NATIONAL PRODUCTIVITY COUNCIL

Productivity

Vol. 50 July - September 2009 No. 2

Focus : Banking and Finance

Guidelines for Contributors

Scope and Coverage

PRODUCTIVITY is the principal journal of the National Productivity Council of India. The Journal aims at disseminating information on concepts of and data on productivity and its growth in India and elsewhere. It also aims at disseminating knowledge on techniques and methods of productivity improvement through effective management of all types of resources. Thus, contributions from a large spectrum of disciplines are accepted for publication. Only those manuscripts that present the results of original research and analysis are acceptable to the Journal. The managerial/policy implications of the study should be highlighted separately towards the end of the paper.

Format of Manuscript

Contributions should be of about 5,000 words length. Tables, illustrations, charts, figures, exhibits, etc., should be serially numbered and typed in separate pages and should not be mixed with the main text. The text should be addressed to the Editor, PRODUCTIVITY, National Productivity Council, Utpadakata Bhawan, Lodi Road, New Delhi - 110 003.

About the References

Only those references which are actually utilized in the text should be included in the reference list. In the text, references should be cited with the surname of the author(s) alongwith the year of publication and the page number, all in brackets. If there are more than one reference by the same author during any year, the year may be subscripted with 'a' or 'b'. For instance, reference may be given at the end of the sentence as: (Szendrovits, 1998a, p. 337). Sources of data need to be given below each table unless otherwise mentioned in the text. Reference list should be alphabetically arranged. Each reference should carry the surname of the author, followed by other names, the title of the paper in quotes, the name of the journal underlined, volume and issue numbers, and the year of publication. In the event of a book, the title should be followed by the publisher's name and year of publication. In the event of a report from an organization, the name of the organization may be cited in the place of the author.

Accompanying Material

The manuscripts should be accompanied by:

1. An abstract of the paper not exceeding 100 words.
2. A declaration that the paper is original and has not been submitted elsewhere for publication.
3. A note about the author(s) not exceeding 50 words.

Subscription :

Subscription and orders for the journal should be sent to the publisher: **MD Publications Pvt Ltd,** New Delhi.

Annual Subscription rates for subscribers are :

In India (Rs.)		In Other Countries (US$)	
Print	1500.00	Print	150.00
Online	1200.00	Online	120.00
Print + Online	1800.00	Print + Online	180.00

Postal Charges : **Rs. 150.00 (In India)**
(US$ 60 (Rest of the World)

All remittance must be paid in favour of :
MD Publications Pvt Ltd,
payable at New Delhi, India

All business correspondence to be addressed to:

MD Publications Pvt Ltd
"MD House", 11, Darya Ganj,
New Delhi-110 002
Phone : +91-11-45355555
E-mail : contact@mdppl.com
Website : www.mdppl.com

ISSN : 0032-9924
e-ISSN : 0976-3902

Productivity

A QUARTERLY JOURNAL OF THE NATIONAL PRODUCTIVITY COUNCIL

Vol. 50 • July - September 2009 • No. 2

MD Publications Pvt Ltd
New Delhi
www.mdppl.com

Publishers & Distributors:

MD Publications Pvt Ltd
"MD House", 11, Darya Ganj,
New Delhi-110 002
Phone : +91-11-45355555
E-mail : contact@mdppl.com
Website : www.mdppl.com

ISSN : 0032-9924
e-ISSN : 0976-3902

Published and printed on behalf of National Productivity Council,
by Mr. Pranav Gupta, **MD Publications Pvt Ltd,**
at Printext, New Delhi, India.

Contents

Focus

Performance Evaluation of Services of Commercial Banks based on Customer Perception: A Fuzzy Approach

S.K. Purohit, Ashutosh Sarkar, Debadyuti Das, and Sushil Kumar Sharma

Delivering quality service has become a necessary pre-requisite for survival amongst all public and private sector banks operating in India in the highly competitive post-liberalized scenario. In this paper, we have made an attempt to evaluate the services of a few Indian banks based on the perception of customers. A number of performance criteria were considered based on customers' notion about the services provided by the banks and their personal experience at the point of interaction with these banks. These performance criteria were identified through informal interview and discussion with the bank managers and a few customers. Most of these identified criteria are imprecise in nature which motivated us to use fuzzy set theoretic analysis for measurement and evaluation. Opinions were obtained from a large number of customers on a 5-point Likert scale and they were subsequently transformed into fuzzy numbers for the purpose of carrying out necessary computation for obtaining utility values of each bank. The banks were finally ranked based on their utility values which represent their capability to satisfy customers.

S.K. Purohit is currently working as a Software Executive in Patni Computer Services; Ashutosh Sarkar is Lecturer in the Department of Mechanical Engineering, Institute of Technology, Banaras Hindu University; Debadyuti Das is Reader in the Faculty of Management Studies, University of Delhi and Sushil Kumar Sharma is Professor and Head in the Department of Mechanical Engineering, Institute of Technology, Banaras Hindu University.

Introduction

The liberalization of the Indian economy has created a proliferation in the number of players in the Indian banking sector and caused an intense competition amongst them. As of now, not only the number of organizations delivering banking services has gone up but these organizations are also constantly competing with each other in order to attract newer customers and also for retaining the existing customer base. In such an environment, delivering *quality service* and providing *customer satisfaction* have become the key strategies for survival. Satisfied customers tend to say good things about the organization which results in improvement in the bottom-line of any business. This necessitates a continuous evaluation of bank's performance and an effort towards meeting customer needs in the best possible manner. Two types of evaluative measures have been in vogue for evaluating the performance of any service organization including commercial banks. These are *perceived service quality* and *customer satisfaction*. Most of the works pertaining to the performance evaluation of service organizations have been devoted towards defining and measuring service quality. Researchers have developed a number of models for measuring service quality, which have in some way or other been also used for the purpose of measuring customer satisfaction.

Gronroos (1978) formulated a model of service quality (SQ) based on the assessment of service on two dimensions, commonly referred to as functional SQ and technical SQ. In 1984, he later explained that customers compare their experiences with their expectations of service quality in forming their judgments about the overall service quality. Gronroos (1993) added another dimension referred

to as *image of the service provider* to his original two dimensions of service quality in his last theory.

Although the works of Gronroos on service quality were the first to be published in academic literature, it has been the works of Parasuraman et al. (1985, 1988), which have received the most attention for their well-known model, SERVQUAL. Their view of service quality is based on the discrepancy between the perception of customers about performance and their expectation on service product. The model has been criticized on the ground of using two scales for measuring performance perceptions and expectations of customers, when one scale would have been shorter, simpler, and more easily understandable for the respondents. The use of expectations scale has been questioned by some researchers (Babakus and Boller, 1992; Cronin and Taylor, 1992). Babakus and Boller (1992) have attempted to combine both expectations and perceptions into a single measure and have shown that such a measure actually outperforms the SERVQUAL scale in terms of both validity and reliability. Cronin and Taylor (1992) developed the SERVPERF model to measure service quality performance using a 7-point scale ranging from very poor to excellent. Avkiran (1999) developed a single scale measure of service quality known as BANKSERV designed to allow customers to express their perceptions and expectations in a single statement. Aldlaigan et al. (2002) proposed a measure of bank service quality referred to as SYSTRA-SQ based on four dimensions, that is, service system quality, behavioral quality, service transactional accuracy, and machine service quality. They further added that customers evaluate service quality at two levels: organizational and transactional.

As regards the evaluative measure pertaining to customer satisfaction, Oliver (1980) proposed a simple model for determining the satisfaction level of customers on the basis of their expectation about the product and subsequent performance of the same. When performance outcome matches or exceeds expectations of customers, satisfaction occurs, otherwise dissatisfaction results when the outcome falls short of their expectations. This model has been extensively used for measuring customer satisfaction both with reference to tangible products as well as intangible service products. Siskos et al. (1998) developed a preference disaggregation model for determining the satisfaction level of customers. In this model, each customer is asked to express his judgments, that is, his global satisfaction and satisfaction with regard to the set of discrete criteria. Mihelis et al. (2001) developed a set of satisfaction dimensions and determined the level of customer satisfaction with reference to a number of commercial banks in Greece based on the principles of multi-criteria analysis and preference disaggregation modeling. The study also highlighted the critical satisfaction dimensions and customer groups with distinctive preferences and expectations.

All these models have been developed by applying suitable statistical tools and techniques after eliciting responses from customers in a 5-point or 7-point Likert scale. However, inviting responses from customers in an absolute scale is fraught with imprecision. Fuzzy set theory is an excellent tool for modeling the kind of uncertainty associated with vagueness and imprecision. Its power lies in the fact that linguistic variables can also be used to represent imprecise concept. Drawing on the set of satisfaction dimensions of banks developed by Mihelis et al. (2001), the present work attempts to develop a framework for performance evaluation of services provided by banks based on customer satisfaction by applying fuzzy mathematics.

Conceptual Framework

As regards the constructs of satisfaction and service quality, although a lot of similarities exist between the two, there remain some differences as well. In order to form satisfaction judgment, consumers must have experienced a service while perceived service quality is not necessarily experience-based. Service quality judgments are more specific about particular attributes while customer satisfaction judgments are more holistic (Oliver, 1997). Further, service quality is linked with cognitive judgments while satisfaction is linked with effective ones. Thus, the dimensions of customer satisfaction are more pervasive than those of service quality.

The foundation of the present work is based on customer satisfaction dimensions developed by Mihelis et al. (2001) who developed the dimensions with reference to commercial banks of Greece. They broadly presented five satisfaction dimensions or criteria. These are: (i) personnel of the bank; (ii) products; (iii) image of the bank; (iv) service; and (v) access. Further, under each satisfaction criterion, several sub-criteria were considered.

In the present work, we have considered experiences of the customers at different points of interaction as the basis for evaluating the performance of banks. Of course, with cut-throat competition in the banking sector, differentiation in products and services offered by various banks exists at a finer level which, in most of the cases, is incomprehensible for the common customers. The authors feel that it is

important to take into account the viewpoints of both customers as well as banking personnel for identifying the broad dimensions of services offered by commercial banks for the ultimate purpose of evaluating the services of banks based on customer perception. The authors, after an initial interaction with some customers as also with a few senior banking personnel of some major commercial banks in India, came out with the following points of interaction (broad criteria) that the customers generally consider important while evaluating the services of their banks. They are—loan; new account opening; infrastructure; draft; deposit; withdrawal; and special services (Fig. 1).

