17817 - 13851} *(20-13)$$

$$= 13 + \frac{7567}{3966} * 7$$

= 13 + 13.355 = 26.4%

PROFITABILITY INDEX

P.I = Total present value of cash inflow/ Total Investment

= 17817/10250 = 1.73 Times

INTERPRETATION

a) The discounted PBP is 3.08 years. The investment will recover in 3 years 1 month.

b) NPV is positive for the proposal.

c) The internal rate of return 26.35%.

d) The profitability index is 1.73 times

e) Average rate of return is 63%

f) BHEL can go for purchasing the crane for its Tuticorin Project since all the Capital Budgeting techniques are positive and generating high returns.

Table 4a
Cash Flows after Tax for Project 3

Years	PBDT	Less depreciation as per income tax	PBT	Less Tax 33%	PAT	ADD Depreciation	CFAT	CCFAT
1	306	1444	-1138	-376	-762	1444	682	682
2	456	402	54	18	36	402	438	1120
3	456	342	114	38	76	342	418	1538
4	486	291	195	64	131	291	422	1960
5	516	247	269	89	180	247	427	2387
6	456	210	246	81	165	210	375	2762
7	495	178	317	105	212	178	390	3152
8	456	152	304	100	204	152	356	3508
9	363	129	234	77	157	129	286	3794
10	393	110	283	94	189	110	299	4093
Total	**4383**	**3505**	**878**	**290**	**588**	**3505**	**4093**	

Table 4 b
Present Values @13% and 20% for Project 3

Years	CFAT	PV@13%	Total PV	PV@20%	Total PV
1	682	0.885	604	0.833	568
2	438	0.783	343	0.694	304
3	418	0.693	290	0.579	242
4	422	0.613	259	0.482	203
5	427	0.543	232	0.402	172
6	375	0.480	180	0.335	126
7	390	0.425	166	0.279	109
8	356	0.376	134	0.233	83
9	286	0.333	95	0.194	55
10	299	0.295	88	0.162	48
Total			**2391**		**1910**

Present value cash inflow = Rs.2391 Lacs

Present value cash outflow= Rs. 4125 Lacs

PAY BACK PERIOD METHOD

$$\text{Base period} + \frac{\text{Investment - CCFAT}}{\text{Next CFAT}}$$

Total investment has not been realized by the cash inflow. So there is no payback period.

AVERAGE RATE OF RETURN

$$\text{ARR} = \frac{\text{Average annual profit after taxes}}{\text{Average Investment over the life of the project}} * 100$$

Average cash inflow=4093/10 = 409

Average Investment = 4125/2 = 2063

= 409/2063*100 = 20 %

NET PRESENT VALUE METHOD

Net present value= cash inflow-cash outflow

= 2391 - 4125

NPV @ 13% = Rs. (-) 1734 Lacs

INTERNAL RATE OF RETURN (IRR)

$$\text{IRR} = \text{Lower rate} + \frac{\text{Inflows at lower rate-investment}}{\text{Inflows at lower rate-Inflow at higher rate}} * (\text{HR-LR})$$

$$= 13 + \frac{2391-4125}{2391-1910} * (20-14)$$

= (-) 12.3%

As a sum of pre discounted cash inflow is less then cost of investment there can't be IRR (or) IRR < o

PROFITABILITY INDEX

P.I = Total present value of cash inflow/ Total Investment

= 2391/4125

= 0.58 Times

INTERPRETATION

a) Total investment has not been realized by the cash inflow. So there is no payback period (PBP).

b) NPV is negative for the proposal.

c) As a sum of pre discounted cash inflow is less then cost of investment there can't be IRR (or) IRR <0.

d) The profitability index is 0.57 times which is low.

e) Average rate of return is 20%..

f) BHEL can reject the proposal to buy the crane for North Chennai since all Capital Budgeting techniques are giving low or negative returns.

Table 5a
Cash Flows after Tax for Project 4

Years	PBDT	Less depreciation as per income tax	PBT	Less Tax 33%	PAT	ADD Depreciation	CFAT	CCFAT
1	1122	2844	-1722	-568	-1154	2844	1690	1690
2	1672	792	880	290	590	792	1382	3072
3	1672	673	999	330	669	673	1342	4414
4	1782	572	1210	399	811	572	1383	5797
5	1892	487	1405	464	941	487	1428	7225

Years	PBDT	Less depreciation as per income tax	PBT	Less Tax 33%	PAT	ADD Depreciation	CFAT	CCFAT
6	1672	414	1258	415	843	414	1257	8482
7	1815	351	1464	483	981	351	1332	9814
8	1672	299	1373	453	920	299	1219	11033
9	1331	253	1078	356	722	253	975	12008
10	1441	216	1225	404	821	216	1037	13045
Total	**16071**	**6901**	**9440**	**3026**	**6144**	**6901**	**13045**	

Table 5 b
Present Values @13% and 20% for Project 4

Years	CFAT	PV@13%	Total PV	PV@20%	Total PV
1	1690	0.885	1496	0.833	1408
2	1382	0.783	1082	0.694	959
3	1342	0.693	930	0.579	777
4	1383	0.613	848	0.482	667
5	1428	0.543	775	0.402	574
6	1257	0.480	603	0.335	421
7	1332	0.425	566	0.279	372
8	1219	0.376	458	0.233	284
9	975	0.333	325	0.194	190
10	1037	0.295	306	0.162	168
Total	**13045**		**7389**		**5820**

Present value cash inflow =Rs. 7389 Lacs.

