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Application of Branch and Bound Technique for 3-Stage Flow Shop Scheduling Problem with Transportation Time

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Abstract

This paper provides a branch and bound technique to solve the three stage flow shop scheduling problem including transportation time. Algorithm is given to find optimal or near optimal sequence, minimizing the total elapsed time. This approach is very simple and easy to understand and, also provide an important tool for decision makers to design a schedule for three stage flow-shop scheduling problems. The method is clarified with the help of numerical illustration.

Keywords: Flow shop scheduling, Branch and Bound, Transportation time, Optimal sequence

1. Introduction:

Scheduling is the allocation of resources over time to perform a collection of task. It is an important subject of production and operations management area. In flow-shop scheduling, the objective is to obtain a sequence of jobs which when processed in a fixed order of machines, will optimize some well defined criteria. Various researchers have done a lot of work in this direction. Johnson (1954), first of all gave a method to minimise the makespan for n-job, two-machine scheduling problems. The work was extended by Ignall and Scharge (1965),Lomnicki (1965), Palmer (1965), Cambell (1970), Bestwick and Hastings (1976) ,Dannenbring (1977), Yoshida and Hitomi (1979),Maggu and Dass (1981), Nawaz et al. (1983) , Sarin and Lefoka (1993) , Koulamas (1998) , Heydari (2003) ,Temiz and Erol(2004) etc. by considering various parameters. Yoshida and Hitomi (1979) considered two stage flow shop problem to minimize the makespan whenever set up times are separated from processing time. The basic concept of equivalent job for a job block has been introduced by Maggu and Dass (1981). Heydari (2003) dealt with a flow shop scheduling problem where n jobs are processed in two disjoint job blocks in a string consists of one job block in which order of jobs is fixed and other job block in which order of jobs is arbitrary. Singh T.P. and Gupta Deepak (2005) studied the optimal two stage production schedule in which processing time and set up time both were associated with probabilities including job block criteria.

Lomnicki (1965) introduced the concept of flow shop scheduling with the help of branch and bound method. Further the work was developed by Ignall and Scharge (1965), Chandrasekharan (1992) , Brown and Lomnicki(1966) , with the branch and bound technique to the machine scheduling problem by introducing different parameters. In many practical situations of scheduling it is seen that machines are distantly situated and therefore, the transportation times are to be considered. In this paper we have extended the study made by Lomnicki(1965) by considering the transportation time. Hence the problem discussed here is wider and has significant use of theoretical results in process industries.

2. Practical Situation:

Many applied and experimental situations exist in our day-to-day working in factories and industrial production concerns etc. In many manufacturing companies different jobs are processed on various machines. These jobs are required to process in a machine shop A, B, C, ---- in a specified order. When the machines on which jobs are to be processed are planted at different places, the transportation time (which includes loading time, moving time and unloading time etc.) has a significant role in production concern.

3. Notations:

We are given n jobs to be processed on three stage flowshop scheduling problem and we have used the following notations:

A_i	:	Processing time for job i on machine A
B_i	:	Processing time for job i on machine B
C_i	:	Processing time for job i on machine C
C_{ij}	:	Completion time for job i on machines A, B and C
t_i	:	Transportation time of i^{th} job from machine A to machine B.
g_i	:	Transportation time of i^{th} job from machine B to machine C.
S_k	:	Sequence using johnson's algorithm
J_r	:	Partial schedule of r scheduled jobs
$J_{r'}$	:	The set of remaining (n-r) free jobs

1. Mathematical Development:

Consider n jobs say i=1, 2, 3 … n are processed on three machines A, B & C in the order ABC. A job i (i=1,2,3…n) has processing time A_i , B_i & C_i on each machine respectively, assuming their respective probabilities p_i , q_i & r_i such that $0 \le p_i \le 1$, $\Sigma p_i = 1$, $0 \le q_i \le 1$, $\Sigma q_i = 1$, $0 \le r_i \le 1$, $\Sigma r_i = 1$. Let t_i and g_i be the transportation time of machine A to machine B and machine B to machine C respectively. The mathematical model of the problem in matrix form can be stated as :

Jobs	Machine A		Machine B		Machine C
i	A_i	t_i	B_i	g_i	C_i
1	A_1	t_1	B_1	g_1	C_1
2	A_2	t_2	B_2	g_2	C_2
3	A_3	t_3	B_3	g_3	C_3
-	----	--	---	---	----
n	A_n	t_n	B_n	g_n	C_n

Tableau – 1

Our objective is to obtain the optimal schedule of all jobs which minimize the total elapsed time, using branch and bound technique.

5. Algorithm:

Step1: Calculate

(i) $g_1 = t(J_r, 1) + \sum_{i \in J'_r} A_i + \min_{i \in J'_r}(B_i + C_i)$

(ii) $g_2 = t(J_r, 2) + \sum_{i \in j'_r} B_i + \min_{i \in J'_r}(C_i)$

(iii) $g_3 = t(J_r, 3) + \sum_{i \in j'_r} C_i$

Step 2: Calculate g = max [g_1, g_2, g_3].We evaluate g first for the n classes of permutations, i.e. for these starting with 1, 2, 3………n respectively, having labelled the appropriate vertices of the scheduling tree by these values.

Step 3: Now explore the vertex with lowest label. Evaluate g for the (n-1) subclasses starting with this vertex and again concentrate on the lowest label vertex. Continuing this way, until we reach at the end of the tree represented by two single permutations, for which we evaluate the total work duration. Thus we get the optimal schedule of the jobs.

Step 4: Prepare in-out table for the optimal sequence obtained in step 4 by considering the significant transportation time between the machines.

6. Numerical Example:

Consider 5 jobs 3 machine flow shop problem. processing time of the jobs on each machine is given. Our objective is to find optimal sequence of jobs to find the minimum elapsed time.

Jobs	Machine A		Machine B		Machine C
I	A_i	t_i	B_i	g_i	C_i
1	15	4	20	5	16
2	25	7	10	8	5
3	10	6	12	3	12
4	18	9	15	7	18
5	16	2	25	6	3

Tableau – 2

Solution:Step1: Calculate

(i) $g_1 = t(J_r,1) + \sum_{i \in J_r'} A_i + \min_{i \in J_r'}(B_i + C_i)$

(ii) $g_2 = t(J_r,2) + \sum_{i \in j_r'} B_i + \min_{i \in J_r'}(C_i)$

(iii) $g_3 = t(J_r,3) + \sum_{i \in j_r'} C_i$

For J_1 = (1).Then $J'(1)$ = {2,3,4}, we get

g_1 = 43 , g_2 = 37 & g_3 = 43 and g = max(g_1, g_2, g_3) = 43

similarly, we have LB(2)= 51 LB(3)= 52 LB(4)= 58

*Step 2 & 3:*Now branch from J_1 = (1). Take J_2 =(12). Then J'_2={3,4} and LB(12) = 51

Proceeding in this way, we obtain lower bound values on the completion time on machine C as shown in the tableau- 3

Step 4:Therefore the sequence S_1 is 3-1-4-5-2 and the corresponding in-out table on sequence S_1 is as in table-4:

Hence the total elapsed time of the given problem is 115 units.

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Tables and Figures:

Table 3: lower bounds for respective jobs are as in tableau-3:

Table 4:In-out table on sequence S_1 is as in tableau-4:

Job I	Machine A In-out	t_i	Machine B In-out	g_i	Machine C In-out
3	0 – 10	6	16 - 28	3	31 - 43
1	10 – 25	4	29 – 49	5	54 – 70
4	25 – 43	9	52 – 67	7	74 – 92
5	43 – 59	2	67 – 92	6	98 -101
2	59 – 84	7	92 – 102	8	110 – 115

Tableau-4

Node Jr	LB (Jr)
(1)	100
(2)	110
(3)	99
(4)	103
(5)	103
(31)	99
(32)	112
(34)	101
(35)	101
(312)	112
(314)	99
(315)	100
(3142)	112
(3145)	99

Tableau-3

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Empirical Analysis of Function Points in Service Oriented Architecture (SOA) Applications

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Abstract:
Service Oriented Architecture (SOA) is an emerging area of software engineering, based on the concept of "re-usable services" to support the development of rapid, economical and stable distributed application even in heterogeneous environments. Function point is considered an accurate and well established approach among its competitors to estimate the efforts, size and functionality of software development projects. Estimating the cost, size and efforts for SOA application is a difficult task due to its diverse nature and loose coupling behavior, which results in an inaccurate estimate to measure the efforts, size and functionality of SOA applications. This research paper explores the shortcomings of function point estimation technique and suggests calibration in its value adjustment factor to properly map the characteristics of SOA applications. A Work flow model is proposed to estimate the efforts and functionality of SOA application to consider the Service development efforts as well as Service Integration efforts. Empirical Results shows considerable improvements in estimation process to reduce the error percentage in performance measures like Magnitude of relative error, Mean Magnitude of relative error and Root Mean Square Error.

Key Words: Service Oriented Architecture (SOA), Integration Efforts, Efforts Estimation, Function Point Analysis,

1. Introduction:

"Service Oriented Computing (SOC)" (Michael 2006) is a contemporary software engineering paradigm, construct on the notion of "service-logic" through which a kind of software development can be reached which is fast, low cost, and rapid, economical and up to the mark even in diverse environments. "Service Oriented Architecture (SOA)" is based on "service" logic, where the components come together to form a group of services, which are "loosely coupled" that fulfills the purpose and caters for the requirement of user and business process. SOA applications are able to assist all kinds of business applications and agile processes particularly in the domain of web services, sanitation, executive institutions of a country, education and on demand business.

1.2. Service

"A service is an implementation of a well defined piece of business functionality, which is discoverable through published interface and used by service consumers when building different applications and business process" (Zdravko 2009).

1.3. SOA Entities and Characteristics

"Service Oriented Architecture" is an architectural paradigm that incorporates a structure of coordination among the major functional components, where the "service consumer" interacts with "service provider" to locate a service which matches it requirement by a process of exploring for "service registry".

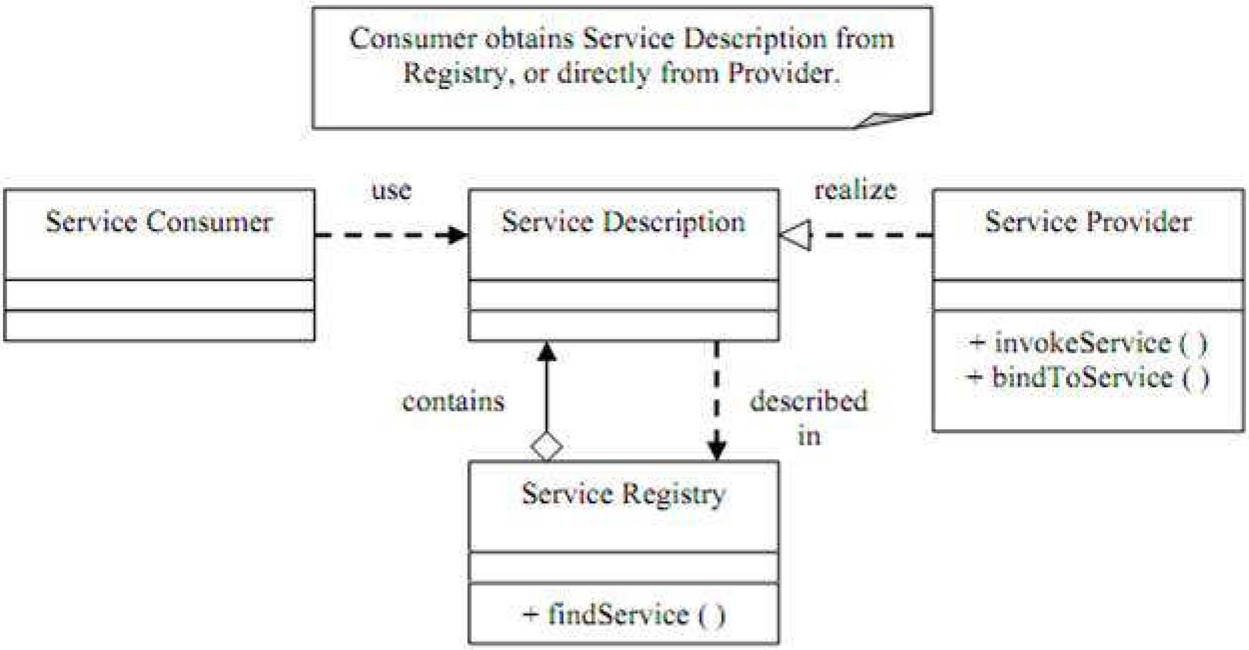

Figure 1.1 Service Oriented Architecture Entities Conceptual Model (James 2003)

"Service Oriented Architecture" lies down some particular rules and features the application of which is mandatory for development of service oriented architecture applications (Bieber 2001).

- Services are self discoverable and dynamically bound
- Services are self contained and modular
- Services are loosely coupled.
- Services are contractual.
- Services are stateless.
- Services are interoperable.
- Services have network addressable interface.
- Services are coarse grained.
- Services are autonomous.
- Services are reusable entities.
- Services are abstract.

2. Effort estimation techniques

"The National Estimating Society (Boehm 1998) has defined Cost Estimating as: The art of approximating the probable cost of something based on information available at the time".

2.1 Function Point Analysis (FPA)

Initially function point counting method consist of four basic components and ten "general system characteristics", in 1983 modification to function point to increase the basic components to five with the total of fourteen "general system characteristics" instead of ten. In 1984 (ifpug 1999) an organization namely "International Function Point User Group (IFPUG)" was established to uniform the counting standards and advancement in the function points. A number of variations to the actual function points have been made by some practitioners and Mark-II function points majorly used in Britain, 3D functions points developed by Boeing, COSMIC full function points, De-marco function points and feature function points have been developed (David 2006). But function points developed by Albrecht are used today and according to "International Software Bench Mark Standards Group" (ISBSG) completed project database almost 90% projects are measured through function points (Christopher 2005). In function point analysis fourteen General System Characteristics (GSCs) are used to construct a Value adjustment factor (VAF) with which the basic function point is adjusted. Although the GSC and VAF are criticized on both theoretical as well as practical grounds but they are used by many practitioners (Zdravko 2009). Author suggests that for SOA environment some GSCs need modifications to truly describe the SOA projects as well as inclusion of new characteristics such as Integration efforts to provide accurate estimates.