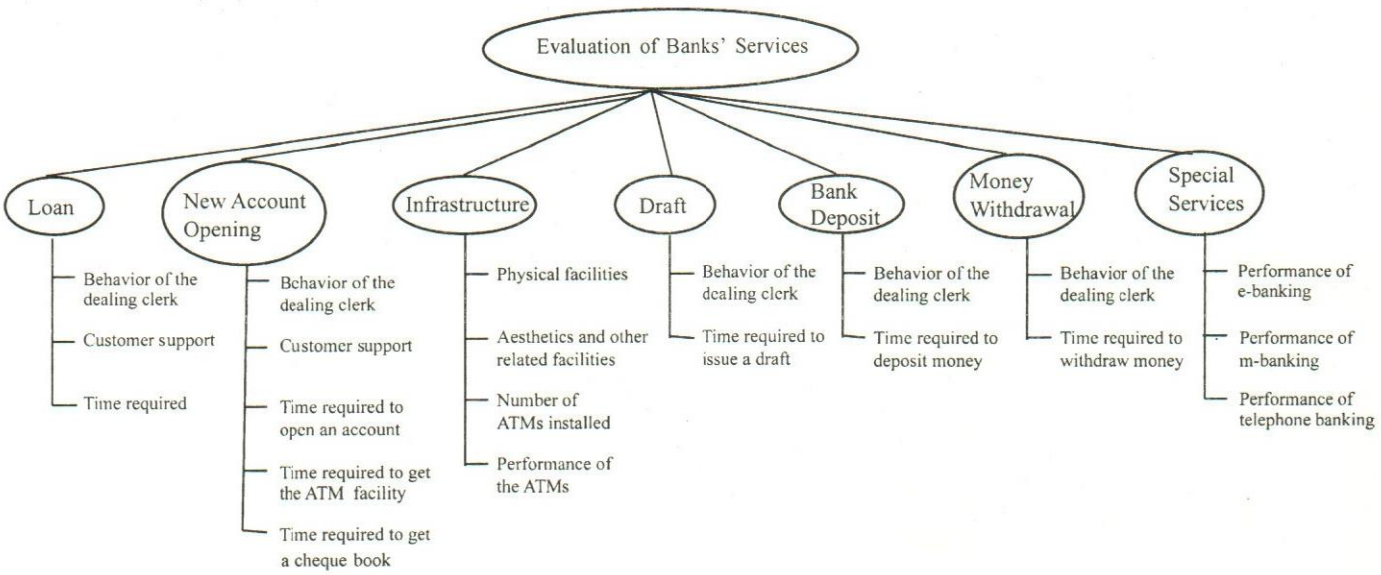


Fig. 1: Evaluation of Banks' Services

Customer's Perception and Fuzzy Numbers

It is evident from Fig. 1 that most of the criteria and sub-criteria used for evaluation of banks' services are highly subjective. Even for criteria on which banks are to be evaluated and can be measured otherwise, are to be assessed subjectively when customers' perception is used. The role of perceptions in human cognition and decision is well discussed by Zadeh (1999). He argued that for such situations quantifying perceptions with crisp numbers is inappropriate and, therefore, recommended the use of fuzzy set theory. Fuzzy approach has been applied in many multiple criteria decision making problem like, supplier selection (Amid et al., 2006; Chen et al., 2006; Dogan and Sahin, 2003; Kahraman et al., 2003), selection of the best main battle tank (Cheng and Lin, 2002), selection of location of a distribution center (Chen, 2001), and supply base reduction problem (Sarkar and Mohapatra, 2006). In the present work, the evaluation of the services of commercial banks has been carried out by applying fuzzy approach for handling the vagueness and imprecision associated with the measurement of various factors. The problem has been defined as follows: Based on the perception of a group of m customers ($E = \{E_1, E_2, ..., E_m\}$) a set of n banks ($B = \{B_1, B_2, ..., B_n\}$) has to be evaluated on a set of K criteria ($C = \{C_1, C_2, ..., C_K\}$). We also assume that each criterion k has a set of l_k number of sub-criteria, represented as ($C_k = \{C_{1_k}, C_{2_k}, ..., C_{l_k}\}$). The customers assign a fuzzy number for each sub-criterion representing their perception of the services of each bank. The customers may use linguistic variables for expressing their perception. Raj and Kumar (1998, 1999) and Sarkar and Mohapatra (2006) have used such linguistic variables for evaluation of river-basin planning alternatives and suppliers respectively. In the present work, we have used five linguistic variables in order to enable the customers to express their perception about the performance of the banks against each criterion and the relative importance of the same. We have assumed equal importance for all sub-criteria under a criterion. Table 1 shows the linguistic variables and their corresponding fuzzy numbers that are used in this paper for evaluating banks' services by the customers.

Table 1: Linguistic Variables and Corresponding Fuzzy Numbers

S. No.	Linguistic Values (For Banks)	Corresponding Fuzzy Numbers	Linguistic Values (For Criteria)
1	W = Worst	(0/0,1/2)	Least important
2	P = Poor	(0/1, 2/2)	Scarcely important
3	M = Average	(1/2, 3/4)	Somewhat important
4	G = Good	(3/3, 4/5)	Considerably important
5	B = Best	(4/5, 5/5)	Absolutely important

The full membership and no membership of a crisp number to a set are quantified either as 0 or 1, respectively. A fuzzy number, however, has a membership value to a set in the range [0, 1]. The membership function for a fuzzy number $\tilde{A}$ represented as (*a*/*b*, *c*/*d*) may be given as:

$$\mu_A = \begin{cases} 0, & x \le a \\ \dfrac{x-a}{b-a}, & a \le x \le b \\ 1, & b \le x \le c \\ \dfrac{d-x}{d-c}, & c \le x \le d \\ 0, & x \ge d \end{cases}$$

where *a*, *b*, *c*, and *d* are real numbers.

Let $\tilde{a}^k_{ij_k}$ be a fuzzy number assigned to the bank B_i by the customer E_j for the sub-criteria C_{lk}, where:

$$\tilde{a}^k_{ijl_k} = \left(\alpha^k_{ijl_k}/\beta^k_{ijl_k}, \gamma^k_{ijl_k}/\delta^k_{ijl_k}\right) \quad (1)$$

The customers' perception about the performance of the banks against criteria *k* may be expressed in a matrix form as:

$$R_k = \begin{array}{c} \\ B_1 \\ B_2 \\ . \\ . \\ . \\ B_n \end{array} \begin{array}{c} E_1 \quad E_2 \quad \ldots \quad E_m \\ \left\{ \begin{array}{c} \\ \tilde{a}^k_{ijl_k} \in £ \\ \\ \end{array} \right\} \end{array} \quad (2)$$

where, £ is the maximum length of the fuzzy scale used for taking opinion of the customers.

Similarly, $\tilde{c}^k_j$ represents the customers' perception about how much importance j[th] customer gives to the criterion k and is expressed as:

$$c^k_j = \left(\varepsilon^k_j/\zeta^k_j, \eta^k_j/\theta^k_j\right) \quad (3)$$

The relative importance of the criteria may also be represented in a matrix form as follows:

$$R = \begin{array}{c} \\ C_1 \\ C_2 \\ . \\ . \\ . \\ C_m \end{array} \begin{array}{c} E_1 \quad E_2 \quad \ldots \quad En \\ \left\{ \begin{array}{c} \\ c^k_j \in £ \\ \\ \end{array} \right\} \end{array} \quad (4)$$

Thus the problem of evaluating banks, addressed in this paper, is a multi-criteria decision making problem (MCDM).

Aggregation of Customer's Perception

Like in all MCDM problems, the individual opinions, expressed by the customers in respect of performance of banks against each criterion, are needed to be aggregated to obtain a single score representing an aggregate performance of each bank. As fuzzy numbers are used to capture customers' perception, we have to use some fuzzy method for aggregation of individual perceptions of the customers and final ranking of banks.

There are a large number of fuzzy methods available in the literature for evaluation of alternatives based on a set of criteria (for example, Aouam et al., 2003; Baas and Kwakernaak, 1977; Buckley, 1984; Chen, 2001; Cheng and Lin, 2002; Raj and Kumar, 1998, 1999). These methods have used fuzzy scores to capture the information related to the alternatives and criteria. These scores are aggregated for each alternative and then these aggregated scores are compared to rate the alternatives. Some of the fuzzy evaluation methods are: (i) weighted rating method (Baas

and Kwakernaak, 1977); (ii) fuzzy outranking method (Aouam et al., 2003); (iii) fuzzy Delphi method (Cheng and Lin, 2002); and (iv) fuzzy analytic hierarchy process (Kahraman et al., 2003). A very simple method for multiple criteria decision making problem is the weighted average method. Raj and Kumar (1998, 1999) have used the fuzzy set based weighted average method to rank river-basin planning alternatives.

All fuzzy MCDM methods use some defuzzification technique with a view to compare the final aggregated score for each alternative which is also a fuzzy number. A large number of techniques are available in the literature for comparing fuzzy numbers (Chen and Lu, 2001; Jain, 1976, 1977; Tran and Duckstein, 2002). In these methods the fuzzy numbers are defuzzified into a crisp number and comparisons are made based on these crisp values. Chen and Lu (2001) proposed a defuzzification method for comparing fuzzy numbers using the concept of right-and-left dominance. The right-and-left dominance estimates the difference in area for two fuzzy numbers from the membership axis to the right-and-left membership function. Tran and Duckstein (2002) proposed a fuzzy distance measure for ranking a set of fuzzy numbers.

Jain (1976, 1977) forwarded a new concept of maximizing set and right utility for comparing fuzzy numbers. However, Chen (1985) highlighting some shortcomings of the Jain's method, improved the definition of the maximizing set and also proposed the concept of minimizing set. He used both the concepts to find utility values for each fuzzy number and used these utility values to rank the fuzzy numbers. Raj and Kumar (1998, 1999) used Chen's method in ranking river-basin planning alternatives.