Present value cash outflow= Rs. 8125 Lacs

PAY BACK PERIOD METHOD

$$\text{Base period} + \frac{\text{Investment - CCFAT}}{\text{Next CFAT}}$$

$$= 5 + \frac{8125 - 7225}{1257}$$

= 5 + 0.71 = 5 .71 years

AVERAGE RATE OF RETURN

$$\text{ARR} = \frac{\text{Average annual profit after taxes}}{\text{Average Investment over the life of the project}} * 100$$

Average cash inflow=13045/10 = 1304.5

Average Investment = 8125/2 = 4063

=1304.5/4063 *100 = 32%

NET PRESENT VALUE METHOD

Net present value= cash inflow-cash outflow

= 7389 - 8125

NPV @ 13% = Rs. (-) 736 Lacs

INTERNAL RATE OF RETURN (IRR)

$$\text{IRR} = \text{Lower rate} + \frac{\text{Inflows at lower rate-investment}}{\text{Inflows at lower rate-Inflow at higher rate}} * (\text{HR-LR})$$

$$= 13 + \frac{7389 - 8125}{7389 - 5820} *(20-13)$$

= 13 + (-3.29) = 9.7%

PROFITABILITY INDEX

P.I = Total present value of cash inflow/ Total Investment

= 7389/8125

= 0.9 Times

INTERPRETATION

a) The discounted PBP is 5.71 years. The investment will recover in 5 years and 7 months.

b) NPV is negative for the proposal.

c) The internal rate of return 9.7%.

d) The profitability index is 0.9 times. This is not good sign.

e) Average rate of return is 32%.

g) BHEL can reject the proposal to buy crane for Neyveli since all the Capital Budgeting Techniques are giving comparatively low returns.

Table 6a
Cash Flows after Tax for Project 5

Years	PBDT	Less depreciation as per income tax	PBT	Less Tax 33%	PAT	ADD Depreciation	CFAT	CCFAT
1	91.8	672	-580.2	-191.5	-388.7	672	283.3	283.3
2	136.8	187	-50.2	-16.6	-33.6	187	153.4	436.7
3	136.8	159	-22.2	-7.3	-14.9	159	144.1	580.8
4	145.8	135	10.8	3.6	7.2	135	142.2	723
5	154.8	115	39.8	13.1	26.7	115	141.7	864.7
6	136.8	98	38.8	12.8	26.0	98	124.0	988.7
7	148.8	83	65.8	21.7	44.1	83	127.1	1115.8
8	136.8	71	65.8	21.7	44.1	71	115.1	1230.9
9	108.9	60	48.9	16.1	32.8	60	92.8	1323.7
10	117.9	51	66.9	22.1	44.8	51	95.8	1419.5
Total	**1315.2**	**1631**	**-315.8**	**-104.3**	**-211.5**	**1631**	**1419.5**	

Table 6b
Present Values @13% and 20% for Project 5

Years	CFAT	PV@13%	Total PV	PV@20%	Total PV
1	283.3	0.885	251	0.833	236
2	153.4	0.783	120	0.694	106
3	144.1	0.693	100	0.579	83
4	142.2	0.613	87	0.482	69
5	141.7	0.543	77	0.402	57
6	124.0	0.480	60	0.335	42
7	127.1	0.425	54	0.279	36
8	115.1	0.376	43	0.233	27
9	92.8	0.333	31	0.194	18
10	95.8	0.295	28	0.162	16
Total	**1419.5**		**851**		**690**

Present value cash inflow = Rs. 851 Lacs.

Present value cash outflow=Rs. 1920 Lacs

PAY BACK PERIOD METHOD

$$\text{Based period} + \frac{\text{Investment - CCFAT}}{\text{Next CFAT}}$$

Total investment has not been realized by the cash inflow. So there is no payback period.