3. Empirical Analysis of Function Points in SOA:

As SOA is implemented mostly by the concept of web services (Francisco 2001), and web services have special characteristics. Function point estimation method was developed almost 31 years ago. Due to technological and methodological advancement many new approaches have been introduced which has changed the nature of software development. Though Function Point is adjusted with most of these changes but recent software specifications do not perfectly meet FP metrics. Function points weight system and its general system characteristics are mostly the same, so it needs modification (Abdullah 2005) as well as to solve integration issue inclusion of new characteristic namely "Service Integration Efforts", as SOA architecture is composed of a mesh of web services. The table listed below describes the proposed GSC which should be modified.

Table 3.1 Proposed General System Characteristics

S.No.	General System Characteristics	Description	Modification Needed: Yes Not needed: No
GSC1	Data communications	In SOA communication b/w services is not done through RPC, but SOA supports a number of protocols such as UDDI, XML, SOAP, JSON used for communication	Yes
GSC 2	Distributed data processing	In SOA services are distributed but controlled centrally through service registry	Yes
GSC 3	Performance	Performance measured in terms of resource utilization, error handling and process optimization	Yes
GSC 4.	Heavily used configuration	Measurement in terms of Software/Hardware Implementation	Yes
GSC 5	Transaction rate	How frequently are transactions executed daily, weekly, monthly, etc.?	No
GSC 6	On-Line data entry	What percentage of the information is entered On-Line?	No
GSC 7	End-user efficiency	Was the application designed for end-user efficiency?	No
GSC 8	On-Line update	How many ILF's are updated by On-Line transaction?	No
GSC 9	Complex processing	Does the application have extensive logical or mathematical processing?	No
GSC 10	Reusability	Was the application developed to meet one or many user's needs?	No
GSC11	Installation ease	How difficult is conversion and installation?	No
GSC 12	Operational ease	How effective and/or automated are start-up, back up, and recovery procedures?	
GSC 13	Multiple sites	In SOA services are developed to be accessed by a number of users at various sites. Instances of single application accessed at various locations at same time.	No
GSC 14	Facilitate change	Was the application	No

		specifically designed, developed, and supported to facilitate change?	
GSC 15	Integration Services	Whether the application needs other services to be integrated to perform its functions	Newly added Characteristics

4. IMPLEMENTATION

In order to perform the empirical analysis of function points in service oriented architecture applications, and to verify and authenticate the Proposed Work Flow Model three case studies are selected. First Case study describes the Course Registration System, secondly describes the Online Resume Bank (ORB) and the third selected case study is Online Banking System. These above cited case studies are developed by two teams of ICIT students as a final project for the fulfillment of their Bachelor degree in Computer Science. In order to estimate efforts one team has estimated it through function point estimation technique, where as the second team has estimated the efforts through proposed modified function point estimation. All these projects are built on the concept of Service Oriented Architecture using XML and ASP.Net as a source code languages. Description of the case studies is provided below. Results are evaluated first empirically through Magnitude of Relative error, Root Mean Square Error and statistically through Correlation and Regression Analysis. Results are discussed in the next chapter.

4.1 Case study 1: Online Resume Bank

Online Resume Bank (ORB) provides a set of services to its users interested in applying for a number of jobs offered by a particular organization. User Register itself through signup service. Resume Builder service offers an easy way to build user profile, Online Job Application service is provided to apply for the published jobs by the system. Current status of the application and application tracking facility is provided. Short listed candidates can print the interview call letter, and other relevant information through this system. This software application is developed on the concept of service oriented architecture frame work by using ASP.Net, XML and Microsoft SQL Server as the programming language tool.

4.2 Case Study 2: Course Registration System

Course Registration System provides services to students, professors and registrars. Using this system a student can register itself into different course’s and view grades reports submitted by Professor for a particular course. Professor can select a course to teach for current semester and submit grades. Whereas a Registrar maintains student as well as professor information and close registration through which information is provided to billing system. The services provided by the Course registration system are provided in the table given below along with their operations. This software application is developed on the concept of service oriented architecture frame work by using ASP.Net, XML and Microsoft SQL Server as the programming language tool

4.3 Case Study 3: Online Banking System

Online Banking System Provides a variety of services to its Customers. These services include Account Opening Service, Transaction Services, online Funds transfer, online account status checking service, online Loan Application submission and displaying Foreign Currency rates. This software application is developed on the concept of service oriented architecture frame work by using ASP.Net, XML and

Microsoft SQL Server as the programming language tool. Services provided by the system are listed in the table given below.

5. Results and discussion

Project No	Description	Estimated Efforts through Function Points	Estimated Efforts through Proposed Function Points	Actual Efforts	MRE1 (Proposed)	MRE2 (FP)
P1	Online Resume Bank	201	222	256	0.13	0.21
P2	Course Registration System	204	218	240	0.09	0.15
P3	Online Banking System	237	254	283	0.10	0.16
MMRE					**0.11**	**0.18**

Root Mean Square Error for Proposed and Actual Estimates

Project No	Description	Estimated Efforts through Function Points	Estimated Efforts through Proposed Function Points	Actual Efforts
P1	Online Resume Bank	201	222	256
P2	Course Registration System	204	218	240
P3	Online Banking System	254	283	152
Root mean Square Error (RMSE) Proposed				**16.60**
Root mean Square Error (RMSE) Function Points				**26.54**

DISCUSSION

Magnitude of relative error describes that proposed estimates are closer to actual efforts as compared to function points estimates. For Project P1 the MRE (Jaswinder 2008) is 13 % as compared to 21%, which describes that MRE for proposed has lesser error value than Function point estimates. For Project P2 MRE is 9 % as compared to 15%, and finally for Project P3 MRE is 0.10 % as compared to Function point MRE 0.16 %. Mean Magnitude of relative error for proposed effort estimation is 0.11 where as for function point estimation it is 0.18, which presents 7% difference among the effort estimation techniques.

6. Conclusion.

Service oriented Architecture (SOA) is a promising new area of software engineering, where services are combined together to form a design structure, which not only fulfills the requirements of users but also support the business processes to compete with its competitors. On the other hand Function Point estimation technique is recognized as an accurate estimation technique amongst its competitors, the calibration of its Value Adjustment Factor, and consideration of Integration efforts shows improvement in its estimation accuracy, and inclusion of new factors in its GSC's, proves that now it properly address SOA characteristics. Results shows the when effort estimation is performed through proposed work flow model the MMRE was 11 %, and 18 % from function point estimation, which shows the proposed work flow model produce lesser error as compared to function point estimation with a difference of 7%. Root mean square error (RMSE) also presents a notable difference in the estimation efforts. Correlation analysis also shows that correlation coefficient (r) has more accurate value as compared to its counterpart. Moreover the Integration efforts were some time ignored, due to its diverse behavior and loose coupling nature, by considering and addressing this important factor will capable the developers to provide accurate estimate for SOA applications to plan schedule, resources and men power for software development.

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Fuzzy Logic Analysis Based on Inventory Considering Demand and Stock Quantity on Hand

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Abstract

The approach is based on fuzzy logic analysis as it does not require the statement and solutions of complex problems of mathematical equations. Here consideration is inventory control problem solutions, for which demand values for the stock and it quantity-on-hand in store is proposed. Expert decisions are considered for developing the fuzzy models, and the approach is based on method of nonlinear dependencies identifications by fuzzy knowledge. The linguistic variables are considered for the membership functions. Simple IF-Then rules are used with expert advices.

Keywords:- Inventory control, Fuzzy logic, Membership Function, Defuzzification.

1. Introduction

The most important problem for the management is the minimization of the inventory storage cost in enterprises and trade stocks including raw materials, stuff, supplies, spare parts and products. The models of this theory are built according to the classical scheme of mathematical programming: goal function is storage cost; controllable variables are time moments needed to order (or distribute) corresponding quantity of the needed stocks. Construction of such models requires definite assumptions, for example, of orders flows, time distribution laws and others.

On the other hand, experienced managers very often make effective administrative decisions on the common sense and practical reasoning level. Therefore, the approach based on fuzzy logic can be considered as a good alternative to the classical inventory control models. This approach elaborated in works requires neither complex mathematical models construction no search of optimal solutions on the base of such models. It is based on simple comparison of the demand for the stock of the given brand at the actual time moment with the quantity of the stock available in the warehouse. Depending upon it inventory action is formed consisting in increasing or decreasing corresponding stocks and materials.

"Quality" of control fuzzy model strongly depends on "quality" of fuzzy rules and "quality" of membership functions describing fuzzy terms. The more successfully the fuzzy rules and membership functions are selected, the more adequate the control action will be.

However, no one can guarantee that the result of fuzzy logical inference will coincide with the correct (i.e. the most rational) control. Therefore, the problem of the adequate fuzzy rules and membership functions construction should be considered as the most actual one while developing control systems on fuzzy logic. In this article it is suggested to build the fuzzy model of stocks and materials control on the ground of the general method of nonlinear dependencies identification by means of fuzzy knowledge bases. The grounding for the expediency to use this fuzzy approach relative to inventory control is given in the first section of the article. The main principles of the identification method applied for modeling are brought forward. The inventory control model is constructed on the basis of fuzzy knowledge base. The problems of fuzzy model tuning and numerical example illustrating application of training data in tuning problem are described. Formulation of conclusions and directions for further research are defined in the final section.

2. Method of identification

The method of nonlinear objects identification by fuzzy knowledge bases serves as the theoretical basis for the definition of the dependency between control actions and the current state of the control system. Originally this method was suggested for medical diagnosis problems solution, and then it was spread on arbitrary "inputs – output" dependencies.
The method is based on the principle of fuzzy knowledge bases two-stage tuning. According to this principle the construction of the "inputs – output" object model can be performed in two stages, which, in analogy with classical methods, can be considered as stages of structural and parametrical identification. The first stage is traditional for fuzzy expert systems. Formation and rough tuning of the object model by knowledge base construction using available expert information is accomplished at this stage. However, as it was mentioned in the introduction, no one can guarantee the coincidence of the results of fuzzy logic inference and correct practical decisions. Therefore, the second stage is needed, at which fine tuning of the model is done by way of training it using experimental data. The essence of the fine tuning stage consists in finding such fuzzy IF-THEN rules weights and such fuzzy terms membership functions parameters which minimize the difference between desired (experimental) and model (theoretical) behavior of the object.

3. Fuzzy model of control

Let us present the inventory control system in the form of the object with two inputs ($x1(t)$, $x2(t)$) and single output ($y(t)$), where: $x1(t)$ is *demand*, i.e. the number of units of the stocks of the given brand, which is needed at time moment *t;* $x2(t)$ is *stock quantity-on-hand*, i.e. the number of units of the stocks of the given brand which is available in the warehouse at moment *t*; $y(t)$ – *inventory action* at moment *t*, consisting in increasing decreasing the stocks of the given brand.[5] System state parameters $x1(t)$, $x2(t)$ and inventory action $y(t)$ are considered as linguistic variables[1], which are estimated with the help of verbal terms on five and seven levels:

$x1(t)$ = Falling(F), Decreased(D), Steady(S), Increased(I) and Rise up(R)

x2 (t) = Minimal(M), Low(L), adequately sufficient (A), high (H) and excessive (*E*)

$y(t)$ = *T*o decrease the stock sharply (D1), To decrease the stock moderately (D2),

To decrease the stock poorly (D3), do nothing (D4), To increase the stock poorly (D5)

To increase the stock moderately (D6), To increase the stock sharply (D7)

Let us note that term "adequately sufficient" in variable x2(t) estimation depicts the rational quantity of the stock on the common sense level and does not pretend to the mathematically strong concept of optimality which envisages the presence of goal function, controllable variables and area of constraints. The Figure (1) is defined by expert way and depicts the complete sorting out of the $(5\times 5 = 25)$ terms combinations in the triplets $x1(t)$, $x2(t)$, $y(t)$. Grouping these triplets by inventory actions types, we shall form fuzzy knowledge base system in following figure (2).
This fuzzy knowledge base defines fuzzy model of the object in the form of the following rules:
IF demand is falling AND stock is excessive, OR demand is falling AND stock is high, OR demand is decreased AND stock is excessive, THEN it is necessary to decrease the stock sharply;
IF demand is falling AND stock is adequately sufficient, OR demand is decreased AND stock is high, OR demand is steady AND stock is excessive, THEN it is necessary to decrease the stock moderately;
IF demand is falling AND stock is low, OR demand is decreased AND stock is adequately sufficient, OR demand is steady AND stock is high, OR demand is increased AND stock is excessive, THEN it is necessary to decrease the stock poorly;
IF demand is falling AND stock is minimal, OR demand is decreased AND stock is low, OR demand is steady AND stock is adequately sufficient, OR demand is increased AND stock is high, OR demand is rising up AND stock is excessive, THEN do nothing;
IF demand is decreased AND stock is minimal, OR demand is steady AND stock is low, OR demand is increased AND stock is adequately sufficient, OR demand is rising up AND stock is high, THEN it is necessary to increase the stock poorly;

IF demand is steady AND stock is minimal, OR demand is increased AND stock is low, OR demand is rising up AND stock is adequately sufficient, THEN it is necessary to increase the stock moderately;
IF demand is increased AND stock is minimal, OR demand is rising up AND stock is minimal, OR demand is rising up AND stock is low, THEN it is necessary to increase the stock sharply.
By definition membership function $\mu\ T\ (u)$ characterizes the subjective measure (in range of [0,1]) of the expert confidence in crisp value *u* corresponding to a fuzzy term T**.**

4. Fuzzy membership functions

For simplification MATLAB is used as tool as consideration of Input membership function as Demand (x1(t)) and In stock Quantity on Hand(x2(t)) and output as (y(t)) for this various linguistic variables are taken into consideration and for that Gaussian bell shaped (Gaussian) membership functions, which parameters allow to change the form of the function, are the most widely practiced.
For Defuzzification i.e. to convert the linguistic value into the crisp output the Centroid method is used with Mamdani approach.

5. Results

The fuzzy logic approach to the above model give the most appropriate result in term of inventory as we can get the value for any input in the system to optimize the inventory mentioned in the Table no 9 which provide the rule viewer for inventory control as one value mentioned in the rule viewer is as input 1 is 41.5 and input 2 is 160 the output i.e inventory should be 0.38 for these values.