Considering its simplicity, we have also used the same method to evaluate banks' performance based on customers' perception. We assume equal relative importance of all sub-criteria under a criterion. The individual scores are first averaged across all experts for each sub-criterion; then these average scores are again averaged across all sub-criteria under each criterion to obtain the grand average score obtained by a bank against each criterion. The average scores obtained by each bank against each sub-criterion and criterion are calculated using the following equations:

$$\tilde{a}_{il_k}^k = (1/m) \otimes \left(\tilde{a}_{i1l_k}^k \oplus \tilde{a}_{i2l_k}^k \oplus \ldots \oplus \tilde{a}_{iml_k}^k \right) \quad (5)$$

$$\tilde{a}_i^k = (1/l_k) \otimes \left(\tilde{a}_{i1}^k \oplus \tilde{a}_{i2}^k \oplus \ldots \oplus \tilde{a}_{il_k}^k \right) \quad (6)$$

The average relative importance for each criterion is similarly calculated using Equation (7):

$$\tilde{c}^k = (1/m) \otimes \left(\tilde{c}_1^k \oplus \tilde{c}_2^k \oplus \ldots \oplus \tilde{c}_m^k \right) \quad (7)$$

The final aggregated score for each bank is obtained by using Equation (8):

$$f_i = (1/K£) \otimes \left\{ \left(a_1 \otimes c_1 \right) \oplus \left(a_2 \otimes c_2 \right) \oplus \cdots \oplus \left(a_K \otimes c_K \right) \right\} \quad (8)$$

The aggregated score $\tilde{f}_i$ obtained by using Equation (4) represents the weighted aggregated score for each bank and now the banks are ranked based on the ranking of $\tilde{f}_i$. As $\tilde{f}_i$ is also a fuzzy number, so a fuzzy ranking method has to be used for ranking $\tilde{f}_i$. The technical detail of obtaining the aggregated score and ranking them are given in the Appendix.

Case Study

The theoretical constructs developed earlier is utilized for ranking four banks operating in India based on the perception of their customers. For the sake of confidentiality, we refer to these banks as B_1, B_2, B_3, and B_4. As mentioned earlier, the authors have done extensive discussion with a large number of customers and bank officials before finalizing the criteria and sub-criteria which has already been depicted in Fig. 1. In order to capture customers' perception on the performance of these banks on various sub-criteria, a questionnaire is prepared and circulated among the customers. The 5-point scale given in Table 1 is employed for the use of customers who mention their perception about the performance of the banks. The responses from the customers were obtained during the period from February 2005 to April 2005 covering all the market segments. A total of 300 questionnaires were distributed out of which 232 questionnaires were received back. After an initial evaluation only 206 questionnaires were found to be valid. All respondents used linguistic variables for expressing their opinion. Using Table 1 we converted the linguistic variables into equivalent fuzzy numbers and used them for further calculations. Tables 2 and 3 show the average (across all customers) values of relative importance of each criteria and the scores obtained by each bank on each sub-criteria, respectively. As mentioned earlier, we have given equal importance to all sub-criteria under a criterion. Therefore, individual scores

Table 2: Relative Importance of the Criteria

S. No.	Criteria	Average Relative Importance
1	Loan	(2.32/2.96, 3.64/4.19)
2	New account opening	(2.77/3.34, 3.85/4.55)
3	Infrastructure	(2.97/3.52, 4,12/4.86)
4	Draft	(3.52/4.19, 4.55/4.86)
5	Deposit	(3.17/3.83, 4.29/4.71)
6	Withdrawal	(3.69/4.50, 4.72/4.93)
7	Special services	(2.32/3.01, 3.70/4.12)

Table 3: Performance of Banks (Average Score of Each Sub-criteria)

Criteria	Sub-criteria	Performance of the Bank Average Score on Each Sub-criteria			
		B1	B2	B3	B4
Loan	Behavior	(1.65/2.33, 2.91/4.00)	(1.46/2.17, 3.17/4.02)	(1.27/2.00, 2.97/3.75)	(1.57/2.22, 2.90/3.87)
	Customer support	(1.51/2.03, 2.98/3.63)	(1.48/3.15, 3.41/3.67)	(1.19/1.89, 2.83/3.43)	(1.31/1.94, 2.87/3.39)
	Time required	(1.30/1.78, 2.57/2.80)	(1.52/2.00, 2.73/2.94)	(1.26/1.83, 2.60/2.80)	(1.42/1.84, 2.75/3.03)
Account opening	Behavior	(1.51/2.15, 3.11/3.85)	(1.85/2.11, 3.40/4.18)	(1.47/2.15, 3.13/3.92)	(1.52/2.20, 3.13/3.84)
	Customer support	(1.41/2.25, 3.34/4.98)	(1.64/2.35, 3.30/4.18)	(1.13/2.02, 3.00/3.86)	(1.25/2.11, 3.04/3.84)
	Time required to open an account	(1.04/1.41, 2.37/2.72)	(1.30/1.54, 2.66/3.05)	(1.26/1.55, 2.52/2.68)	(1.20/1.54, 2.47/2.81)
	Time required to get an ATM	(0.67/0.86, 1.80/1.96)	(0.75/0.95, 1.88/2.03)	(0.76/0.89, 1.84/2.02)	(0.81/1.00, 1.93/2.11)
	Time required to get a cheque book	(1.14/1.74, 2.63/3.06)	(1.15/1.77, 2.68/3.11)	(1.18/1.65, 2.55/2.94)	(1.36/1.86, 2.72/3.18)
Infrastructure	Physical facilities	(1.48/2.12, 3.04/3.75)	(1.52/2.07,3.07 3.92/)	(1.47/2.05, 2.97/3.65)	(1.61/2.25, 3.11/3.77)
	Aesthetics	(1.05/1.78, 2.70/3.18)	(1.00/1.73, 2.68/3.18)	(1.21/1.94, 2.81/3.28)	(1.34/2.04, 2.88/3.36)
	Number of ATMs	(1.01/1.75, 2.75/3.40)	(0.96/1.75, 2.75/3.45)	(1.21/1.81, 2.81/3.50)	(1.34/2.00, 2.95/3.61)
	Performance of ATM	(1.90/2.44, 3.34/4.01)	(1.98/2.28, 3.37/4.11)	(1.94/2.42, 3.28/3.92)	(1.86/2.40, 3.27/3.86)
Draft	Behavior	(1.19/1.97, 2.94/3.72)	(1.46/2.13, 3.10/3.89)	(1.37/2.05, 3.00/3.68)	(1.31/2.00, 2.93/3.62)
	Time required	(0.96/1.47, 2.38/2.74)	(0.96/1.37, 2.34/2.77)	(0.76/1.18, 2.16/2.55)	(0.79/1.27, 2.22/2.61)
Deposit	Behavior	(1.61/2.26, 3.18/3.91)	(1.82/2.29, 3.18/3.82)	(1.61/2.28, 3.19/3.91)	(1.45/2.15, 3.10/3.85)
	Time required	(0.61/1.09, 1.84/2.01)	(0.64/1.05, 1.98/2.20)	(0.55/0.92, 1.84/1.97)	(0.36/0.81, 1.68/1.81)
Withdrawal	Behavior	(1.63/2.27, 3.18/3.89)	(1.61/2.22, 3.15/3.91)	(1.37/2.05, 3.00/3.69)	(1.43/2.16, 3.05/3.76)
	Time required	(0.51/0.94, 1.84/2.01)	(0.86/1.32, 2.18/2.37)	(0.55/0.87, 1.79/1.92)	(0.47/0.61, 1.72/1.88)
Special services	Performance e-banking	(1.98/2.98, 3.47/3.79)	(2.21/2.69, 3.52/4.38)	(2.00/2.59, 3.48/4.24)	(2.07/2.69, 3.54/4.09)
	Performance m-banking	(1.03/2.01, 2.88/3.66)	(0.95/1.87, 2.85/3.63)	(1.03/1.93, 2.93/3.75)	(1.16/2.00, 3.00/3.83)
	Performance telephone -banking	(1.26/2.18, 2.91/3.53)	(1.02/1.77, 2.68/3.17)	(1.25/2.00, 2.94/3.58)	(1.58/2.25, 3.16/3.77)

Table 4: Performance of Banks (Average Score)

Criteria	Performance of the Bank Average Score			
	B1	B2	B3	B4
Loan	(1.48/2.04, 2.82/3.35)	(1.48/2.44, 3.11/3.54)	(1.24/1.90, 3.07/3.32)	(1.43/2.00, 2.84/3.43)
Account opening	(1.15/1.68, 2.65/3.31)	(1.15/1.68, 2.65/3.31)	(1.16/1.65, 2.61/3.08)	(1.30/1.74, 2.66/3.16)
Infrastructure	(1.36/2.03, 2.95/3.59)	(1.36/2.03, 2.95/3.59)	(1.46/2.10, 2.93/3.59)	(1.54/2.18, 3.05/3.65)
Draft	(1.08/1.72, 2.66/3.28)	(1.08/1.72, 2.66/3.28)	(1.07/1.67, 2.58/3.12)	(1.05/1.63, 2.58/3.12)
Deposit	(1.11/1.67, 2.51/2.96)	(1.11/1.67, 2.51/2.96)	(1.08/1.60, 2.52/2.94)	(0.91/2.08, 2.39/2.83)
Withdrawal	(1.07/1.61, 2.56/2.95)	(1.07/1.61, 2.56/2.95)	(0.96/1.46, 2.40/2.81)	(0.95/1.38, 2.38/2.82)
Special services	(1.43/2.39, 3.09/3.66)	(1.43/2.39, 3.09/3.66)	(1.43/2.17, 3.11/3.85)	(1.63/2.31, 3.23/3.89)

obtained in all sub-criteria under a criterion are averaged to obtain average scores for that particular criterion. The average scores obtained by each bank against each criterion are shown in Table 4.

Once we obtained the average scores of all criteria for each bank and the relative importance for each criterion, we use Equation A.1 through A.12 given in the Appendix to find out the aggregated score for each bank, and their total utility value. The final aggregated score for each bank as obtained by using Equation A.1 through A.6 are given as follows:

$f_1 = (0.730[0.084, 0.534]/1.348, 2.277/3.047\ [0.0546, -0.8105])$

$f_2 = (0780\ [0.078, 0.513]/1.372, 2.329/3.112\ [0.0538, -0.8302])$

$f_3 = (0.700\,[0.077, 0.501]/1.279, 2.255/2.974\ [0.0474, -0.772])$

$f_4 = (0.723\ [0.066, 0.456]/1.353, 2.24/2.997\ [0.052, -0.813])$

From the aggregated scores for the banks we can get the minimum and maximum values of the support formed by them as $x_{\min} = 0.700$ and $-x_{\max} = 3.112$. The various utility values for each bank are then calculated by using Equation A.12. The banks are finally ranked in order of decreasing utility values of the corresponding aggregated score and they are shown in Table 5. It is observed in Table 5 that the utility values for the banks are very close and these close utility values suggest that the Indian banking industry is highly competitive.