AVERAGE RATE OF RETURN

$$\text{ARR} = \frac{\text{Average annual profit after taxes}}{\text{Average Investment over the life of the project}} * 100$$

Average cash inflow=1419.5/10 = 141.95

Average Investment = 1920/2 = 960

= 141.93/960 *100 = 15%

NET PRESENT VALUE METHOD

Net present value= cash inflow-cash outflow

= 851 - 1920

NPV @ 13% = Rs. (-) 1069 Lacs

INTERNAL RATE OF RETURN (IRR)

$$\text{IRR} = \text{Lower rate} + \frac{\text{Inflows at lower rate-investment}}{\text{Inflows at lower rate-Inflow at higher rate}} * (\text{HR-LR})$$

$$= 13 + \frac{851 - 1920}{851 - 690} * (20-14)$$

= (-) 33.5 %

As a sum of pre discounted cash inflow is less then cost of investment there can't be IRR (or) IRR < o

PROFITABILITY INDEX

P.I = Total present value of cash inflow/ Total Investment

= 851/1920

= 0.44 Times

INTERPRETATION

From the above data analysis we derived the results as follow

a) Total investment has not been realized by the cash inflow. So there is no payback period (PBP).

b) NPV is negative for the proposal.

c) As a sum of pre discounted cash inflow is less then cost of investment there can't be IRR (or) IRR <0.

d) The profitability index is 0.44 times, it is very least.

e) Average rate of return is 14.78% .

f) BHEL can reject the proposal to buy a crane for Kalpakkam since all Capital Budgeting techniques are giving negative or low returns.

4. Findings

The study concerned with the capital budgeting with reference to BHEL-PSSR Unit. The data is collected, organized, analyzed and interpreted. The following findings are obtained from the analysis of data.

1. The first project generates unequal cash flows for 10 years. The initial investment is Rs.5125 Lacs. The Payback period is 4.24 years. The investment will recover in 4 years and 2 months. Net present value is positive for the proposal. The internal rate of return for the proposal is 19%. The profitability index is 1.22 times > 1. Average rate of return is 44%. BHEL can purchase the crane for this project at Bellary.

2. The second project generates unequal cash flows for 10 years. The initial investment is Rs 10250 Lacs. The Payback period is 3.08 years. The investment will recover in 3 years and 1 month. Net present value is positive for the proposal. The internal rate of return for the proposal is 26.4%. The profitability index is 1.73 times. Average rate of return is 63%. BHEL can purchase the crane for this project at Tuticorin.

3. The third project generates unequal cash flows for 10 years. The initial investment is Rs 4125 Lacs. Total investment has not been realized by the cash inflow. So there is no payback period. Net present value is negative for the proposal. As a sum of pre discounted cash inflow is less then cost of investment there can't be IRR (or) IRR <0. The profitability index is 0.57 times, it is not good. Average rate of return is 20%. BHEL can reject the proposal to purchase a crane for this project at North Chennai.

4. The fourth project generates unequal cash flows for 10 years. The initial investment is Rs 8125 Lacs. The Payback period is 5.71 years. The investment will recover in 5 years and 7 months. Net present value is negative for the proposal. The internal rate of return for the proposal is 9.6%. The profitability index is 0.9 times this is not good sign. Average rate of return is 32 %. BHEL can reject the proposal to purchase a crane for this project at Neyveli.

5. The fifth project generates unequal cash flows for 10 years. The initial investment is Rs 1920 Lacs. Total investment has not been realized by the cash inflow. So there is no payback period (PBP). NPV are negative for the proposal. As a sum of pre discounted cash inflow is less then cost of investment there can't be IRR (or) IRR <0. The profitability index is 0.44 times, it is very least. Average rate of return is 15%. BHEL can reject the proposal to purchase a crane for this project at Kalpakkam as all the Capital Budgeting techniques are giving negative or low returns.

4.1 SUGGESTIONS AND RECOMMENDATIONS

a) Importance of Capital Budgeting to any organization was analyzed by scanning through the important theoretical concepts relating to Budget.

b) There should be effective coordination between the different departments like Project management, Sales after services, Finance, Human resource, Commercial, Marketing etc; this will enhance the efficiency of the organization.

c) The expenses of the business are highly increasing year to year. So the business could take necessary steps to control the expenditure by the use of cost reduction techniques.

d) BHEL can transfer the cranes to different sites whenever the need arises thereby it can save huge cost by keeping fresh purchases of Cranes to the minimum.

e) Communication is difficult at large firms and people at all levels are busy, so the financial analysis of a large project and the reporting of it must be kept simple and clear.

4.2 CONCLUSION

The study on the Capital Budgeting decision indicates that the company has a slew of projects involving large outlays. It also indicates that depending on each project's financial projections, prudent Capital Budgeting decisions need to be taken as it involves huge investments.

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Edited by Dr. (Ms.) Mani K. Madala and published and printed by Dr. U. K. Debnath, National Institute of Industrial Engineering, Vihar Lake, NITIE, P.O., Mumbai 400 087 and printed by him at ALCO CORPORATION, A Wing, Gala No. 55, Gr. Floor, Virwani Industrial Estate, Goregaon (E), Mumbai - 63.