6. Conclusion

The approach to inventory control problems solution, which uses the available information about current demand values for the given brand of stock and it quantity-on-hand in store, is proposed. The approach is based on the method of nonlinear dependencies identification by fuzzy knowledge bases. It was shown that fuzzy model data sample allows approximating model control to the experienced expert decisions.
The advantage of the approach proposed consists in the fact that it does not require the statement and solution of the complex problems of mathematical programming. Expert IFTHEN rules are used instead which are formalized by fuzzy logic and tuned with the help of data.
Further development of this approach can be done in the direction of the adaptive (neuro fuzzy) inventory control models creation, which are tuned with the acquisition of new experimental data about successful decisions. Besides that with the help of supplementary fuzzy knowledge bases factors influencing the demand and quantity-on-hand values (seasonal prevalence, purchase and selling praises, delivery cost, plant-supplier power and others) can be taken into account.
The approach proposed can find application in the automated management systems of enterprises and trade firms. It can also be spread on the wide class of the optimal control problems in reliability and complex systems maintenance.

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Functional dependency

$y(t) = f(x1(t), x2(t))$

x2(t)

E	D1	D1	D2	D3	D4
H	D1	D2	D3	D4	D5
A	D2	D3	D4	D5	D6
L	D3	D4	D5	D6	D7
M	D4	D5	D6	D7	D7
	F	D	S	I	R

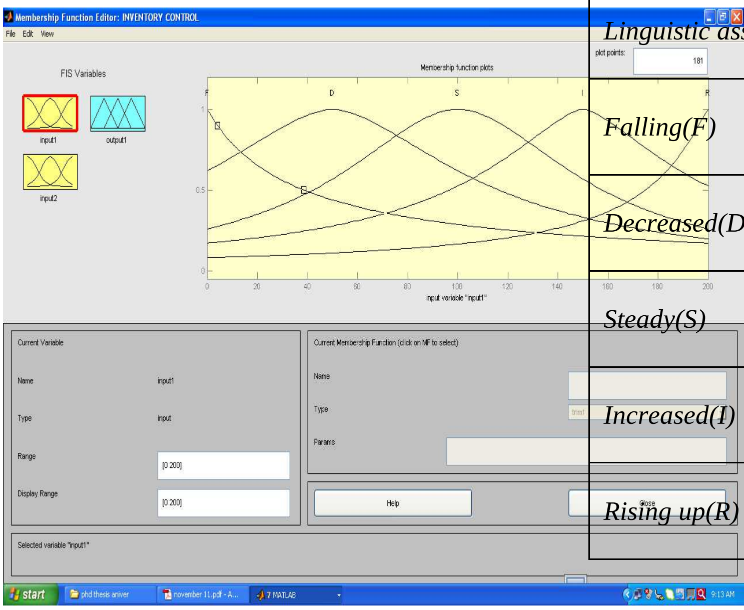
x 1(t)

Fig (1) Dependencies between parameters and inventory actions

IF		Then
Demand x1 (t)	*Stock quantity-on-hand x2(t)*	*Inventory action y(t)*
F F D	E H E	D1
F D S	A H E	D2
F *D* *S* *I*	*L* *A* *H* *E*	D3
F *D* *S* *I* *R*	*M* *L* *A* *H* *E*	D4
D *S* *I* *R*	*M* *L* *A* *H*	D5

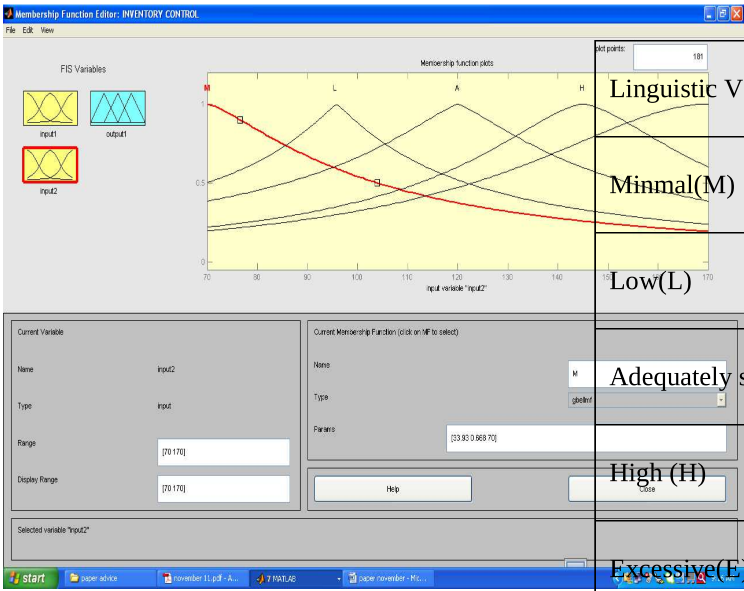
S *I* *R*	M L A	D6
I *R* *R*	*M* *M* *L*	D7

Figure (2) Grouping of Triplet as fuzzy Knowledge base system



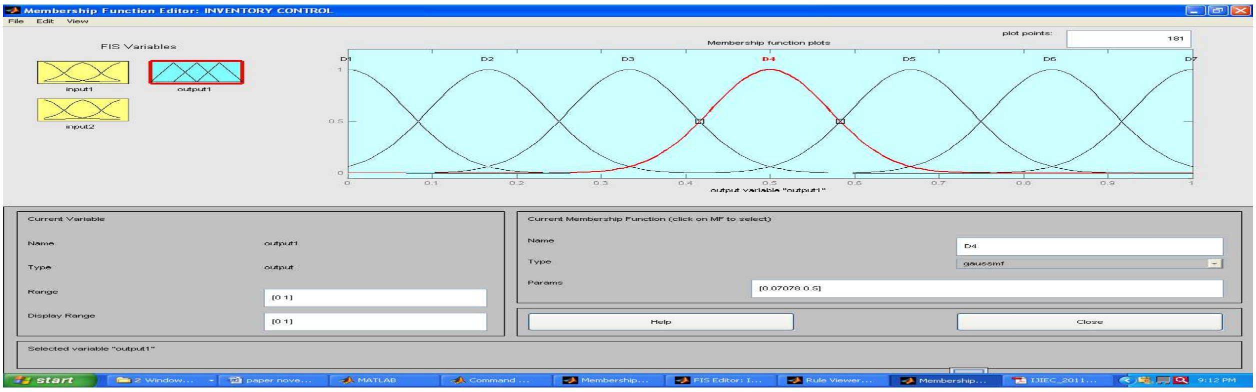
Linguistic assessment	*Parameter*
Falling(F)	*1.15*
Decreased(D)	*34.51*
Steady(S)	*105*
Increased(I)	*170.1*
Rising up(R)	*199.1*

Figure (3) Input membership function parameter of variable x1(t) Demand

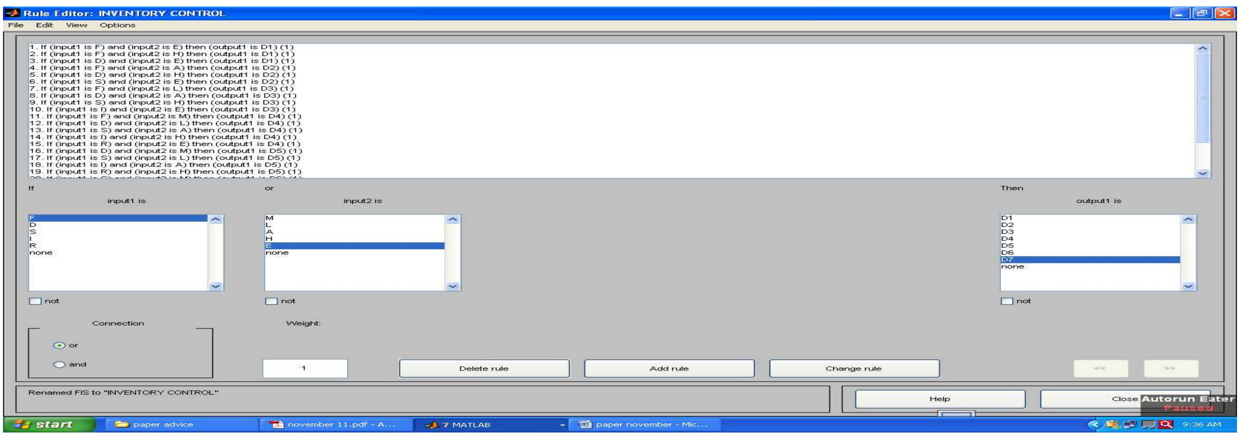


Linguistic Variable	Parameter
Minmal(M)	75.09
Low(L)	88.12
Adequately sufficient(A)	125
High (H)	157
Excessive(E)	168

Figure (4) Input Membership Functions for In stock quantity on hand



Figure(5) Output Membership Functions for Inventory Models



Figure(6) Rule base editor for inventory control

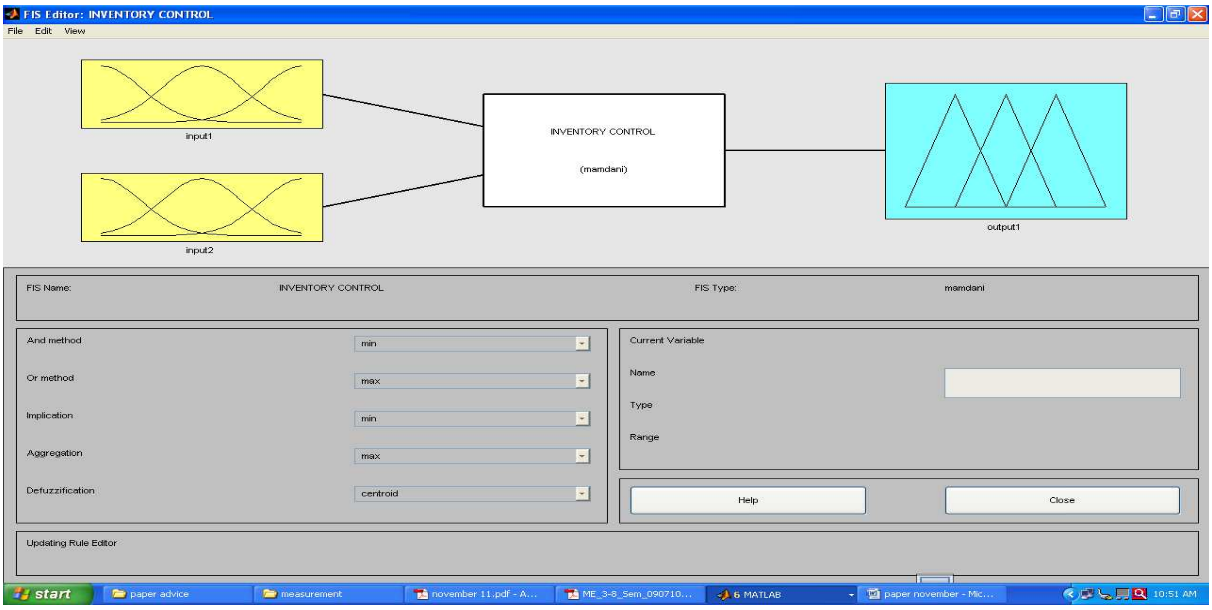


Figure (7) Defuzzfication Apporach

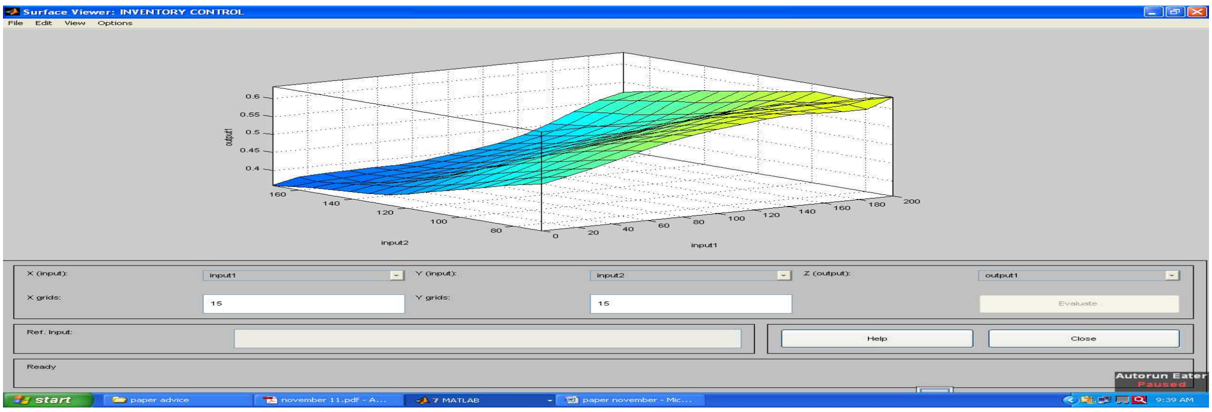


Figure (8) Surface Viewer for inventory control

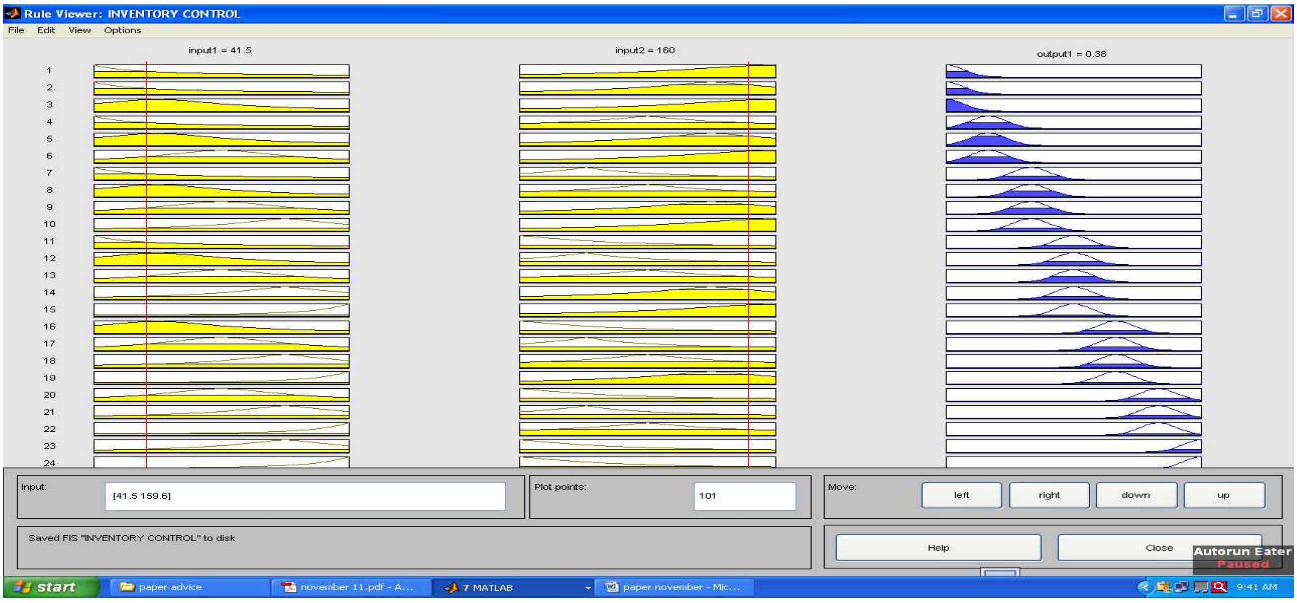


Figure (9) Rule Viewer for Inventory Control

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Growth of Industrial Production in Selected Indian Manufacturing Industries: Is It Productivity Driven or Input Accumulated?