Table 5: Aggregate Score of Banks

Bank	X_{iR}	X_{iL}	U_i	Ranking
1	2.485	1.202	0.476	2
2	2.518	1.227	0.491	1
3	2.45	1.157	0.406	4
4	2.445	1.127	0.461	3

Conclusion

In the present study, the performance of few Indian commercial banks based on points of customer interaction is evaluated. A number of performance criteria at these points, where customers frequently interact, were identified through informal interview and discussion with the bank managers and customers. Most of these identified criteria are imprecise in nature and, in such an environment, fuzzy set theory is an excellent tool for measurement and analysis. Opinions were obtained from large number of customers in a 5- point Likert scale in order to evaluate the performance of these banks. Subsequently, these opinions were transformed into fuzzy number for the purpose of carrying out necessary computation. Finally, the utility values of all four banks were found out, which reflect the overall performance of the banks on all seven criteria. One of the interesting observations made in the case study is that the Indian banking industry is highly competitive in respect of its multifarious services.

APPENDIX

We define, $S = S_1 \cup S_2 \cup ... \cup S_n$, $x_{min} = \inf S$ and $x_{max} = \sup S$, $0 < w \leq 1$ for a set of fuzzy numbers $\tilde{A}_i$ $(i = 1, 2, ..., n)$ where S_i is support for the fuzzy number $\tilde{A}_i$. We also define the membership function of the maximizing set ($\tilde{f}_M$) and minimizing set ($\tilde{f}_m$) for this set of fuzzy numbers as:

$$\mu_{\tilde{f}_M}(x) = \begin{cases} w[(x - x_{min})/(x_{max} - x_{min})]^r & x_{min} \leq x \leq x_{max} \\ 0 & \text{Otherwise} \end{cases} \quad \text{A.1}$$

$$\mu_{\tilde{f}_m}(x) = \begin{cases} w[(x - x_{max})/(x_{min} - x_{max})]^r & x_{min} \leq x \leq x_{max} \\ 0 & \text{Otherwise} \end{cases} \quad \text{A.2}$$

We assume the membership function for the maximizing set and the minimizing set as linear by assuming r = 1. The left and right utility values for the fuzzy number A_i are then defined respectively as:

$$U_M(i) = \sup_x (\mu_{\tilde{f}_M}(x) \wedge \mu_{A_i}) \quad \text{A.3}$$

$$U_m(i) = 1 - \sup_x (\mu_{\tilde{f}_m}(x) \wedge \mu_{A_i}) \quad \text{A.4}$$

The symbol $\wedge$ represents intersection. The total utility value U_i for the fuzzy number A_i is now calculated as:

$$U_i = [U_M(i) + U_m(i)]/2 \quad \text{A.5}$$

The fuzzy numbers A_i (i = 1, 2, ..., n) are ordered based on their total utility value and the fuzzy number with the maximum value of utility value is ranked ahead of others. Let ε^k, ζ^k, η^k, θ^k and α_i^k, β_i^k, γ_i^k, δ_i^k, respectively be the averages across experts for relative weights of criteria and individual score for the banks then following Raj and Kumar (1998, 1999) the final aggregated score for the bank B_i is expressed as:

$$\tilde{f}_i = (\alpha_i[L_{i1}, L_{i2}]/\beta_i, \gamma_i/\delta_i[U_{i1}, U_{i2}]) \quad \text{A.6}$$

where;

$$\alpha_i = \left(\sum \alpha_i^k \varepsilon^k\right)/K\pounds, \quad \beta_i = \left(\sum \beta_i^k \zeta^k\right)/K\pounds,$$
$$\gamma_i = \left(\sum \gamma_i^k \eta^k\right)/K\pounds, \quad \delta_i = \left(\sum \delta_i^k \theta^k\right)/K\pounds \quad \text{A.7}$$

$$L_{i1} = \left\{\sum \left(\beta_i^k - \alpha_i^k\right)\left(\zeta^k - \varepsilon^k\right)\right\}/K\pounds \quad \text{A.8}$$

$$L_{i2} = \left[\sum \left\{\alpha_i^k \left(\zeta^k - \varepsilon^k\right) + \varepsilon^k \left(\beta_i^k - \alpha_i^k\right)\right\}\right]/K\pounds \quad \text{A.9}$$

$$U_{i1} = \left\{\sum \left(\delta_i^k - \gamma_i^k\right)\left(\theta^k - \eta^k\right)\right\}/K\pounds \quad \text{A.10}$$

$$U_{i2} = -\left[\sum \left\{\delta_i^k \left(\theta^k - \eta^k\right) + \theta^k \left(\delta_i^k - \gamma_i^k\right)\right\}\right]/K\pounds \quad \text{A.11}$$

The total utility value for Bank, B_i, is calculated using the following relation:

$$U_T(i) = \left[-U_{i2}/2U_{i1} - \left\{(-U_{i2}/2U_{i1})^2 + (X_{iR} - \delta_i)/U_{i1}\right\}^{1/2} + 1 + L_{i2}/2L_{i1} - \left\{(L_{i2}/2L_{i1})^2 + (X_{iL} - \alpha_i)/L_{i1}\right\}^{1/2}\right]/2 \quad \text{A.12}$$

where:

$$x_{max} = \sup_{1 \leq i \leq n}(\alpha_i)$$

$$x_{min} = \inf_{1 \leq i \leq n}(\delta_i)$$

$$X_{iR} = \left[2x_{min} - U_{i2}(x_{max} - x_{min})/U_{i1} + (x_{max} - x_{min})^2/U_{i1} - (x_{max} - x_{min})\left\{(-U_{i2}/U_{i1} + (x_{max} - x_{min})/U_{i1})^2 + 4(x_{min} - \delta_i)/U_{i1}\right\}^{1/2}\right]/2$$

and:

$$X_{iL} = \left[2x_{max} + L_{i2}(x_{max} - x_{min})/L_{i1} + (x_{max} - x_{min})^2/L_{i1} - (x_{max} - x_{min})\left\{(L_{i2}/L_{i1} + (x_{max} - x_{min})/L_{i1})^2 + 4(x_{max} - \alpha_i)/L_{i1}\right\}^{1/2}\right]/2$$

The alternatives are finally ranked in descending order of their corresponding utility values.

References

Aldlaigan, A.H. and Buttle, F.A. (2002), "SYSTRA-SQ: A New Measure of Bank Service Quality," *International Journal of Service Industry Management*, 13(4): 362–81.

Avkiran, N.K. (1999), "Quality Customer Service Demands Human Contact," *The International Journal of Bank Marketing*, 17(2), 61–71.

Babakus, E. and Boller, G.W. (1992), "An Empirical Assessment of the SERVQUAL Scale," *Journal of Business Research*, 24: 253–68.

Buckley, J. J. (1984), "The Multiple Judge, Multiple Criteria Ranking Problem: A Fuzzy Set Approach," *Fuzzy Sets and Systems*, 13: 25–37.

Chen, C.T. (2001), "A Fuzzy Approach to Select Tthe Location of the Distribution Centre," *Fuzzy Sets and Systems*, 118: 65–73.

Chen, S.H. (1985), "Ranking Fuzzy Numbers with Maximizing Set and Minimizing Set," *Fuzzy Sets and Systems*, 17: 113–29.

Chen, C.T., Lin, C.T. and Huang, S.F. (2006), "A Fuzzy Approach for Supplier Evaluation and Selection in Supply Chain Management," *International Journal of Production Economics*, 102: 289–301.

Chen, L. and Lu, H. (2001), "An Approximate Approach for Ranking Fuzzy Numbers Based on Left and Right Dominance," *Computer and Mathematics with Applications*, 41: 1589—1602.

Cheng, C. and Lin, Y. (2002), "Evaluating the Best Main Battle Tank Using Fuzzy Decision Theory with Linguistic Criteria Evaluation," *European Journal of Operational Journal*, 142: 174–86.

Cronin, J.J. and Taylor, S.A. (1992), "Measuring Service Quality: A Re-examination and Extension," *Journal of Marketing*, 56(July): 55–68.

Dogan, I. and Sahin, U. (2003), "Supplier Selection Using Activity-Based Cosing and Fuzzy Present Worth Techniques," *Logistics Information Management*, 16(6): 420–26.

Gronroos, C. (1978), "A Service-Oriented Approach to Marketing of Services," *European Journal of Marketing*, 18(4): 36–44.

Gronroos, C. (1993), "Towards a Third Phase in Service Quality Research: Challenges and Future Directions," in T.A. Swartz, S.W. Bowen, and S.W. Brown (eds) *Advances in Services Marketing and Management*, pp. 49–64. JAI Press, Greenwich, CT: JAI Press.

Jain, R. (1976), "Decision Making in the Presence of Fuzzy Variables," *IEEE Transactions Systems Man and Cybernetics*, 6: 698–703.

Jain, R. (1977), "A Procedure for Multi-Aspect Decision Making Using Fuzzy Sets," *International Journal of Systems Science*, 8: 1–7.

Kahraman, C., Cebeci, U. and Ulukan, Z. (2003), "Multi Criteria Supplier Selection Using Fuzzy AHP," *Logistics Information Management*, 16(6): 382–94.

Lai, Y.J. and Hwang, C.L. (1994), *Fuzzy Multiple Objective Decision Making Methods and Applications*. Berlin: Springer-Verlag.

Mihelis, G. et al. (2001), "Customer Satisfaction Measurement in the Private Bank Sector," *European Journal of Operational Research*, 130: 347–60.

Newman, K. (2001), "Interrogating SERVQUAL: A Critical Assessment of Service Quality Measurement in a High Street Retail Bank," *International Journal of Bank Marketing*, 19(3): 126–39.

Oliver, R.L. (1980), "A Cognitive Model of the Antecedents and Consequences of Satisfaction Decisions," *Journal of Marketing Research*, 17(November): 460–69.

Oliver, R.L. (1997), *Satisfaction: A Behavioral Perspective on the Consumer*. New York: McGraw Hill.

Parasuraman, A., Zeithmal, V.A., and Berry, L.L. (1985), "A Conceptual Model of Service Quality and Its Implications for Future Research," *Journal of Marketing*, 49(Fall): 41–50.

Parasuraman, A., Zeithmal, V.A., and Berry, L.L. (1988), "SERVQUAL: A Multiple-Item Scale for Measuring Customer Perceptions of Service Quality," *Journal of Retailing*, 64(1, Spring): 12–40.

Raj, P. A. and Kumar, D. N. (1998), "Ranking Multi Criteria River Basin Planning Alternatives Using Fuzzy Numbers," *Fuzzy Sets and Systems*, 100: 89–99.