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Abstract:

The present article attempts to examine the contribution of inputs and total factor productivity growth to the growth of output by considering the aggregate manufacturing sector and seven selected manufacturing industries of India during the period 1979-80 to 2003-04. Major findings of the study indicate that output growth in the selected Indian manufacturing industrial sectors is driven mainly by inputs accumulation while the contribution of total factor productivity growth remains either minimal or negative. The growth rate of total factor productivity in almost all the industries under our study is gradually declining, especially during the post-reforms period. The change in pattern of sources of output growth may have taken place due to liberalization policies and structural reforms undertaken during the 1990s.

Key words: Growth, productivity, input, manufacturing, industry, India.

1. Introduction:

India has been adopting a highly protective industrial and foreign trade regime since 1951. The liberalisation of Indian economy initiated slowly in the 1980's and key economic liberalisations via structural adjustment programs began from 1991. By virtue of this programme, intensive charges have been made in industrial policy of India Government. Relaxing of licensing rule, reduction tariff rates, removal of restrictions on import etc are among those which have been initiated at early stage. The policy reforms had the objectives to make Indian industries as well as entire economy more efficient, technologically up-to-date and competitive. This was done with the expectation that efficiency improvement, technological up-gradation and competitiveness would ensure Indian industry to achieve rapid growth. In view of greater openness of Indian economy due to trade liberalization, private sector can build and expand capacity without any regulation.Earlier,the protective regime not only prohibited entry into industry and capacity expansion but also technology, output mix and import content. Import control and tariff provided high protection to domestic industry. There was increasing recognition by the end of 1980’s that the slow and inefficient growth experienced by Indian industry was the result of a tight regulatory system provided to the Indian industry.

The logic that manufacturing industries play a special role in the growth process involves two related propositions: (i) that manufacturing activity contributes to overall growth in ways not reflected in conventional output measures; and (ii) that this growth premium is larger in the case of manufacturing relative to its output share than for other sectors of the economy. According to Cornwall (1977), the manufacturing sector would act as engine of growth for two reasons –it displays dynamic economies of scale through “learning by doing” (Young, 1928, Kaldor, 1966,1967).With increased output, the scope for learning and productivity increase becomes larger. Thus, the rate of growth of productivity in manufacturing will depend positively on the rate of growth of output in manufacturing (called as the Kaldor-Verdoorn law). Secondly, manufacturing sector leads to enhanced productivity growth through its linkages with other manufacturing and non-manufacturing sectors.

1.1. Manufacturing as an Engine of Growth – Arguments:

The development path as followed by a large number of developed countries is from agriculture to manufacturing to services. The productivity being higher in the manufacturing sector and the sector being more dynamic, the transfer of labour / resources from agriculture to manufacturing would immediately lead to increased productivity (termed as a *structural change bonus*), thereby contributing to growth. Moreover, there exists opportunities for capital accumulation and for embodied and disembodied technological progress which act as an engine of growth (Cornwall, 1977). Capital accumulation can be more conveniently realized in spatially concentrated manufacturing than in spatially dispersed agriculture. Technological advance is concentrated in the manufacturing sector and diffuses from there to other economic sectors such as the service sector. The manufacturing sector also offers important opportunities for economies of scale in large number of key industries like steel, cement, aluminium, paper, glass, chemical, fertilizer etc which are less available in agriculture or services. Incidentally, due to the increasing use of ICTs in service sectors and their inherent characteristic of negligible marginal cost, these economies are no longer restricted to manufacturing.

Linkages in terms of both forward and backward and spillover effects within manufacturing and other sectors are stronger for manufacturing than for agriculture or mining. Increased final demand for manufacturing output will persuade increased demand in many sectors supplying inputs. In addition to these backward linkages, Cornwall (1977) emphasizes that the manufacturing sector also has numerous forward linkages, through its role as a supplier of capital goods (and the new technologies that these goods embody). Lastly, Engel's law states that as per capita incomes rise, the share of agricultural expenditure in total expenditure declines and the share of expenditure on manufactured goods increases. The implication of this is that if countries specialize in agricultural and primary products, they will not gain from expanding world markets for manufacturing goods.

[Insert Table-1 here]

Table 1 shows that annual growth rate of industrial production is gradually increasing in Indian manufacturing over years as Index number of Industrial Production depicts so. Against this background information, this article aims at examining whether growth in industrial output of selected manufacturing industries of our research consideration like –Iron&steel, aluminium, cement, glass, fertilizer, chemical and paper and pulp etc. is as a result of productivity growth or input accumulation.

Results obtained through such an exercise are expected to help identify the character of growth path followed by the manufacturing sector of India in the context of Krugman's thesis. For that purpose, it considers the data of a seven energy intensive industries mentioned above.

Rest of the paper is organised as follows. Section 3 presents methodology and data source, while Section 4 gives empirical results. Major conclusions of the analysis are presented in Section 5.

3.Methodology and data source:

3.1. Econometric model:

This paper covers a period of 25 years from 1979 -80 to 2003-04.The entire period is sub-divided into two phases as pre-reform period (1979 -80 to 1991-92) and post-reform period (1991-92 to 2003-04).

The partial factor productivity has been estimated by dividing the total output by the quantity of an input. In this paper, TFPG is estimated under three input framework applying translog index of TFP as below: -

$$\Delta \text{Ln } TFP(t) =$$

$$\Delta \text{Ln } Q(t) - \left[\frac{S_L + S_L(t-1)}{2} \times \Delta \text{Ln } L(t)\right] - \left[\frac{S_K(t) + S_K(t-1)}{2} \times \Delta \text{Ln } K(t)\right] - \left[\frac{S_M(t) + S_M(t-1)}{2} \times \Delta \text{Ln} M(t)\right]$$

Q denotes gross output, L Labour, K Capital, M material including energy input.

ΔLn Q(t) = Ln Q(t) – Ln Q(t – 1)

ΔLn L(t) = Ln L(t) – Ln L(t – 1)

ΔLn K(t) = Ln K(t) – Ln K(t – 1)

ΔLnM(t) = Ln M(t) – Ln M(t – 1)

S_K, S_L and S_M being income share of capital, labor and material respectively and these factors add up to unity. ΔLn TFP is the rate of technological change or the rate of growth of TFP.

Using the above equation, growth rates of total factor productivity have been computed for each year. These have been used to obtain an index of TFP in the following way. Let Z denote the index of TFP. The index for the base year, Z(0), is taken as 100. The index for the subsequent years is computed using the following equation:

Z(t) / Z(t-1) = exp[ΔLnTFP(t)].

The translog index of TFP is a discrete approximation to the Divisia index of technical change. It has the advantage that it does not make rigid assumption about elasticity of substitution between factors of production (as done by Solow index). It allows for variable elasticity of substitution. Another advantage of translog index is that it does not require technological progress to be Hicks-neutral. The translog index provides an estimate of the shift of the production function if the technological change is non-neutral.

After that ,growth of output of those industries under our research consideration has been compared with productivity growth and inputs accumulation to be acquainted with nature of contribution of productivity growth and inputs accumulation in output growth of the industries.

3.2.Data source:

The present study is based on industry-level time series data taken from several issues of Annual Survey of Industries, National Accounts Statistics, *CMIE* and Economic survey, Statistical Abstracts (several issues), *RBI* Bulletin on Currency and Finance, Handbook of Statistics on Indian Economy, Whole sale price in India prepared by the Index no of office of Economic Advisor, Ministry of Industry etc covering a period from 1979-80 to 2003-04.

4. Empirical results regarding Growth in output, employment, partial factor productivity and total factor productivity growth:

The reforms initiated in 1990s added momentum to enhance the competition, productivity and efficiency. Productivity is a relationship between real output and input; it measures the efficiency with which inputs are transformed into outputs in the production process. Increased productivity is related with more output produced with either the same amount of inputs, or with fewer inputs, or with little increment in inputs. Higher productivity growth is associated with increase in capital intensity, labour productivity and capital productivity and material productivity. Empirical evidence suggests that productivity in turn reduces unit cost; enhance product quality, increase workers wage, and offers returns on investment. Productivity is the prime determinant of a country's level of competitiveness, higher standard of living and sustained growth in the long run. The present section is an attempt to analyze the response of energy intensive industries in India in terms of inputs and output growth as well as in terms of total factor productivity growth to new policy initiatives started in 1991 at aggregate level.

Therefore, in this section, we have tried to measure total factor productivity growth, partial productivity growth in respect of material, labour and capital inputs. Partial productivity indices defined as the real output per unit of any particular real input like labour, material or capital, are the simplest and most intuitive measures of productivity. One point is to be noted in the context of partial productivity analysis is that it tends to depend, to a great extent, on capital intensity.

In cement industry, broad variations in the magnitude of TFPG are found in the estimation. The estimated TFPG of Indian cement sector at the aggregate reveals contradictory rates of TFPG growth (both positive and negative) and it varies over years within the same sector. But, our aggregate analysis also depicts sign of declining trend in average TFP growth rate during post-reform period as compared to pre-reform period. It is evident that the estimated average growth rate of TFP at aggregate level in cement sector for the period 1979-80 to 1991-92 is 1.44 percent p.a whereas post-reform period covering 1991-92 to 2003-04 in our study witnessed a further decreasing growth of 1.013 percent p.a., a noticeable decline from growth rate as in pre-reform period. The trend growth rate of TFP in Indian cement sector is assessed to be -0.0043 percent for the entire period 1979-80 to 2003-04 (estimated from semi-log trend) implying average overall annual deceleration of -0.0043 percent p.a. On the whole, impact of economic reforms on TFPG at aggregate level was adverse as the average rate of TFPG estimated in the pre-reform period furthermore decreased in post-reform period. Moreover, difference between mean TFPG of two periods is statistically significant at 0.05 levels thereby indicating that average TFPG between two periods are statistically different. The estimated TFPG rate at the aggregate level of Indian aluminium industry for the entire period, 1979-80 to 2003-04 reveals paradoxical pictures with positive as well as negative rates. During pre-reforms period (1979-80 to 2003-'04), aluminium sector has recorded a negative growth rate of -0.2008 %. It could be noticed from the average TFPG estimated during the post- reforms period that the reform process yielded negative results on the productivity levels of the aluminium sector because it is visible from the estimated average TFPG that there is a significant drop in the extent of negative TFPG which is -1.43% when compared to that in the pre-reform period. Total factor productivity growth in iron and steel industry displays declining growth rate in post-reforms period compared to pre-reform period. It is evidenced from table 2 that the estimated growth rate of TFP at aggregate level for the period 1979-80 to 1991-92 is 0.5650 percent p.a whereas post-reform period covering 1991-92 to 2003-04 in our study witnessed a declining positive growth of 0.4761 percent p.a., a noticeable downfall from growth rate as shown in pre-reform period. On the whole, impact of economic reforms on TFPG of iron industry at aggregate level was adverse as the average rate of TFPG estimated in the pre-reform period furthermore decreased in post-reform period. Within the same industry, over the years, there exist severe variations in total factor productivity growth. Analysis of the TFPG of Indian chemical industry shows declining growth rate in negative fashion during post- reforms period. The pre-reform era (1979-80 to 1991-92) witnessed a positive growth rate of 0.6525 percent but during post-reforms period (1991-92 to 2003-04), it is estimated to be -0.3231 percent p.a. Moreover, total factor productivity growth shows contradictory positive and negative trends over years within the same industry. Inspection of average TFPG of fertilizer industry in India exhibits an overall negative growth rate in TFP. It is obvious from table 2 that the estimated growth rate of TFP for the period 1979-80 to 1991-92 is 0.44 percent p.a which signifies a positive rate of growth in TFP where as post-reform period covering 1991-92 to 2003-04 in our study witnessed a sharp negative growth of -1.12 percent p.a., a steeper fall from growth rate as revealed in pre-reform period. This decline is due to reduced capacity utilization caused by downfall in production rather than being a consequence of lack of technical progress. The growth rate of TFP in Indian fertilizer sector is assessed to be –0.055 percent p.a. implying average overall annual deceleration for the entire period 1979-80 to 2003-04. On the whole, impact of economic reforms on TFPG at aggregate level was poor as the positive average rate of TFPG estimated in the pre-reform period declined to negative growth in post-reform period. More over, difference between mean TFPG of two periods is statistically significant at 0.05 levels thereby indicating that average TFPG between two periods are statistically different.

In paper and pulp sector, the estimated growth rate of TFP for the period 1979-80 to 1991-92 is 0.64 percent per annum whereas during the post-reform period, 1991-92 to2003-04, TFPG shows slight downward trend which is estimated to be 0.58 percent per-annum but average growth rate for the entire period is significantly negative (-0.014 percent). Moreover, TFPG varies widely among years within the same paper sector. Total factor productivity growth of Indian glass industry during pre-reform period declined in a negative fashion which is posted as -0.09 and in post-liberalization period, it further declined to -0.68.Large variations in the magnitude of TFPG are found in the evaluation. The estimated TFPG of the Indian glass industry at the aggregate level reveals differing rates of productivity growth over years. Over our study period, negative trend in the TFPG is observed at aggregate level.

Therefore, overall analysis of average TFPG growth suggests that in all the industries taken up under our study, average TFPG growth depicts declining growth rate during post-reform periods as compared to pre-reform periods.

This does not mean, however, that reforms failed to have a favorable effect on industrial productivity. Rather, some research undertaken recently (Goldar and Kumari, 2003; Topalova, 2004) has shown that trade liberalization did have a positive effect on industrial productivity. The explanation for the slowdown in TFP growth in Indian manufacturing in the post-reform period seems to lie in the adverse influence of certain factors that more than offset the favorable influence of the reforms. Two factors that seem to have had an adverse effect on industrial productivity in the post-reform period are (a) decline in the growth rate of agriculture and (b) deterioration in capacity utilization in the industrial sector (Goldar and Kumari,2003). Uchikawa (2001, 2002) has pointed out that there was an investment boom in Indian industry in the mid-1990s. While the investment boom raised production capacities substantially, demand did not rise which led to capacity under-utilization.Goldar and Kumari (2003) have presented econometric evidence that indicates that the slowdown in TFP growth in Indian manufacturing in the post-reform period is attributable to a large extent to deterioration in capacity utilization.

[Insert Table-2 here]

The table 2 depicts the overall growth rate in value added, capital, employment and partial productivity in energy intensive industries under our study. The picture that emerges for the Indian cement sector is that the overall long-term growth in output (value added) is 7.94 percent per annum in this sector during 1979-80 to 2003-04 which is associated with a rapid growth of capital (10.29 percent per annum) and comparatively a low growth of employment (3.43 percent per annum). Comparing the annual growth rates during 1979-80 to 1991-92 with those of 1991-92 to 2003-04, the post-reform period, it is found that there is a sharp decline in growth rate of value added from 10.49 per cent per annum in pre-reform period to 5.74 per cent per annum in post-reform period. Labour productivity for the whole period increased at an annual rate of 4.88 per cent per annum while capital productivity decreased at a rate of -1.75 per cent per annum. Capital intensity for the entire period is 6.97 per cent per annum. Estimates for the sub-periods reveal differences in the growth rates. Labour productivity decreases at a higher rate, i.e. at a 6.50 per cent per annum in the pre-reform period as against 3.80 per cent per annum in the post-reform period. Capital productivity shows a sign of negative trend in the first period of the analysis and it decreases sharply in the second period. Capital intensity decreases slightly at a 6.51 per cent per annum in the post-reform period as against 7.96 per cent per annum in the pre-reform period. The estimate of total factor productivity (TFP) growth of Indian cement industry is -0.0043 per cent per annum over the entire period, 1979-80 to 2003-04. Total factor productivity growth is lowered down during the post-liberalization period than during the pre- reforms period of the analysis. In iron and steel industry, labour productivity for the whole period shows a growth rate at an annual average of 5.81 percent per annum whereas capital productivity shows an annual average growth rate of 0.80 percent. Capital intensity for the entire period is 5.05 whereas an estimate for the sub-period shows difference in growth rates. Post-reform capital productivity and labour productivity shows increasing trend. Capital intensity increases at higher rate from 4.59 percent in pre-reform period to 5.5 percent in post-reform period. Total factor productivity growth is declining associated with declining growth rate in capital, employment during post-reform period. In a nutshell, for iron and steel sector, post-reform era witnessed declining growth rate in total factor productivity but acceleration in capital intensity as well as capital, material and labour productivity.

Table 2 also shows that overall long-term growth of 6.76 percent in value added (output) in Indian iron and steel industry during 1979-80 to 2003-04 is associated with rapid growth of capital(6 percent per annum) and low growth of labour(0.82 percent per -annum). Comparing the annual growth rate of pre-reform period (1979-80 to 1991-92) with that of post-reform period, it is evident that there is an increase in the growth rate of value added from 6.29 percent in pre-reform period to 6.90 percent in post-reform period. It is evident that the revival of growth in output in post 90s was not accompanied by adequate generation of employment in iron and steel sector. Several explanations have been cited for that. It is argued that capital-intensive techniques were adopted because of increase in real wage in 1980s and onward. According to Nagaraj (Cited in A.K.Ghosh.1994), the "overhang' of employment that existed in 1970s were intensively used in the 1980s, thus generating only few additional employment opportunities in the latter decades. It has also been argued that labour retrenching technique was difficult after introduction of the job security regulation in the late1970s and this forced the employers to adopt capital-intensive production techniques (Goldar, 2000). Productivity of capital increased from 0.26 to 1.33 along with that of labour productivity, which increased from 4.7 to 7.06 during these two time frames. These changes were reflective of an increase in the rate of growth of capital intensity. The data also shows that the increase in the growth rate of output as is evident from the table 2 is not accompanied by an increase in the productivity.

In aluminium industry**,** labour productivity for the whole period shows a growth rate at an annual average of 1.39 percent per annum whereas capital productivity shows an annual average growth rate of 0.23 percent. Capital intensity for the entire period is 1.16 whereas an estimate for the sub-period shows difference in growth rates. Consequent to economic reforms in July, 1991, capital productivity shows increasing trend but labour productivity reflects dismal declining trend. Capital intensity decreases at higher rate from 3.21 percent in pre-reform period to 1.04 percent in post-reform period. Total factor productivity growth is sharply declined associated with declining growth rate in capital as well as employment during post-reform period. In a nut shell, for aluminium sector, post-reform era witnessed declining growth rate in total factor productivity accompanied by acceleration in capital and material productivity. Overall long-term growth of 6.21 percent in value added (output) in Indian aluminium industry during 1979-80 to 2003-04 is associated with rapid growth of employment (3.82 percent per-annum). It is obvious that there is a decrease in the growth rate of value added from 6.27 percent in pre-reform period to -2.20 percent in post-reform period. The revival of growth in output in post 90s was not possible by adequate generation of employment in aluminium sector. Productivity of capital increased from 2.34 to 7.88 whereas labour productivity declined sharply from 5.10 to 1.89 during these two time frames. These changes were reflective of a decline in the rate of growth of capital intensity.

In paper and pulp industry, productivity of capital decreased from -0.60 to -1.83 along with that of labour productivity, which decreased from 4.71 to 3.02 during these two time frames. These changes were reflective of an increase in the rate of growth of capital intensity. The data also shows that the decrease in the growth rate of productivity as is evident from the table 2 is accompanied by a decrease in the growth rate of output.Labour productivity for the whole period shows a growth rate at an annual average of 4.86 percent per annum whereas capital productivity shows an annual average growth rate of -0.61 percent. Capital intensity for the entire period is 5.47 whereas an estimate for the sub-period shows difference in growth rates. Capital productivity and labour productivity during post-reform era shows simultaneously declining trend. Capital intensity increases slightly in post-reform period. Total factor productivity growth is decelerating with declining growth rate in capital, employment during post-reform period. In brief, for paper sector, post-reform era visualized some kind of declining growth rate in total factor productivity along with acceleration in capital intensity as well as material productivity but value added, employment and capital growth along with capital and labour productivity reflects declining growth rate.

In fertilizer sector, labour productivity for the entire period,1979-80 to 2003-04, shows a growth rate at an annual average of 10.02 percent per annum whereas capital productivity shows a negative annual average growth rate of -1.06 percent. Capital intensity for the entire period is 11.12 whereas an estimate for the sub-period shows difference in growth rates. With the initiation of new policy regime in 1991, capital productivity shows abrupt decreasing trend which turns out to be negative (-5.52 percent) but labour productivity growth displays slightly accelerated growth rate during post reform periods. Capital intensity also decreases from 15.17 percent in pre-reform period to 8.32 percent in post-reform period. Total factor productivity growth is declining associated with declining growth rate in value added, employment, and capital intensity during post-reform period. Therefore, for fertilizer sector, post-reform era is evidenced by declining growth rate in total factor productivity but acceleration in capital growth, material and labour productivity. Overall long-term growth of 8.93 percent in value added (output) in Indian fertilizer industry during 1979-80 to 2003-04 is associated with rapid growth of capital (8.71 percent per annum). Comparing the annual growth rate of pre-reform period (1979-80 to 1991-92) with that of post-reform period, it is evident that there is a decline in the growth rate of value added from 15.33 percent in pre-reform period to 3.74 percent in post-reform period. Productivity of capital decreased from 3.20 to -5.52 but labour productivity increased from 10.13 to 10.21 during these two time frames. These changes were reflective of a decline in the rate of growth of capital intensity. The data also shows that the decrease in the growth rate of output is accompanied by a decrease in the productivity.

In glass sector, labour productivity for the whole period of our study shows a growth rate at an annual average of 6.19 percent per annum and capital productivity shows an annual average growth rate of -3.08 percent . Capital intensity for the entire period is 10.06 whereas an estimate for the sub-period shows difference in growth rates. After economic reforms in July, 1991, capital productivity and labour productivity shows decreasing trend. Capital intensity increases at higher rate from -6.36 percent in pre-reform period to12.52 percent in post-reform period. Total factor productivity growth is declining in negative fashion associated with declining growth rate in capital and employment growth declines during post-reform period. In short, for Glass sector, post-reform era witnessed declining growth rate in total factor productivity, labour and capital productivity but acceleration in capital intensity as well as material productivity. Comparing the annual growth rate of pre-reform period (1979-80 to 1991-92) with that of post-reform period, it is evident that there is a decrease in the growth rate of value added from 10.34 percent in pre-reform period to 4.76 percent in post-reform period showing an average growth rate of 6.19 percent during the entire period. It is evident that the revival of growth in output in post 90s was not possible by adequate generation of employment in Glass sector. Productivity of capital decreased from 2.39 to -5.27 along with that of labour productivity which shows abrupt decline from 1.53 to -0.26 during these two time frames. The data also shows that the decrease in the growth rate of output is also accompanied by a decrease in the productivity.

In chemical industry, labour productivity for the entire period of our study shows a growth rate at an annual average of 7.61 percent per annum whereas capital productivity shows an annual average growth rate of 0.34 percent. Capital intensity for the entire period is 5.58 whereas an estimate for the sub-period shows slight difference in growth rates. Capital productivity and labour productivity shows decreasing trend with the introduction of reforms in 1991. Capital intensity increases very negligibly from 5.52 percent in pre-reform period to 5.50 percent in post-reform period. Total factor productivity growth is declining in negative fashion associated with declining growth rate in value added. In short, for chemical sector, post-reform era witnessed declining growth rate in total factor productivity, labour and capital productivity but acceleration in capital growth as well as material productivity is noticed. There is a decrease in the growth rate of value added from 8.04 percent in pre-reform period to 6.85 percent in post-reform period showing an average growth rate of 7.61 percent during the entire period. The stimulation of growth in output in post 90s was not possible by adequate generation of employment in Glass sector. Productivity of capital decreased from 1.07 to -0.05 along with that of labour productivity which shows abrupt decline from 6.57 to 5.10 during these two time frames. The data also shows that with the decrease in the growth rate of output, total factor productivity decreases.

On the whole, value added in all the industries except iron&steel sector declined sharply during the post-reforms period whereas post-reform period shows that growth in capital investment gradually declined in all the industries except chemical and fertilizer. Growth in employment also declined in all industries except chemical during post-liberalized scenario. Analysis of partial productivity shows that material productivity increases in all the sectors except cement industry, capital productivity declined during post-reform period in all industries except aluminium and iron industry. Post-reform era witnesses declining growth rate of labour in all energy intensive industries except fertilizer and iron&steel industries.

For a very long time, economic theory highlighted capital and labour, the two primary factors of production, as the key driving force behind production and growth. It was only in the 1950s that technological advancement as an important source of growth was brought into the discussion of mainstream economic theory. Solow's (1957) pioneering attempt to estimate the contribution of physical factors to growth, by introducing the technique of growth accounting, revealed that only 1/8th of the growth of the US economy during the first half of the present century could be explained by the growth of its endowments of physical factors, leaving the remaining to a "residual" (termed as technical progress or total factor productivity growth (TFPG)). Focus shifted thereafter from physical factors to the role of technology in production and growth. It is fairly well established now that technological advancement resulting from R&D is the most important factor behind today's productivity growth. Indeed, the growth experience of most advanced industrial nations has been driven by TFPG rather than by growth in factor endowments. For these nations, operating essentially on the frontiers of global technology, TFP growth necessarily implies an outward shift of the technological frontier. Of course, the contribution of TFPG to their economic growth has not been uniform across all industrialized nations. Hayami (1999), for instance, compared the sources growth in Japan and the USA during their respective high growth periods (1958-70 for Japan and 1929-66 for the USA) and found, not surprisingly, that Japan's growth was attributable to both capital input growth as well as technical progress as opposed to the US experience of predominantly technology driven growth – TFP contribution being 53 per cent for Japan's growth and 80 per cent for the USA. Even, for the late industrializing countries in East Asia (the so-called East Asian Tigers: South Korea, Hong Kong, Singapore and Taiwan), the contribution of TFP has been observed to be much more moderate than the US experience. According to World Bank (1993), approximately two-thirds of the observed growth in these economies may be attributed to accumulation of physical and human capital and the rest came from total factor productivity growth. This is not to deny that productivity growth did play a very important role in East Asian success, but it was clearly not the sole (and not even the dominant) factor.

With the prediction of non-sustainability of growth registered by the East Asian countries, Krugman's thesis [Krugman 1994] leaves an implicit appeal for most of the developing economies to examine their positions. In a situation of fragile total factor productivity growth (TFPG), a syndrome which most of the developing countries encounter, it becomes imperative to undertake an analysis of growth decomposition

of output in Indian manufacturing industries to identify its major contributing factors. Such a result is likely to help provide appropriate policy guidelines while projecting the long-run growth trajectory of the countries.

Theoretically, sources of economic growth are composed of factor accumulation and productivity growth. The first source may lead to high growth rates, but only for a limited period of time. Thereafter, the law of diminishing returns inevitably occurs. Consequently, sustained growth can only be achieved through productivity growth, that is, the ability to produce more and more output with the same amount of input. Some researchers argued that the Soviet Union of the 1950s and the 1960s, and the growth of the Asian 'Tigers' are as examples of growth through factor accumulation (e.g. Krugman, 1994). On the other hand, growth in the industrialized countries appears to be as the result of improved productivity (e.g. Fare et *al*, 1994).