Raj, P. A. and Kumar, D. N. (1999), "Ranking Alternatives with Fuzzy Weights Using Maximizing Set and Minimizing Set," *Fuzzy Sets and Systems*, 105: 365–75.

Sarkar, A. and Mohapatra, P.K.J. (2006), "Evaluation of Suppliers Capability and Performance: A Method for Supply Base Reduction," *Journal of Purchasing and Supply Management*, 12(3): 148–63.

Siskos, Y., Grigoroudis, E., Zopounidis, C., and Saurais, O. (1998), "Measuring Customer Satisfaction Using a Collective Preference Disaggregation Model," *Journal of Global Optimization*, 12: 175–95.

Tran, L. and Duckstein, L. (2002), "Comparison of Fuzzy numbers using a fuzzy Distance Measure," *Fuzzy Sets and Systems*, 130: 331–41.

Zadeh, L.A. (1999), "From Computing with Numbers to Computing with Words—From Manipulation of Measurements to Manipulation of Perceptions," IEEE Transactions on Circuit and Systems—I: Fundamental Theory and Applications, 45 (1): 105–19.

Zadeh, L.A. (1965), "Fuzzy Sets," *Information and Control*, 8: 338–53.

Zimmerman, H.J. (1983), "Using Fuzzy Sets in Operational Research," *European Journal of Operational Research*, 13(3): 201–16.

"Every time you are tempted to react in the same old way, ask if you want to be a prisoner of the past or a pioneer of the future."

— Deepak Chopra

Growth of Bank Deposits and its Determinants: A Pragmatic Study on Commercial Banks

Jaynal Ud-din Ahmed

Commercial banks are highly sensitive organizations open to public security; they must continuously ensure their profitability, which is essential for their growth and viability as also for infusing public confident. Thus, banks have assumed greater responsibilities in mobilizing domestic resources for financing the priorities of the economy. The resource mobilization is an integral part of banking activity. Bank deposit has certain peculiar features which combine the cannons of liquidity, profitability, and security. The present paper is an attempt to evaluate the growth of deposit mobilization of banks and its determinants in Barak valley region of Assam in the context of national scenario. For this purpose 16 commercial banks operating in the region have been considered over a period of 11 years, that is, 1997 to 2007 on the basis of statistical and financial tools.

Jaynal Ud-din Ahmed is Reader at the Department of Management, North Eastern Hill University, Tura Campus, Chandmari–794002, Tura, Meghalaya.

Introduction

Banking system in India being the dominant segment of financial sector, accounts for a major portion of fund flow. Banks are the vehicles for monetary policy signals, credit channel, and facilitator of payment system. Deepening and widening of the financial markets, growing disintermediation process, adoption of modern technology, rising customer expectation, innovative financial services and scheme supplement with suitable credit delivery mechanism and challenges for which banks would be required to reorient their organizational structure and modify their strategies. Commercial banks are highly sensitive organizations open to public security and as such, they must continuously ensure their profitability, which is essential for their growth and viability as also for infusing public confident. Thus, banks have assumed greater responsibilities in mobilizing domestic resources for financing economic priorities. Deposit mobilization is the most important function of commercial banks. Among different sources of funds available to the banks, deposit mobilization is the mainstay of bank liabilities (Desai, 1971). The successful functioning of banks depends on their ability to mobilize deposits.

Deposit mobilization is a significant indicator of bank's performance. The basic principle of bank branch expansion is to tap deposit and culminate savings habit of the community. Further, tapping of potential savings and marshalling them for strategic uses for productive purposes in particular is the main objective of bank's nationalization. As a result various schemes were launched over the years. Under the 20-point program (1975), the government directed the banks to make all possible efforts to access new deposits that can only expedite the pace of lending activities. The financial sector reform (Government of India, 1991) also highlighted the need for

growth of financial savings and their efficient channelization into industrial activity (Khanna, 1999). There has been a substantial rise of bank deposits since nationalization. The aggregate deposits of scheduled commercial banks during 2006–07 grew by 24.6% as compared to 17.8% in 2005–06. The bank deposit as % of GDP at current prices rose from 53.5% in 1999–2000 to 70.1% in 2006–07. The amount of deposit per office increased dramatically during post-reform era from Rs 0.56 crores in June 1969 to Rs 12.55 crores in March 2000, and further to Rs 36.75 crores in March 2007. This indicated the efficiency of banking sector in mobilizing deposits from the economy as a whole.

In the changing scenario of commercial banking in liberalized era, the importance of efficiency has assumed a critical significance for the viability of banks particularly in the backward regions of the country. This scenario poses the vital question as to whether the performance of commercial banks in terms of growth of deposits is up to the desired extent in backward areas. The present work is an attempt to evaluate the growth of deposit mobilization of banks and its determinants in Barak Valley region of Assam in the context of national scenario.

A Background Highlight

The bank nationalization witnessed a fantastic achievement in the banking system through the expansion of bank branches. The establishments of more rural branches undoubtedly have served the twin objective of mobilization of rural deposits and channelization of credit to the rural areas. However, the pace of acceleration of deposit mobilization depends on the economic and industrial infrastructures of higher magnitude as well as creating greater awareness among rural populace for effective use of bank credit. Otherwise rural deposit would continue to be siphoned off to urban centers (Raul, 1997, pp. 111, 112). Therefore, the credit absorption capacity in the rural areas largely depends on the availability of required infrastructure.

The number of commercial banks in the country as a whole declined from 300 in 2000–01 to 183 in 2006–07, but there is a quantum fly of number of bank offices from 7,015 on June 1969 to 67,868 in 1999–2000 and further to 73,836 in March 2007. The share of rural bank offices declined to 41.4% in 2006–07 from 49.9% in 1999–2000 which indicates the neglected approach of expansion of banking activities in backward regions. The entire branches of banks in India are yet to equip with computer technology which ultimately leads to lower productivity and increase in transaction cost. As in March 2007, fully computerized branches constituted 42.2% and branches under core banking solution was 44.3% to total branches in India (Reserve Bank of India, 2007). The deposits of scheduled commercial banks as a percentage of national income increased from 15.5% in 1969 to 22.4% in 1975 and further to 49.7% in March 1999. The bank deposits have increased by 11 times during 1991–2006, that is, from Rs 192,540 crores in 1990–91 to Rs 2,109,050 crores in 2005–06. The bank advances also registered a robust growth of 30.6% during 2006–07 as compared to 33.3% in 2004–05.

Studies on Deposit Performance of Banks

There have been many studies conducted dealing with resource mobilization of commercial banks both in India and abroad. A brief review of these literatures is highlighted in the following paragraphs to highlight the importance of the study. This section starts with a survey of some overall studies on bank's efficiency in various operational aspects at the global level.

Zazzaro and Lucchetti (2001) offered a methodological contribution to the empirical analysis of the relationship between banking and economic growth by suggesting a new indicator for the state of development of the banking system based on a measure of bank's microeconomic efficiency. This new approach is then applied to analyze the relationship between the banking system and economic growth in the Italian regions, through a dynamic panel technique. There exists some cross country studies on financial health of banks. The recessions cause banking crisis studied by Hardy and Pazarbasioglu (1999) and Kaminsky and Reinhart (1999). Salas and Saurina (2002) established the significant role of economic slump in increasing loan problem in Spanish banks. Shu (2002) observed that bad loans as a proportion to total loans of banks decrease with high economic growth in Hong Kong. Recently, some studies investigated the feedback effect from the banks to the real economy. Hoggarth et al. (2005) observed cyclicality of aggregate write-offs in UK banks. Qayyum and Khan (2006) investigated empirically the efficiency, scale economies, and technological progress of commercial banks operating in Pakistan. They observed that that the domestic banks operating in Pakistan are relatively less efficient than their foreign counterparts.

In Indian context, Desai (1971) viewed that deposits are the basis for commercial bank's fund and accounts for around 98% of bank liabilities. Battacharya (1985)

studied implications of bank deposit mobilization and opined that the ability of banks to play developmental role depends on mobilization of deposits. Rangarajan (1991) pointed out that improving the quality of loan assets is the true test of improved efficiency of banking system. Malhotra (1991) examined the nature and efficacy of banking instruments and suggested that with the emergence of various savings media, banks should diversify their product and develop instruments for meeting the requirements of borrowers, investors, and savers.

Narasimham Committee (1991) identified the weakness of banking sector and recommended provision for capital adequacy, liberalization of interest rate, reduction in SLR, rehabilitation of banks by the government, introduction of prudential norms relating to income recognition, asset classification, and provisioning, easy norms for entry of foreign bank, etc.

Raju and Sasikumar (1994) studied the growth of deposits of commercial banks in Kerala in the national scenario since nationalization. They found that the state Kerala was lagging behind in terms of deposit mobilization, but it shed little light on the identification of determinants of deposits. Sengupta (1995) in his paper examined the impact of financial sector and economic reforms in India in the context of financial market imperfection. The study pointed out that the banks will have to move step-by-step decision to reach the goal through trial and error in the practical world. Kohli (1997) observed the existence of significant linkages between bank credit and investment in both agriculture and industries in India. He suggested that although direct credit program for priority sector lending is effective in India, affirmative support to small-scale units is required. Satish and Gopalakrishna (1997) suggested that systematic manner of bank operation will ensure the viability of rural banking. Khanna (1999) highlighted the need for growth of financial savings and their efficient channelization into industrial activity. Joshi (1999) in his paper viewed that banking sector reforms has been over emphasized on profits neglecting distributive role of banks. Strong and high net worth companies within the organized sector are capable of raising funds at a considerable rate of interest while credit disbursal to small borrowers has sharply been declined. Hugar (1998), analyzing the first phase of reform, found that with the introduction of reform packages, banks have improved their profitability, started cleaning their balance sheet, and improved the NPA position, but they are yet to give more focus on rationalizing cost structure. Srivastava (2000) stressed on speed of the process of computerization of bank branches to enhance the profitability, operating efficiency, and to diversify the earning base.

In an increasingly integrated global economy, Ravi (2002) stressed the introduction of branch rationalization policy for bringing down loss-making branches of banks. He also suggested continuous stress should be given on reducing deposit costs and burden, manpower re-deployment of loss-making branches. Kapoor (2004) highlighted that the performance of banks in the eve of the second-generation reform was U-turn due to the preparedness of banks to meet worldwide competition. Ahmed and Raul (2005) observed the impact of the significant changes owing to the onset of economic liberalization program which occurred in banking practices. Rao (2007) examined the performance of commercial banks with some established parameters like, business per branch, operating profit per branch, return on assets, return on equity, credit deposit (C/D) ratio, etc. Choudhury (1984) dealt with the reasons and consequences of growth of commercial banks during the undivided Cachar district in the post-nationalization phase. The study sheds little light on bank's performance in terms of growth of deposit.