Therefore, a major focus of the present study is to analyze the contribution of inputs and TFPG to output growth. On the basis of the methodology outlined earlier, source specific growth of output is reported in Table 3.

[Insert Table-3 here]

Traditionally (owing to Solow), the sources of output growth are decomposed into two components: a component that is accounted for by the increase in factors of production and a component that is not accounted for by the increase in factors of production which is the residual after calculating the first component. The latter component actually represents the contribution of TFP growth.

Therefore, the pertinent question of whether output growths of these industries are the result of factor accumulation or productivity-driven has been tested for these energy intensive industries. Table 4 shows the relative contribution of TFP growth and factor input growth for the growth of output during

1979-80 to 2003-04. Observing the growth path, it is apparent that in all the industries under our study, TFP growth contribution is either negative or negligible and insignificant across the entire time frame. Therefore, it is true that increase in factor input is responsible for observed output growth and TFP contribution plays negligible role in enhancing output growth. Therefore, output growth in energy intensive industries in India was fundamentally dominated by accumulation of factors resulting input-driven growth and TFP has a negligible or negative contribution to output growth.

5. Summary and Conclusions:

The present exercise attempts to examine the contribution of inputs and total factor productivity growth to the growth of output by considering the aggregate manufacturing sector and seven selected manufacturing industries of India during the period 1979-80 to 2003-04. Major findings of the study indicate that output growth in the selected Indian manufacturing industrial sectors is driven mainly by inputs accumulation while the contribution of TFP remains either minimal or negative. The growth rate of total factor productivity in almost all the industries under our study is gradually declining, especially during the post-reforms period. Therefore, manufacturing sector, being input driven output growth sector of India, does not remain outside the purview of the sustainability issue raised by Krugman.

The pattern of sources of output growth with respect to source of productivity growth and input accumulation remains unchanged during two periods but the relative contribution of each source of growth to output growth from pre-liberalisation to post-liberalisation period has increased for some other industries but has decreased for some other industries. On the other hand, for some of the industries the relative contribution has changed from positive during pre-liberalisation period to negative during post-liberalisation period or from negative during pre-liberalisation period to positive during post-liberalisation period. The change in pattern of sources of output growth may have taken place due to liberalization policies and structural reforms undertaken during the 1990s.

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Table:1:Annual Growth rate of Industrial Production

Period	Index of Industrial Production(IPP) (Base:1993-94)	Annual Growth rate(%)
1998-99	145.2	4.1
1999-2000	154.9	6.7
2000-01	162.6	5.0
2001-02	167.0	2.7
2002-03	176.6	5.7
2003-04	189.0	7.0
2004-05	204.8	8.4
2005-06	221.5	8.2
2006-07	247.0	11.5

Source: Statistical Abstract,2007-08.

Table: 2: Growth rate of value added, capital, employment and partial factor productivity etc. in selected manufacturing industries in India (%)

Industry	Year/Growth rate	Value added	Capital	Employment	Material productivity	Capital productivity	Labour Productivity	Capital intensity	Total factor productivity growth
Cement	1979-'80 to 2003-'04	7.94 **(7.78)**	10.29 **(6.05)**	3.43 **(0.65)**	2.93 **(1.49)**	-1.75 **(1.64)**	4.88 **(7.09)**	6.97 **(5.36)**	-0.0043 **(1.24)**
	1979-'80 to 1991-'92	10.49 **(6.67)**	11.97 **(4.34)**	4.15 **(0.23)**	4.66 **(1.23)**	-1.42 **(2.23)**	6.5 **(6.43)**	7.96 **(4.11)**	1.44 **(1.53)**
	1991-'92 to2003-'04	5.74 **(4.38)**	8.66 **(4.63)**	2.26 **(-0.81)**	0.71 **(1.61)**	-2.08 **(-0.23)**	3.80 **(5.24)**	6.51 **(5.48)**	1.013 **(0.44)**
Aluminium	1979-'80 to 2003-'04	5.21 **(7.78)**	4.98 **(6.05)**	3.82 **(0.65)**	2.39 **(1.49)**	0.23 **(1.64)**	1.39 **(7.09)**	1.16 **(5.36)**	0.0011 **(1.24)**
	1979-'80 to 1991-'92	6.27 **(6.67)**	4.99 **(4.34)**	2.69 **(0.23)**	-0.48 **(1.23)**	2.34 **(2.23)**	5.10 **(6.43)**	3.21 **(4.11)**	-0.2008 **(1.53)**
	1991-'92 to2003-'04	-2.20 **(4.38)**	0.60 **(4.63)**	2.09 **(-0.81)**	4.45 **(1.61)**	7.88 **(-0.23)**	1.89 **(5.24)**	1.04 **(5.48)**	-1.43 **(0.44)**
Iron&steel	1979-'80 to 2003-'04	6.76 **(7.78)**	6.00 **(6.05)**	0.82 **(0.65)**	1.83 **(1.49)**	0.80 **(1.64)**	5.81 **(7.09)**	5.05 **(5.36)**	-0.13 **(1.24)**
	1979-'80 to 1991-'92	6.29 **(6.67)**	6.18 **(4.34)**	0.93 **(0.23)**	1.39 **(1.23)**	0.26 **(2.23)**	4.7 **(6.43)**	4.59 **(4.11)**	0.5650 **(1.53)**
	1991-'92 to2003-'04	6.90 **(4.38)**	5.67 **(4.63)**	0.59 **(-0.81)**	1.76 **(1.61)**	1.33 **(-0.23)**	7.06 **(5.24)**	5.50 **(5.48)**	0.4761 **(0.44)**
Chemical	1979-'80 to 2003-'04	7.61 **(7.78)**	7.33 **(6.05)**	1.81 **(0.65)**	3.07 **(1.49)**	0.34 **(1.64)**	5.71 **(7.09)**	5.58 **(5.36)**	-0.07 **(1.24)**
	1979-'80 to 1991-'92	8.04 **(6.67)**	6.94 **(4.34)**	1.47 **(0.23)**	1.67 **(1.23)**	1.07 **(2.23)**	6.57 **(6.43)**	5.52 **(4.11)**	0.65 **(1.53)**

	1991-'92 to2003-'04	6.85 **(4.38)**	7.84 **(4.63)**	2.39 **(-0.81)**	4.59 **(1.61)**	-0.05 **(-0.23)**	5.10 **(5.24)**	5.50 **(5.48)**	-0.32 **(0.44)**
Fertilizer	1979-'80 to 2003-'04	8.93 **(7.78)**	8.71 **(6.05)**	2.23 **(0.65)**	2.55 **(1.49)**	-1.06 **(1.64)**	10.02 **(7.09)**	11.12 **(5.36)**	-0.05 **(1.24)**
	1979-'80 to 1991-'92	15.33 **(6.67)**	8.79 **(4.34)**	6.61 **(0.23)**	1.90 **(1.23)**	3.20 **(2.23)**	10.13 **(6.43)**	15.17 **(4.11)**	0.44 **(1.53)**
	1991-'92 to2003-'04	3.74 **(4.38)**	10.14 **(4.63)**	-1.67 **(-0.81)**	2.70 **(1.61)**	-5.52 **(-0.23)**	10.21 **(5.24)**	8.32 **(5.48)**	-1.12 **(0.44)**
Paper&pulp	1979-'80 to 2003-'04	6.47 **(7.78)**	7.08 **(6.05)**	1.62 **(0.65)**	2.12 **(1.49)**	-0.61 **(1.64)**	4.86 **(7.09)**	-0.14 **(1.24)**	-0.002 **(1.24)**
	1979-'80 to 1991-'92	7.79 **(6.67)**	7.38 **(4.34)**	1.70 **(0.23)**	2.28 **(1.23)**	-0.60 **(2.23)**	4.71 **(6.43)**	0.64 **(1.53)**	0.64 **(1.53)**
	1991-'92 to2003-'04	4.50 **(4.38)**	6.58 **(4.63)**	1.21 **(-0.81)**	2.48 **(1.61)**	-1.83 **(-0.23)**	3.02 **(5.24)**	0.94 **(0.44)**	0.58 **(0.44)**
Glass	1979-'80 to 2003-'04	6.19 **(7.78)**	9.52 **(6.05)**	-0.32 **(0.65)**	1.52 **(1.49)**	-3.08 **(1.64)**	7.18 **(7.09)**	10.06 **(5.36)**	-0.104 **(1.24)**
	1979-'80 to 1991-'92	10.34 **(6.67)**	0.23 **(4.34)**	1.53 **(0.23)**	-0.50 **(1.23)**	2.39 **(2.23)**	8.92 **(6.43)**	6.36 **(4.11)**	-0.09 **(1.53)**
	1991-'92 to2003-'04	4.76 **(4.38)**	0.09 **(4.63)**	-0.26 **(-0.81)**	2.80 **(1.61)**	-5.27 **(-0.23)**	5.30 **(5.24)**	12.52 **(5.48)**	-0.68 **(0.44)**

 # Growth rates for the entire period are obtained from semi-log trend.

 # # Figures in the parenthesis indicate growth rates of respective parameters in aggregate manufacturing.

Source: Own estimate.

Table -3: Contribution of TFPG to output growth under liberalized trade regime

Industry	Contribution of TFPG and inputs to output growth	Phase 1 (1979-'80 to '85-'86)	Phase 2 (1986-'87 to '91-'92)	Phase 3 (1992-'93 to '97-'98)	Phase 4 (1998-'99 to2003-04)	Pre-reform period (1979-'80 to 1991-'92)	Post-reform period (1991-'92 to 2003-'04)	Entire period (1979-'80 to03-'04)
Cement	Output growth	11.05	9.93	6.03	4.75	10.49	5.74	7.94
	Contribution of Input growth	10.05 (95.02%)	8.74 (88.02%)	5.12 (84.91%)	5.29 (111.37%)	9.62 (91.71%)	4.73 (82.35%)	7.944 (100.054%)
	Contribution of TFPG	0.55 (4.98%)	1.19 (11.98%)	0.91 (15.09%)	-0.54 (-11.37%)	0.87 (8.29%)	1.013 (17.65%)	-0.0043 (-0.054%)
Aluminium	Output growth	5.89	6.65	-3.66	-1.23	6.27	-2.20	5.21
	Contribution	3.09	10.19	-5.41	-0.18	6.64	-2.23	5.32

	of Input growth	(52.46 %)	(153.23%)	(-147.81%)	(-14.63%)	(105.9%)	(-101.36%)	(102.11%)
	Contribution of TFPG	2.80 (47.53%)	-3.54 (-53.23%)	1.75 (47.81%)	-1.05 (-85.37%)	-0.37 (-5.90%)	0.03 (1.36%)	-0.11 (-2.11%)
Iron&steel	Output growth	4.43	7.33	7.79	6.91	6.29	6.9	6.76
	Contribution of Input growth	3.69 (83.21%)	6.51 (88.81%)	7.09 (90.98%)	6.2 (89.67%)	5.72 (91.02%)	6.42 (93.1%)	6.89 (101.92%)
	Contribution of TFPG	0.74 (16.79%)	0.82 (11.19%)	0.70 (9.02%)	0.71 (10.33%)	0.57 (8.98%)	0.48 (6.90%)	-0.13 (-1.92%)
Chemical	Output growth	7.29	8.06	9.15	5.20	8.04	7.68	7.61
	Contribution of Input growth	7.64 (104.80%)	6.4 (79.40%)	11.04 (111.59%)	5.74 (110.38%)	7.39 (91.92%)	8.0 (104.17%)	7.68 (100.92%)
	Contribution of TFPG	-0.35 (-4.80%)	1.66 (20.60%)	-1.06 (-11.59%)	-0.54 (-10.38%)	0.65 (8.08%)	-0.32 (-4.17%)	-0.07 (-0.92%)
Fertilizer	Output growth	3.67	26.99	7.09	-2.05	15.33	3.74	8.93
	Contribution of Input growth	3.95 (107.63%)	25.82 (95.66%)	7.43 (100.46%)	-1.30 (63.41%)	14.89 (97.13%)	4.86 (127.08%)	8.98 (127.63%)
	Contribution of TFPG	-0.28 (-7.63%)	1.17 (4.34%)	-0.34 (-0.46%)	-0.75 (36.59%)	0.44 (2.87%)	-1.12 (-27.08%)	-0.05 (-27.63%)
Paper&pulp	Output growth	6.38	9.40	5.70	2.72	7.79	4.5	6.47
	Contribution of Input growth	4.67 (73.2%)	9.83 (104.58%)	5.55 (97.37%)	3.43 (100.71%)	7.15 (91.78%)	3.56 (79.11%)	6.472 (100.03%)
	Contribution of TFPG	1.71 (26.80)	-0.43 (-4.58)	0.15 (2.63)	-0.71 (-26.10)	0.64 (8.22%)	0.94 (20.89%)	-0.002 (-0.03%)
Glass	Output growth	7.92	12.77	2.62	2.86	10.34	4.76	6.19
	Contribution of Input growth	8.38 (105.81%)	12.48 (97.73%)	1.86 (70.99%)	2.25 (78.67%)	10.43 (100.87%)	5.44 (114.29%)	6.29 (101.62%)
	Contribution of TFPG	-0.46 (-5.81%)	0.29 (2.27%)	0.76 (29.01%)	0.61 (21.33%)	-0.09 (0.87 %)	-0.68 (-14.29%)	-0.10 (-1.62%)

Source: Own estimate

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A Study of the Recruitment and Selection process: SMC Global

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Abstract

Better recruitment and selection strategies result in improved organizational outcomes. With reference to this context, the research paper entitled Recruitment and Selection has been prepared to put a light on Recruitment and Selection process. The main objective is to identify general practices that organizations use to recruit and select employees and, to determine how the recruitment and selection practices affect organizational outcomes at SMC Global Securities Ltd. The research methodology applied is the exploratory. The data was collected through well structured questionnaires. The source of data was both primary and secondary. Sample size was 30. Data analysis has been done with the help of SPSS software. The company considered portals as the most important medium of hiring employees. The employees working in the company consider the employee references are one of the most reliable source of hiring the new employees. Company always takes in consideration the cost-benefit ratio.
Keywords: Recruitment, Selection, Reference, Interview, Hiring, Performance.

1. Introduction

1.1Recruitment and selection

Successful human resource should identify human resource needs in the organization. Once the needs are identified, the process of recruitment or acquisition function starts.