From the review of these earlier studies it is revealed that not many studies are based exclusively on the deposit mobilization of commercial banks. Most of the studies narrated the deposit related performance and the determinants of banks efficiency. However, the studies relating to the mobilization of deposits and its determinants remained un-researched in the study area.

The Background of Commercial Banks in the Study Area

The Barak valley comprised of three districts, namely, Cachar, Karimganj, and Hailakandi of south Assam. The economy of the valley had been a periphery to the economic mainstream of Bengal during the British rule. The partition of the country in the wake of independence and the consequent emergence of East Pakistan (now Bangladesh) not only had shattered the traditional cheapest and quickest lines of transport and communication, but also had snapped the age-old channels of trade, commerce, and transactions. The post-independence phase did not adequately compensate the valley for all the loss inflicted on it by partition.

The institutional finance is essential for the socio-economic development of an area. But unfortunately, the rate of growth of flow of institutional finance in the valley

has not shown significant rise. The valley has 12.5% of the total bank offices of state Assam. At present, 12 public sector banks, one regional rural bank, and three private banks are operating with a network of 147 branches. Cachar district is bestowed with 72 branches (51 public sector banks, 19 RRBs, and two private banks) while Karimganj district has 52 branches (32 public sector banks, 17 RRBs, and three private banks). Whereas 12 branches (13 public sector banks, eight RRBs, and two private banks) in Hailakandi district are taking care of banking activities (GoA, 2005).

The growth performance of banks in the area under study in the national scenario has been summarized on the basis of parameters as presented in Table 1.

reflected in the C/D ratio. It slipped to 19.3% in 2007, from 38.6% in 1991 in the context of the national average which increased from 54.2% in 1991 to 55.8% in 1999 and further a noteworthy increase to 73.5% in 2007.

Apart from this, the process of computerization which is a starting point of technological initiatives, has been reaching in a very slow rate in the branches of banks in the districts. Only 10% of the total bank branches are fully computerized and a few, that is, very negligible fraction of bank branches under core banking solution (United Bank of India, 2007). As on today only State Bank of India has ATM facilities in the area. The RBI has been encouraging banks to use technology-based solutions for increased financial inclusion. Credit delivery in rural areas

Table 1: Performance of Banks in Barak Valley vis-à-vis India

S.No.	Performance Indicators	Barak Valley			All India Average		
		1991	1999	2007	1991	1999	2007
1	Number of commercial banks	13	15	15	272	298	183
2	Branch expansion of banks (number)	140	140	149	60,646	67,868	73,836
3	Population served per office ('000)	29,100	37,800	40,000	14,000	15,000	16,000
4	Total deposits (Rs in crores)	233.94	457.72	1,391.91	201,199	607,268	2,608,309
5	Deposit per branch (Rs in crores)	2.72	8.95	15.3	3.34	14.50	36.75
6	Total advances (Rs in crores)	91.25	125.12	313.72	105,524	261,279	1,928,913
7	Advances per branch (Rs in crores)	1.06	1.69	2.8	2.02	6.53	27.57
8	C/D ratio	38.6	20.8	19.3	54.2	55.8	73.5

Sources: Figures for March compiled and computed from:

(i) Basic Statistical Returns, Reserve Bank of India, Mumbai

(ii) Lead Bank Offices of the region, United Bank of India

It has been observed that during 1991, population that served per branch at all India average was 15,000, which raised to 16,000 in March 2007. The same has increased to 40,000 in December 2007 from 29,100 in 1991 in the study area. The deposits per branch are far behind the national level. The absolute figures were Rs 2.72 crores in 1991, Rs 8.95 crores in 1999, and Rs 15.3 crores in 2007. During the period 1991–2007 deposits per office in the districts increased by seven times in contrast to 11 times increase in the country as a whole. On the other hand, the advances per branch in the districts remain low than that of the national level. The net result of discrepancies is expensive for banks with large number of small accounts. Thus, information technology enabled method being the best alternative for rural credit delivery can reduce the cost of delivery. But unfortunately the process of computerization and IT methods are extremely narrow in the area under study.

Objectives of the Study

With this backdrop the researcher is ventured with an evaluation of deposit performance of commercial banks in a backward region. For this purpose commercial banks operating in three districts have been considered over a

period of 12 years, that is, 1997 to 2007, on the basis of statistical and financial tools. The specific objectives are:

1. To study the extent of mobilization of bank deposit in the districts under study.
2. To examine the relationship between the growth of deposits and growth of advances of banks.
3. To identify the factors influencing the growth of deposits in backward areas.

Hypotheses Framed

The following operational hypotheses have been framed to meet these objectives of the study:

1. There exists close correlation of deposit mobilization per branch between the districts and the national level over the years.
2. There is no difference in the growth of incremental deposit as well as incremental credit.
3. The economic position has a direct bearing on the deposit mobilization of commercial banks.

Methodology Adopted

The entire study is based on the secondary data. The sources of secondary data are financial statements compiled by the regional offices of the banks operating in the study area, RBI bulletins, lead bank statements, Directorate of Economic and Statistics, various reports, surveys, published and unpublished research papers, and dissertations. In order to study the extent of deposit mobilization, correlation matrix between incremental deposits of study area and the incremental deposits of the country as a whole has been considered. The correlation coefficient between the deposit per office and advances per office has been used to assess the relationship between growth of deposits and advances. The following multiple regression model has been fitted on the independent variables, viz.namely, Gross Domestic Product (GDP) at current prices, index of consumer prices, interest rate on deposit, and branch expansion to identify the determinants of deposit mobilization of banks:

$$Y_t = \beta_1 + \beta_2 X_1 + \beta_3 X_2 + \beta_4 X_3 + \beta_5 X_4 + U_t$$

where:

Y_t is the deposit mobilization of bank

X_1 the GDP at current prices

X_2 Index of consumer prices

X_3 Interest rate on deposit

X_4 bank branch expansion

U_t is the error term

β_1 is the intercept

β_i (i = 1,2,3 .....5) is the regression coefficients

Deposit Mobilization of Commercial Banks: The Analysis

Bank Group-wise Deposit Mobilization

The resource mobilization is an integral part of banking activity. The bank deposit has certain peculiar features which combine the cannons of liquidity, profitability, and security. Deposits are the most secure and liquid financial assets available to an investor and it can accelerate banks lending to various sectors. The government directed the banks to make all possible efforts to access new deposits which can only expedite the pace of lending activities. There has been a substantial rise of bank deposits during the period under consideration. The extent and volume of deposit mobilization an important parameter of banking performance is presented in Table 2.

It has been observed that in December 1997, the total bank deposits relating to all banks in Barak valley stood at Rs 32,608 lakhs of which PSBs accounted only 88.3% against the national average of 82.8%. This suggests that deposit mobilization in the valley maintained the same pace as in the all-Indian level. The percentage share of PSBs deposit however increased from 88.3% in December 1997 to 91.6% in December 2007. During, 1997–2007, total bank deposits of the valley increased by 4.27 times against 3.70 times at national level. The performance of private banks and regional rural banks in the growth of deposit mobilization is not up to the mark. The percentage share of deposits of private banks remains around 6% during the period. The scene of deposit culture of private banks in the districts is reverse against all India shares of private banks' deposits which have declined to 4.7% in December 2007 from 6.2% in 1997. However, it has increased to 14.3% in 2004–05 from 3.5% in 1984-85 at the national level.

A comparison of growth of bank deposits may be made by compound growth rate (Cgr) during 1997–2007. This can further be verified with coefficient of variation (Cv). The growth of deposits of PSBs during the period (Cgr = 35.8) was better than the growth of deposits in private banks

Table 2: Deposits of Commercial Banks in Barak Valley (1997–2007) (in Rs Lakhs)

Year as on December	Public Sector Banks			Assam Gramin Vikas Bank	Private Sector Banks	Total Commercial Banks
	SBI Group	Nationalized Banks	Total			
1997	8,781 (26.9)	20,417 (62.6)	29,198 (88.3)	1,353 (4.5)	2,053 (6.2)	32,608 (100)
1998	10,939 (28.6)	23,757 (62.2)	34,696 (89.9)	1,561 (5.1)	1,885 (5.9)	38,142 (100)
1999	13,018 (28.7)	27,806 (61.7)	40,824 (88.1)	2,252 (6.1)	2,696 (5.9)	45,772 (100)
2000	15,334 (29.3)	30,822 (59.0)	46,156 (88.3)	3,311 (6.3)	2,735 (5.7)	52,202 (100)
2001	17,310 (28.1)	38,834 (61.2)	56,144 (88.9)	3,864 (6.0)	3,604 (6.1)	63,612 (100)
2002	22,997 (28.9)	47,581 (59.7)	70,578 (89.1)	4,841 (6.1)	4,189 (5.9)	79,608 (100)
2003	26,637 (28.0)	56,646 (59.5)	83,283 (87.5)	6,736 (7.1)	5,105 (5.4)	95,124 (100)
2004	27,319 (24.9)	68,713 (62.7)	96,032 (87.7)	7,213 (6.5)	6,209 (5.6)	10,,454 (100)
2005	29,424 (25.7)	78,923 (63.9)	108,347 (89.6)	8,753 (5.4)	7,452 (4.3)	124,552 (100)
2006	28,790 (25.0)	76,087 (59.9)	104,877 (86.7)	10,984 (7.2)	7,908 (6.1)	123,769 (100)
2007	36,462 (29.8)	81,246 (65.8)	117,708 (91.6)	13,242 (3.7)	8,241 (4.7)	139,191 (100)
Cgr	**21.3**	**26.9**	**35.8**	**42.9**	**34.3**	**26.8**
Cv	**36.6**	**47.7**	**41.3**	**48.3**	**38.9**	**45.1**

Note: Figures in the parentheses indicate percentage to total deposit.

Source: Lead Bank Office, United Bank of India, Cachar, Karimganj and Hailakandi districts.

(Cgr = 34.3). It could thus be inferred from the analysis that the reform measures introduced following Narasimham committee recommendations have played little in mobilizing deposits in the area under study.