Recruitment is the discovering of potential candidates for actual or anticipated organizational vacancies. Or, from another perspective, it is a linking activity bringing together those with jobs to fill and those seeking job. The ideal recruitment effort will attract a large number of qualified applicants who will take the job if it is offered. It should also provide information so that unqualified applicants can self select themselves out of job candidacy; this is, a good recruiting program should attract the qualified and not attract the unqualified. This dual objective will minimize the cost of processing unqualified candidates.

Definition of Recruitment

- Recruitment is the process of attracting prospective employees and stimulating them for applying job in an organization.
- Recruitment is the process of hiring the right kinds of candidates on the right job.

Methods of Recruitment

There are various methods of recruitment but for the sake of simplicity, they have been categorized under two broad headings.

- Internal Recruitment
- External Recruitment

Benefits and Importance of Recruitment:

(1).Helps to create a talent pool of potential candidates for the benefits of the organization.
(2).To increases the pool of job seeking candidates at minimum cost.
(3).It helps to increase the success rate of selection process by decreasing the no of visits qualified or over qualified job applicants.
(4).Helps in identifying and preparing potential job applicants who will be the appropriate candidature for the job.

(5).Finally it helps in increasing organization and individual effectiveness of various recruiting techniques and for all the types of job applicants. .

1.2Selection:

Selection is the process of picking individuals who have relevant qualifications to fill jobs in an organization. Selection is much more than just choosing the best candidate. It is an attempt to strike a happy balance between what the applicant can and wants to do and what the organization requires.

Importance of Selection

Selecting the right employees is important for three main reasons: performance, costs and legal obligations.

Performance: At first, our own performance depends in part of our own subordinates. Employees with right skills will do a better job for any company and for the owner. Employees without these requisite skills or who are abrasive would not perform effectively and the company performance will suffer to a great extent. So there is a time to screen out undesirables and to choose the better and perfect candidate that can effectively contribute to company success.

Cost: Second, it is important because it is costly to recruit and hire employees so cost-benefit ratio have to be considered while hiring of employees in order to avoid any unnecessary wastage of money and the valuable resources .The total cost of hiring a manager could easily be 10 times as high as once one add search fees, interviewing time, reference checking, and travel and moving expenses.

Legal Obligations: Thirdly it is important because of the two legal implications of incompetent hiring. Firstly equal employment law requires nondiscriminatory selection procedures for selected groups. Secondly, courts will find the employer liable when employees with criminal records or other problems use access to customers' homes to commit crimes. Lawyers call hiring workers with such backgrounds, without proper safeguards, negligent hiring. So the negligent hiring highlights the need to think through what the job human requirements are. So in order to avoid the concept of negligent hiring, it is necessary to make a systematic effort in order to gain relevant information about the applicant and verify all the documentation.

Essentials and Prerequisites for Selection:

(1) Picking individuals possessing relevant qualifications.
(2) Matching job requirements with the profile of the candidates.
(3) Using multiple tools and techniques to find the most suitable candidate suitable.
(4) Of achieving success on the job

The Process of Selection:

(1) Reception
(2) Screening Interview
(3) Application Blank
(4) Selection Tests
(5) Selection Interview
(6) Medical Examination
(7) Reference Checks
(8) Hiring Decisions

Selection is usually a series of hurdles or steps. Each one must be successfully cleared before the applicant proceeds to the next.

2.Literature review

According to Edwin B Flippo

Recruitment is nothing but the process of searching the candidates for employment and then stimulating them for jobs in the organization. It is the activity that links the employees and the job seekers. It is also defined as the process of finding and attracting capable applicants for employment. It is the pool of applicants from which the new employees are selected. It can also be defined as a process to discover sources of manpower to meet the requirement of the staffing schedule and to employ effective measures for attracting the manpower in adequate numbers in order to facilitate the effective selection of an efficient working force.

According to David A De Cenzo
The recruitment needs are of three types which are as follow:
(a) First one is Planned Needs: These are the needs that arise from the changes in the organization and retirement policy creating vacancy for new jobs.
(b).Second one is Anticipated Needs: These are those movements in personal which an organization can predict by studying trends both in external as well as internal environment.
(c) Last one is Unexpected Needs:
These needs arise due to various reasons like deaths, resignations, accidents, illness, relocation etc.

Taylor, P. (1998). Seven staff selection myths
This article outlines seven commonly held misconceptions about recruitment And selection practices. Areas discussed include the validity of various Recruitment and selection measures (e.g., interviewing, reference checks), the Conditions necessary to maximize the effectiveness of these practices, and Common mistaken perceptions of the interview process. This article is most Useful for readers interested in workforce development theory and research.

3.Research methodology
The purpose of this section is to describe the methodology carried out to complete the work. The methodology plays a dominant role in any research work. The effectiveness of any research work depends upon the correctness and effectiveness of the research methodology.

Objectives of the study
- To identify general practices that organizations use to recruit and select employees.
- To determine which recruitment and selection practices are most effective.
- To determine how the recruitment and selection practices affect organizational outcomes.

Research design:-
Exploratory research:-The research design used in this project is the exploratory type. Exploratory type of research is used because the sources of information are relatively few and the purpose is merely to find and to understand the possible actions.
The exploratory study is often used as an introductory phase of a larger study and results are used in developing specific technique for larger study.

Sampling technique:-
Judgmental Sampling
Judgmental sampling is a form of convenience sampling in which the population elements are selected based on the judgment of the researcher.
Target population and Sample size
- The target population was the employees of the HR department of SMC Global Securities Ltd. The employees targeted were of all age group.
- A sample size of 30 employees of SMC has been taken.

4.Analysis

Data analysis is very important aspect of project, as it basically involves the analysis of all the information that we collected. The information collected needs to be analyzed so that we can interpret the information and provides the justification for the work we have done during our research. Data analysis is a body of methods that help to describe facts, detect patterns, develop explanations and test hypothesis.
Data analysis has been done with the help of SPSS software. After the respondents had filled in the questionnaires, the data was entered into the software and the analysis was made thereby.
The data has been presented in the form of graphs, bar charts, pie charts etc.
After analysis of each of the question in a questionnaire the interpretation of the same is also being provided which includes the reason about the particular aspect of the organization and we can also judge the frequency and application of the same in a particular context so that we are able to find out the exact fact behind the particular aspect of an organization on which are whole project report is based.

Analysis of Questionnaire

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5.Findings

The findings from the analysis including charts, bars, and graphs are listed as follows:-

- The company considered portals as the most important medium of hiring employees and then employee references are also act as the important source of recruiting people and also with my working experience with the company I found them most effective.
- The employees working in the company consider the employee references are one of the most reliable source of hiring the new employees and also to some extent portals, but before hiring from portals the references provided there are need to be confirmed as I did during my training period.
- The most important feature in company's recruitment &selection policy is that we need to take in consideration the ratio between the turn-up and line-up candidates, and after analysis I found it most of the employees are also holding the same opinion.
- The existing recruitment process of company is good but it has some shortcomings that is being Covered in recommendations and on overall the recruitment department has pressure on it.
- After analysis of the company selection procedure I found out the company is using quite effective method of doing selection of candidates and they always take in consideration the cost-benefit ratio which is quite important from the long perspective of hiring employees.
- The ratio of selected candidates to joining candidates is quite effective and highest in number as the employees being selected are also of the view that they are analyzed properly and effectively.

6.Conclusions

The main thing that I want to conclude firstly is that with the help of analysis, feedback generated through questionnaire I found that the company is following an effective Recruitment and Selection process to maximum extent.

As per my study, out of the various methods of sourcing candidates, the best one is – getting references via references and networking. In the process, I came across various experiences where the role of an HR and the relevant traits he finds in the candidates were displayed. The structure of the financial sector (as well as that of SMC Ltd) was known along with the analysis that recruitment is an ongoing process in this industry and therefore new innovative methods have to be thought of and applied to meet the demand. Company should focus on long term consistent performance rather then short term.
The emphasis towards training and enhancing skills of recruiters needs to be more and also consistent.
Even though an HR manager has many challenges to face in order to ensure that the human resource department contributes to the bottom-line and emerges as a strategic partner in the business, it is "Talent acquisition", that is the key determining factor in how well an Human resource department contributes towards the achievement of the overall objective of the organization and therefore is a daunting task for any HR manager

7.References

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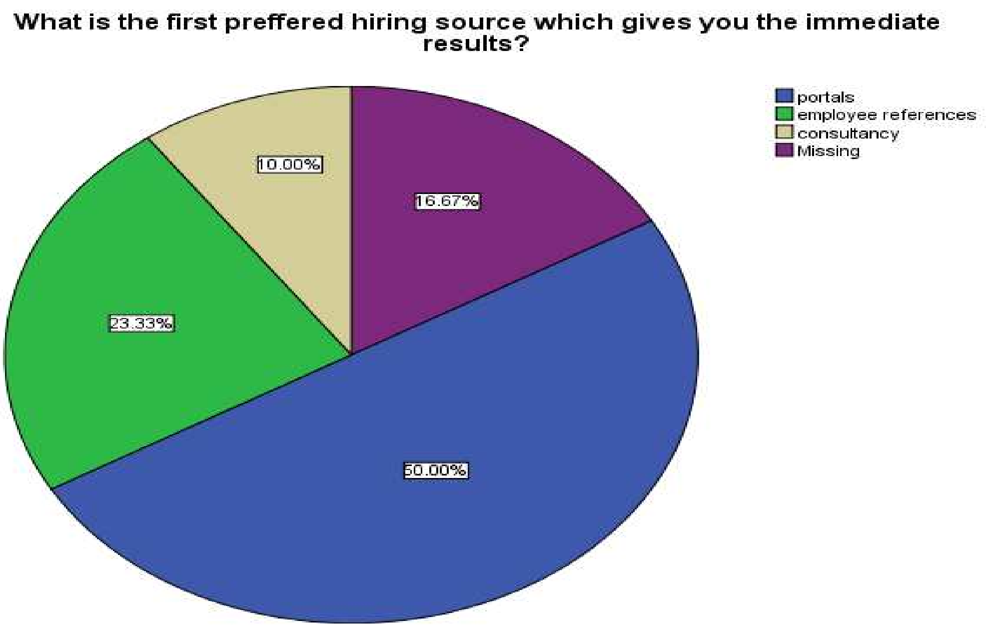
Figures



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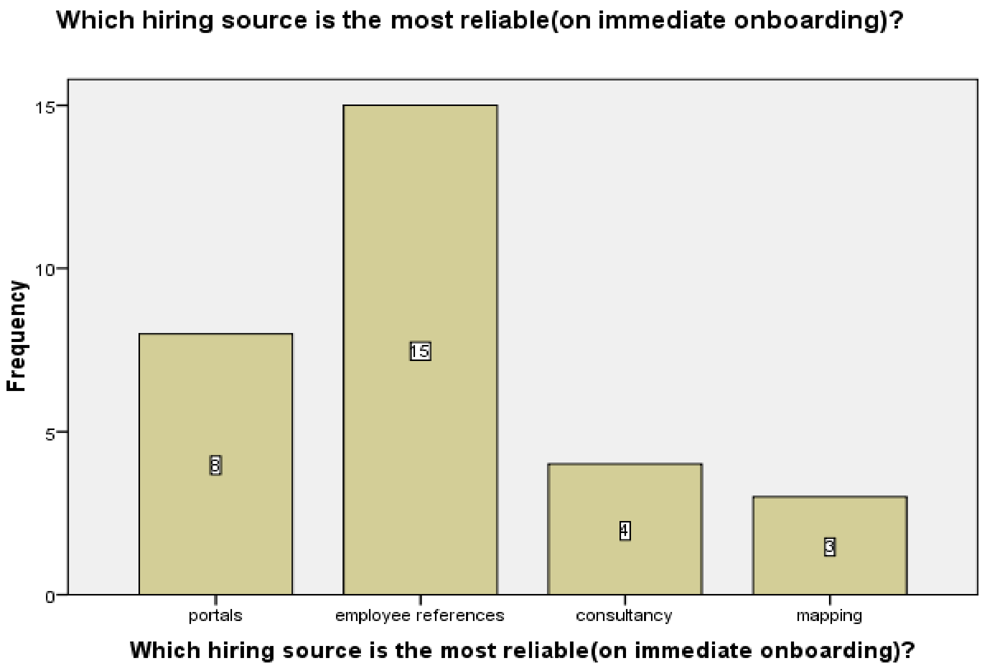

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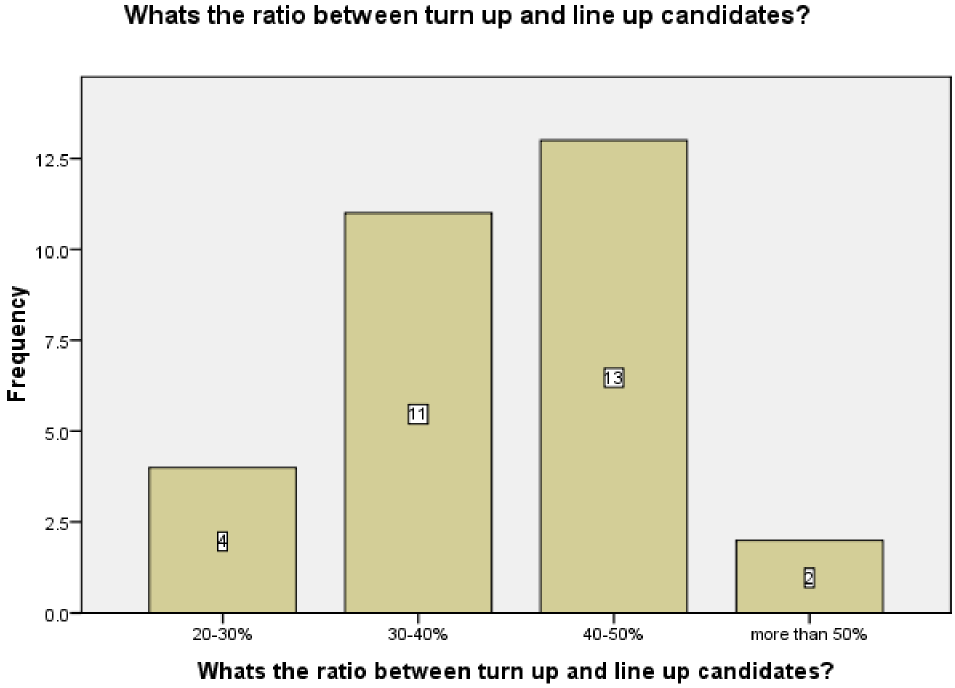

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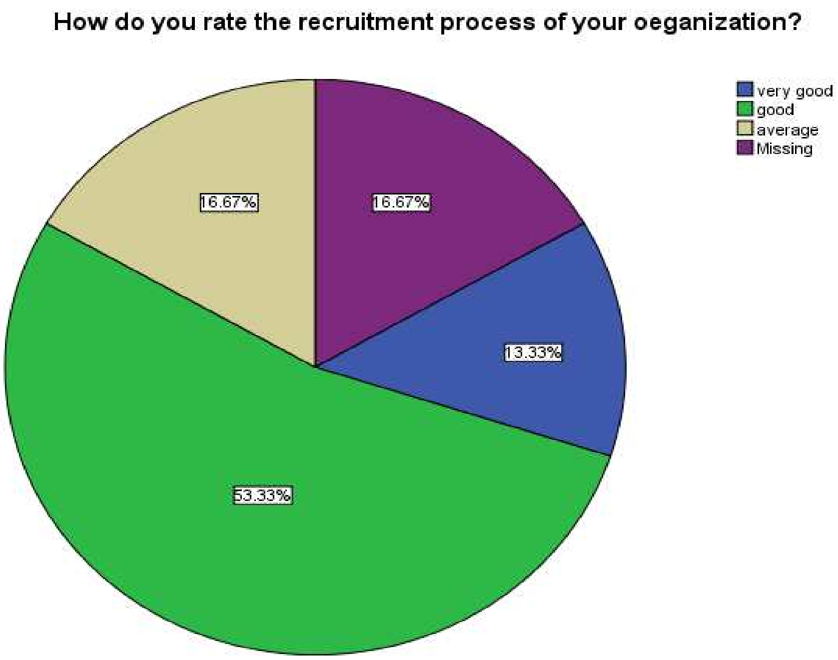

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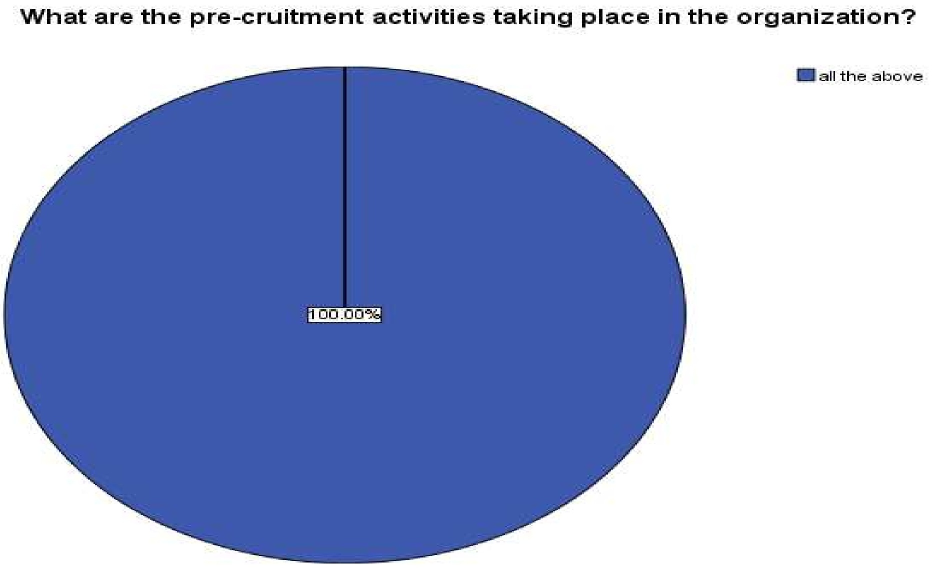

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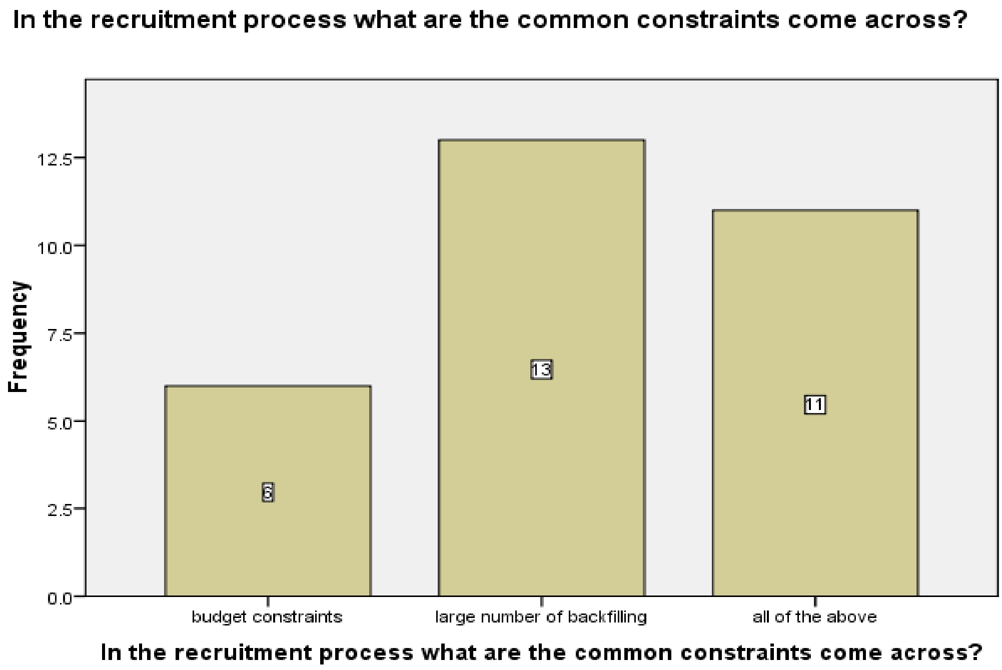

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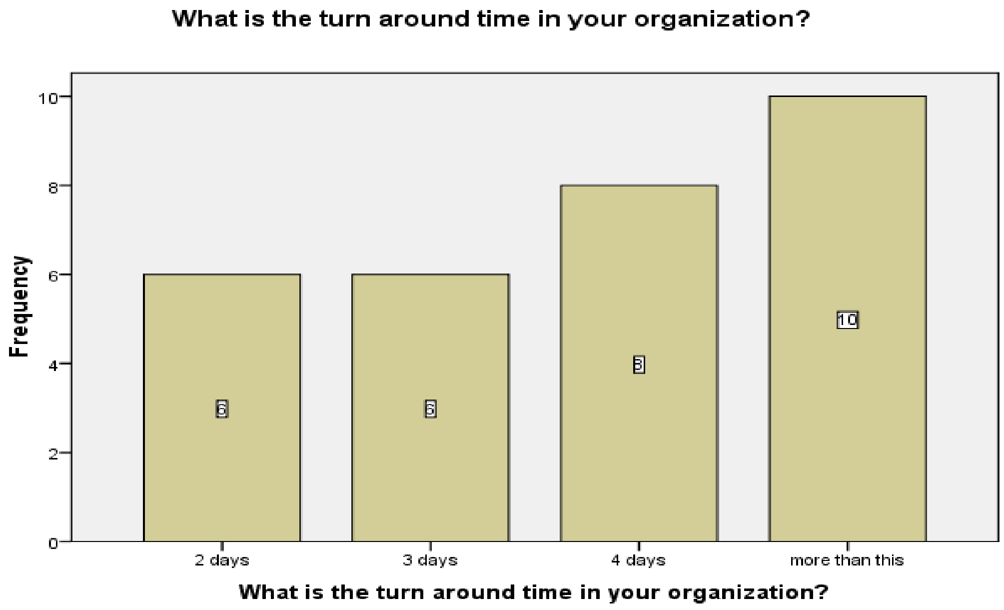

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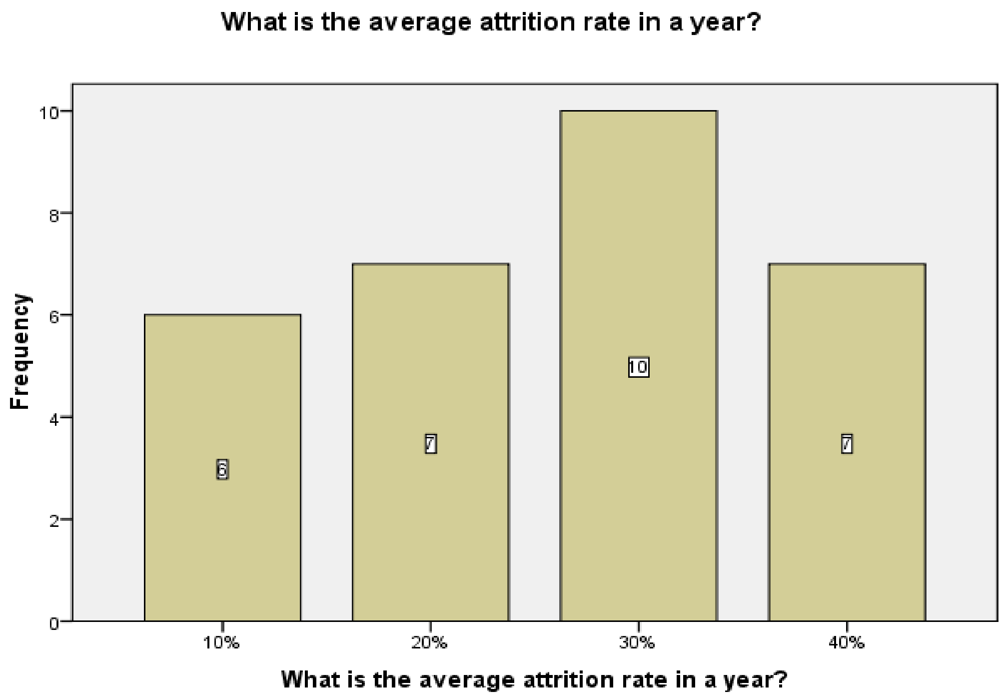

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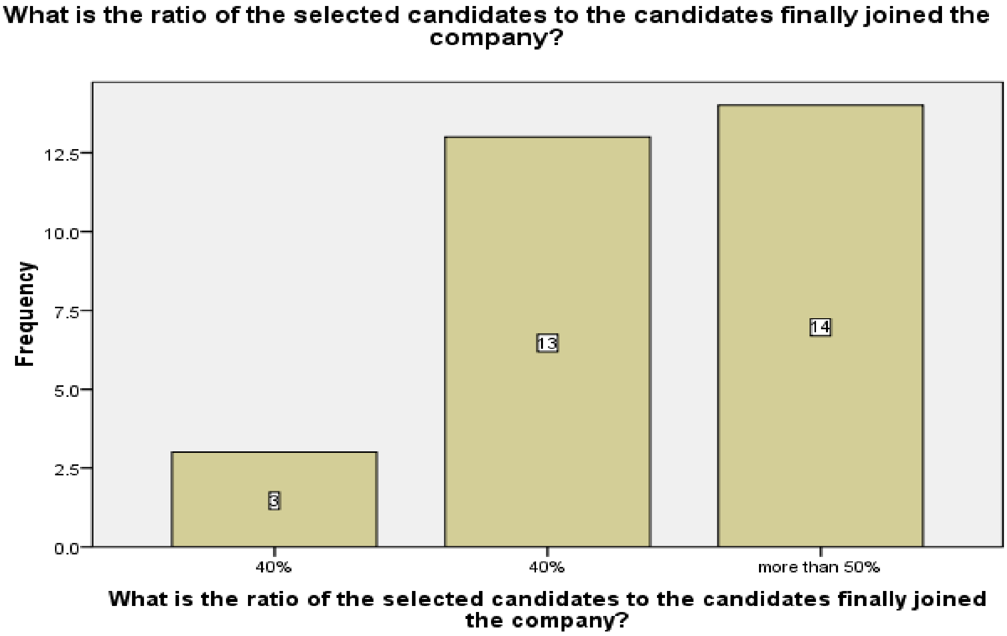

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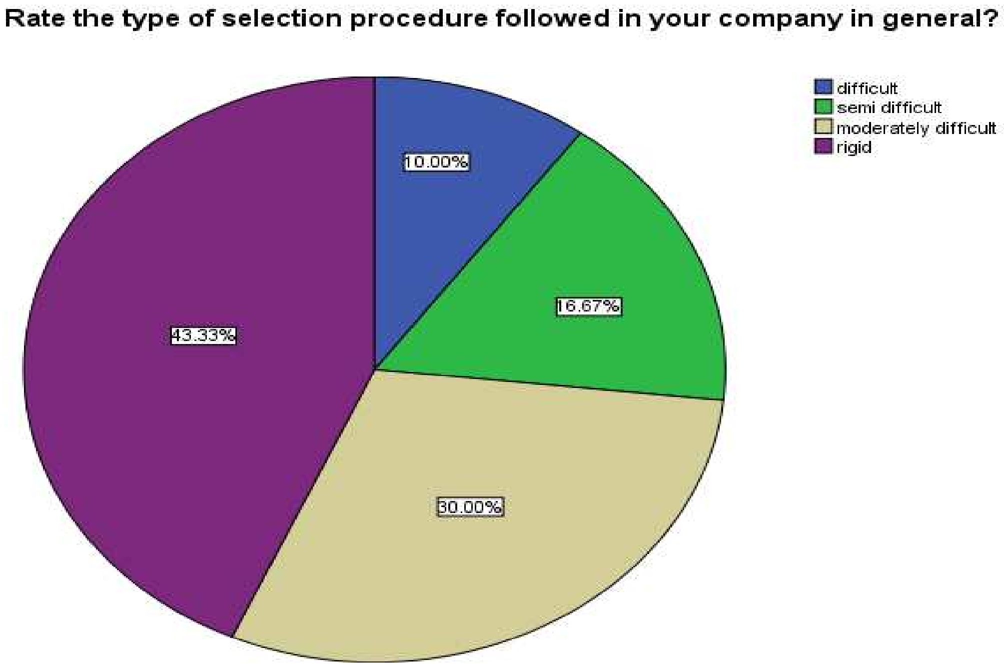

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