Deposits and Advances per Branch

The underlined principle of branch expansion is to mobilize more deposit. The banks in this respect have been mobilizing rural savings and culminated the savings habit of rural masses. Table 3 furnishes the district-wise position of the growth of deposit per office and advances per office. The deposit per branches of banks turned out to be Rs 264.9 lakhs, Rs 309.1 lakhs, and Rs 531.4 lakhs for Karimganj, Cachar, and Hailakandi districts, respectively in 1997. The same has swelled to Rs 1,487.9 lakhs, Rs 1,678.5 lakhs, and Rs 1,784.2 lakhs for Karimganj, Cachar, and Hailakandi districts, respectively in 2007. The notable feature revealed from the analysis of bank deposit performance is that the districts have witnessed significant growth rate in deposit per office despite all impediments. This shows a close interaction of bank personnel and rural population during the reform era. However, in this respect, the banks of the area under study failed to maintain national trend. The districts are yet to catch up the state's average deposit per office as in March 1999. In 1997 the deposit per office in India was Rs 797 lakhs, which increased to Rs 2,265 lakhs in 2004, and further to Rs 3,675 lakhs in 2007. Thus, additional bank branches under lead bank scheme have taped the deposits from rural masses as well as the population of the districts as a whole and also endeavored to cultivate the savings habit among them.

Commercial bank credit is an important input variable in the production function of agriculture, industry, commerce, and allied productive activities for the socio-economic development of the country. Apart from the quantum of bank credit, its development, composition, and direction are equally important in the realization of the country's various macroeconomic goals. The growth of advances measured in terms of advances per branch

Table 3: District-wise Deposits per Branch and Aadvances per Branch (in Rs Lakhs)

Year	Deposit Per office (Rs)				Advances Per Office (Rs)		
	Karimganj	Cachar	Hailakandi	All India	Karimganj	Cachar	Hailakandi
1997	264.9	309.1	531.4	797	93.4	96.7	220.9
1998	300.6	360.9	665.7	898	97.9	106.2	224.2
1999	392.1	451.6	734.9	1,098	105.8	124.8	257.2
2000	395.3	491.2	749.2	1,255	104.0	133.4	262.5
2001	405.3	631.5	973.7	1,456	89.6	140.6	273.0
2002	521.1	757.8	1,137.1	1,659	115.8	165.1	283.3
2003	605.3	921.8	1,269.0	1,925	91.2	188.2	302.7
2004	817.2	1,024.1	1,354.2	2,265	109.5	206.2	433.1
2005	980.1	1,290.7	1,450.3	2,574	115.9	287.0	499.6
2006	1,097.7	1,523.0	1,597.4	3,047	168.4	302.7	573.0
2007	1,487.9	1,678.5	1,784.2	3,675	196.0	379.3	583.4

Source: Lead Bank Office, UBI, Cachar, Karimganj and Hailakandi districts.

operating in the districts is far behind the national level credit per office during 1997–2007. Moreover, the districts except Hailakandi are yet to catch up the state's average credit per office as in March 1999 (North-Eastern Institute of Bank Management, 1999).

Further, an attempt has been made to assess the relationship between growth of deposits of banks both in the national level and that in the study area. We employ in this respect the analysis of correlation coefficient between incremental deposits per office of banks in India and incremental deposits per office in the districts under study, namely, Karimganj, Cachar, and Hailakandi during the period under consideration. The matrix of "r" value is presented in Table 4. The econometric analysis reveals that correlation coefficient in the districts under study and national level in respect of incremental deposit is statistically significant at 5% level of significance. This indicates the banks in the district under study are mobilizing deposit over the years at par with the national level. The correlation coefficient of inter district deposit mobilization, on the other hand, shows that banks in the districts are performing well even at the same pace of inculcating the saving habit of the population. Thus, a further analysis is required in respect of the factors influencing growth of deposit of banks.

Inter-relationship between Growth of Deposits and Growth of Advances

Now banks' performance in terms of growth of deposit per office and advances per office has been measured by using correlation coefficient (r) pertaining to the period under consideration. The high correlation coefficient will undoubtedly indicate more savings habit of the people as well as higher volume of credit deployment in the district. The results obtained are presented in Table 5.

The analysis explores the existence of high positive "r" value for all districts under study. However, "r" value appeared to be statistically significant for Cachar district and significant only at 1% level of significance for Karimganj and Hailakandi districts. These highlight that the performance of banks in respect of deposit mobilization and credit deployment is not satisfactory. The analysis also reveals an inter-district credit gap as well as variation in the deposit mobilization during the aforesaid period. On the other hand, insignificant correlation coefficient implies that there is a scope of expediting the pace of banking operation in the districts under study.

Table 4: Correlation Coefficient of Incremental Deposit per Office between the Districts and India

	All India	Karimganj	Cachar	Hailakandi
All India	1.00			
Karimganj	0.818*(3.762)	1.00		
Cachar	0.852*(4.305)	0.493(1.499)	1.00	
Hailakandi	0.801*(3.540)	0.751*(2.999)	0.690*(2.524)	1.00

Notes:* indicates 5% level of significance.

Figures in parentheses indicate "t" value.

$t_{0.05}$ (10df) = 1.812

Table 5: Correlations between Deposits per Office and Advances per Office

'r'	't' value (cal)	't' value (tab)	
		1%	5%
r_k = 0.544	1.813 *	2.764	1.812
r_c = 0.7	1.111 **	2.764	1.812
r_H = 0.71	2.851 *	2.764	1.812

Notes: K = Karimganj; C = Cachar; H = Hailakandi.

* Significant at $t_{.01}$

** Significant at $t_{.01}$ and $t_{.05}$

The aforesaid analysis implies that the banks in the study area do not deploy credit at the same rate as they have mobilized from the area. This indicates the siphoning of fund from the area of the study to the other region. Further, this has been confirmed by the analysis of C/D ratio that majority of banks in the study area has not attained the C/D ratio of 60% stipulated at the national level. C/D ratio is considered as dependable indicator of efficiency of bank's participation in the developmental process. It indicates the extent of bank deposits advanced to multifarious activities in the area. Nambiar (1980) articulated that low credit absorption capacity due to low infrastructural facilities in the area particularly in "No industrial region" is the main hurdle of increasing in C/D ratio. The commercial banks, financial institutions along with developing and implementing authorities of the area, can only take a challenge against the congenital impediments to sustain the economic development of that area. C/D ratio is not an unbiased indicator since it depends on two variables—total deposits and total advances. It has been observed that banks may have to grant advances to the beneficiaries through several government sponsored schemes. In this case with the increase of advances, the C/D ratio will increase with the deposit variable remaining constant. Sikidar (1990, p. 160) has aptly viewed that the C/D ratio should be looked into its segment and disaggregated forms and for extending advances the sources of fund are deposits, refinance from higher financial institution, and accretion of profit. The C/D ratios of banks can be viewed from Table 6.

It is evident from Table 6 that the districts under study have failed to achieve national average of C/D ratio over the years. The reason of significant declining of the C/D ratio in the area under study may be attributed to non-recovery of loans, willful defaulters, lack of supervision of end use of bank credit, lack of implementation of bankable schemes, and so on. This exhibited poor credit absorption capacity of the entire area along with lack of entrepreneurial zeal to undertake viable projects.

Table 6: District-wise C/D Ratio (End of March) (Ratios in percentage%)

Districts	1999	2000	2001	2002	2003	2004	2005	2006	2007
Karimganj	48.9	35.8	34.5	21.3	22.0	19.8	20.0	18.7	19.0
Cachar	30.7	31.5	30.2	22.9	22.6	20.0	19.8	22.3	20.1
Hailakandi	43.2	36.8	32.7	21.8	20.5	23.1	21.9	20.1	18.9
Barak valley	38.6	36.9	32.3	22.3	20.8	20.1	20.9	19.5	19.3
India	54.2	56.7	59.2	57.3	55.8	55.9	62.6	70.1	73.5

Sources: (i) Lead Bank Office, UBI, Cachar, Karimganj, and Hailakandi districts.
(ii) Report on the Trend and Progress of Banking in India, various issues.

Table 7: Regression Summery of Independent Variables

Variables	β	"t" value	Sig.	F	R^2	Adjusted R^2
β 0 (constant)	–	-0 .423	0.683			
GDP at current prices (Gdp)	0.928	5.963	0.000	102.691		
Index of consumer prices (Indc)	0.009	0.098	0.924	(000[a])	0.979	0.969
Interest rate on deposit (Intd)	-0.137	-1.614	0.141	Sig.		
Branch expansion (Br)	0.121	0.588	0.571			

Note: Significant at p = 0.05.

Determinants of Deposit Mobilization of Commercial Banks

Deposit mobilization is the basic pointer of performance of commercial banks. However, the pace of growth of deposit received by the bank is influenced by several factors. We, in this respect have considered the factors like GDP, index of consumer prices, interest rate on deposit, and branch expansion on the basis of the established literature and works on this field. To study the inter-dependency among the variables we have fitted regression equation which is found to be:

Y (Deposit) = – 9614. 632 + 4411E-02 Gdp + 0.407 Indc – 1691.538 Intd + 254.852 Br

SE. (22756.221) (007) (4.131) (1048.337) (433.177)

The other results obtained are presented in Table -7. The analysis shows that $R^2 = 0.979$. This indicates about 98% variations in the deposit mobilization of commercial banks in the districts under study is explained by independent variables. It is further confirmed by F-ratio that turns to be statistically significant. This implies the independent variables like branch expansion, interest rate on deposit, and GDP are perfect determinants of dependent variable, namely, deposit mobilization. However β (beta) value of each of the independent variables is statistically not significant at 5% level of significance except GDP at current prices indicating that variables have no direct impact on deposit mobilization in the study area. In other words, it can be argued that growth of bank deposit is very much subjective and only depends on economic condition of the society.

References

Ahmed, J.U. and Raul, R.K. (2005), *Public Sector Banks in India: Impact of Financial Sector Reforms*. New Delhi: Kalpaz Publications.

Battacharya, B.N. (1985), *Regional Behaviour of Bank Deposits and its Implications to Deposit Mobilizations*. Pune: National Institute of Bank Management.

Choudhury, S. (1984), "*Growth of Commercial Banking in Cachar and its Impact of the District with Special Reference to Nationalized Banks*," PhD dissertation, Guwahati University.

Desai, Vasant (1971), *Indian Banking. Nature and Problems*. Bombay: Himalaya Publishing House.

Government of Assam (2005), *Statistical Hand Book*. Assam: Directorate of Economics and Statistics.

Government of India (1991), *Report of the Committee on Financial System*, December, Ministry of Finance.

Hardy, D.C. and Pazarbasioglu (1999), "Determinants and Leading Indicators of Banking Crisis: Further Evidence," *IMF Staff Papers*, 46(3).

Hoggarth, G., Sorensen, S. and Zicchino, L. (2005), "Stress Tests of UK Banks Using a VAR Approach, Bank of England," Working Paper No. 282, pp. 1–44.

Hugar, R.S. (1998), "Challenges to the Banking Industry," *The Indian Institute of Bankers*, pp. 157, 158.

Joshi, P.N. (1999), "Banking Sector Reforms: The Other Side of Coin," *Economic and Political Weekly*, XXXIV(14): 797–98.

Kaminsky, G.L. and Reinhert, E.S. (1999), "The Twin Crisis: The Causes of Banking and Balance of Payment Problems," *American Economic Review*, 89, available at http:// home.gwu.edu/graciela

Kapoor, G.P. (2004), *Commercial Banking*. New Delhi: APH. Publishing Corporation.

Khanna, S. (1999), "Financial Reforms and Industrial Sector in India," *Economic and Political Weekly*, p. 3239.

Kohli, R. (1997), "Directed Credit and Financial Reforms," *Economic and Political Weekly*, October 18.

Lucchetti, R. and Zazzaro, A. (2001), "Banks' Inefficiency and Economic Growth: A Micro-Macro Approach," *Scottish Journal of Political Economy*, Scottish Economic Society, 48(4, September): 400–24.

Malhotra, R.N. (1991), "Banking in the 90's," *Financial System of India*, 1: 1–4.

Nambiar, P.C.D. (1980), "Banking Policy; Which Direction," *Commerce*, September 20, Vol. 13.

North-Eastern Institute of Bank Management (1999), Guwahati, Assam.

Office of Lead District Manager, United Bank of India, Silchar, Assam.

Qayyum, A. and Khan, S. (2006), "X-efficiency, Scale Economies, Technological Progress and Competition of Pakistani's Banks," MPRA Paper 2654, University Library of Munich, Germany.

Raju, G. and Sasikumar, K. (1994), *Growth of Deposits of Commercial Banks: A Comparative Study of Kerala with All India,* in Nair (ed.), *Recent Trends in Banking*.

Rangarajan, C. (1991), "Banking Development since 1947; Achievement and Challenges," *Financial System in India*, Vol. II.

Rao, D.S. (2007), "Reforms in Indian Banking Sector: Evaluation Study on the Performance of Commercial Banks," *Finance India*, XXI(2, June): 591–97.

Raul, R.K. (1997), *Industrial Finance in India*. New Delhi: Anmol Publications.

Ravi, K. (2002), "Rationalizing Bank Branches; Some Issues," *IBA Bulletin*, (March): 66–72.

Reserve Bank of India (2006–07), *Trend and Progress of Banking in India*.

Salas, V. and Saurina, J. (2002), "Credit Risk in Two Institutional Regime: Spanish Commercial and Saving Banks," *Journal of Financial Services Research*, 22(3):203–24.

Satish, P. and Gopalakrishna, C.K. (1997), "Viability of Rural Banking," *Economic and Political Weekly*, pp. 2711–16.

Shu, C. (2002), *The Impact of Macro Economic Environment on the Asset Quality of Hong Kong's Banking Sector,* Hong Kong Monetary Authority, available at http://www.bis.org/pub/

Sikidar, S. (1990), E*conomic Development of Tribal India*. New Delhi: Ashish Publishing House.

Sengupta, A. (1995), "Financial Sector and Economic Reforms in India," *Economic and Political Weekly*, January 7, 39–43.

Srivastava, R. (2000), "Computerization in Indian Banks," *Banking Finance*, February.

"A mind that is stretched to a new idea never returns to its original dimension."

— Oliver Wendell Holmes

Focus

Productivity Performance of State Co-operative Apex Banks in India: An Analytical Study of Northern Region

S.S. Chahal and Vijay Singh Hooda

Co-operative banking in India has an extensive network as compared to that in regional rural and commercial banks. Co-operative banks are playing a significant role in disbursement of credit and mobilizing savings through various types of banks at different levels. But there is a need to evaluate the performance and strengthen these institutions in the eyes of financial inclusion concept. The present paper is an attempt to disclose the real position of state co-operative banks' productivity of the northern region in India. Because productivity is linked with profitability, higher the productivity, proportionately lower will be the establishment cost. The study reveals that the Chandigarh State Co-operative Bank has shown better performance in terms of deposits per employee and deposits per branch. Haryana State Co-operative Bank (HARCO Bank) has topped with highest Average Compound Growth Rate (ACGR) in terms of advances per employee, business per employee, and business per branch. Himachal Pradesh State Co-operative Bank has shown average performance, while Jammu & Kashmir and Rajasthan State Co-operative Banks have shown poor performances among the selected banks considering all parameters. It may be suggested that the policy makers of these banks may consider productive compensation plan which should be matched with performance measures.

Dr S.S. Chahal is Professor at the Department of Commerce, M.D. University, Rohtak, Haryana and Vijay Singh Hooda is Research Scholar at the Department of Commerce, M.D. University, Rohtak, Haryana.

Introduction

In India, the co-operatives are the most suitable instrument for socio-economic development of the rural economy. It has a network of approximately 0.59 million societies which cover 100% of villages co-operative institutions which have made significance progress in various important sectors of the Indian economy. In the prevailing liberalized economic environment with emphasis on globalization, it is being recognized that the success of co-operative movement is dependent on the productive employment of available resources like employees, financial resources, and fixed assets and premises, etc.

The Rural Short-term Co-operative Credit Structure comprises State Co-operative Banks (StCBs) at the state level (apex), District Central Co-operative Banks (DCCBs) at district level, and Primary Agricultural Credit Societies (PACS) at village level. As on March 2007, there were 31 StCBs (with 938 branches), 371 DCCBs (with 12,928 branches), and a total of 97,224 PACS.

State co-operative banks also known as apex banks, finance, co-ordinate, and control working of the DCCBs in each state. The StCBs are playing a significant role at being the linkage between Reserve Bank of India (RBI) at the top and bottom. The main function of an apex bank is to balance the financing of the movement in its area, serving as a clearing house for the cheques, rediscounting commercial papers, advancing loans, and making advances to central co-operative banks. StCBs (apex banks) are the main constituents of Short-term Rural Credit co-operatives. They provide short-term and medium-term loans for agricultural as well as non-agricultural purposes. They mobilize the deposits through various attractive schemes. They are playing a significant role in income generation,

employment generation, and uplifting the standard of living of their beneficiaries.

Co-operative banking in India has an extensive network as compared to other commercial banks. Co-operatives are playing a significant role in disbursement of credit and mobilizing savings through various types of banks at different levels. But there is a need to strengthen and evaluate the performance of these institutions in the eyes of financial inclusion concept. StCB, an apex institution in each state, decides, formulates, and controls the functioning of co-operative bank in its respective state within the supervision of NABARD. To strengthen the StCBs, it is essential to measure and analyze the productivity of these banks. Because productivity is linked with profitability, higher the productivity, proportionately lower will be the establishment cost. Keeping this view in the mind, the present study is undertaken as an attempt to disclose the real position of StCBs' productivity in the competitive environment.

Review of Literature

Many studies have been conducted to analyze the efficiency and productivity of banking system using various approaches, some of these studies are:

- Bhattacharya et al. (1996) examined the relative performance of commercial banks under three different kinds of ownership (public, private, and foreign) during the post-deregulation period.
- Prashanta Athma and Pramadwara Sriniwas (1997) analyzed the productivity of commercial banks in their research paper. They found that productivity showed a rise in all three bank groups though it was relatively higher in the case of private sector foreign banks.
- Kumbhakar and Sarkar (2002) examined the relationship between deregulation, ownership, and total factor productivity growth of public and private sector banks over the period of 1986–96.
- Cheema and Aggarwal (2002) examined the productivity in commercial banks. They considered that productivity is a measure to know whether the resources or inputs have been used efficiently or not. Their study showed that the commercial banks operating in India are below the level of efficiency.
- Naidu and Nair (2003) analyzed the technical efficiency of commercial banks between the pre- and post-reforms periods. They concluded that a technical efficiency level among banks of this group has declined in the post-reform period, indicating the enhanced competition among banks.
- Usha Arora and Richa Verma (2005) analyzed the operational and productivity efficiency of public sector banks in India in their research paper. They studied the relative efficiency of public sector banks from 1991–92 to 2003–04. They proved that Corporation Bank ranks highest in operational and productivity parameters, which results in higher efficiency while Indian Bank ranks lowest in this regard.
- Karampal and Puja Goyal (2008) analyzed the cross relationship among various components of productivity like earning per employee, business per employee, and profit per employee for public, private, and foreign sector banks within Indian banking industry. They concluded that public sector banks are growing with consistent pace and intra-group variations are also less than other sectors. They concluded that private and foreign sector banks are showing significant relation between earnings per employee and profits per employee.

Most of the studies were undertaken for measuring the productivity and operational parameters of the commercial banks, but no one has studied the growth of co-operative banks on the basis of productivity parameters. This paper examines the productivity of StCBs of the northern region in India.

Conceptual Framework of Productivity in Banking Industry

Productivity is at the heart of economic growth and development, improvement in standards of living, and quality of life. A sound financial infrastructure is prerequisite for economic development. The financial institutions can be sound if they achieve higher levels of productivity. The entire exercise of financial sector reforms is aimed at improving profitability by improving efficiency and productivity. In general, productivity is the relationship between the outputs and inputs of an organization, this is usually stated as:

$$\text{Productivity} = \frac{\text{Output}}{\text{Input}}$$

This ratio describes how efficiently the resources should be utilized. Higher productivity means accomplishing more resources or achieving higher output in terms of volume and quality for the same input. Productivity indices are very useful in intra-firm and inter-firm comparisons. That is

why productivity measurement should be the first priority for any productive improvement managers at organization as well as national level. But there are many difficulties in measuring productivity in service industries where quality of service assumes greater importance. In case of banks, the distinction between input and output is not clear. But productivity in banks can be measured in terms of the outputs (like deposits and advances) per inputs (like employees and branches).

Objectives

To achieve the main objective of evaluating the performance of StCBs of the northern region in India, some sub-objectives are:

- To measure the productivity of selected StCBs in terms of employees.
- To measure the productivity of selected StCBs in terms of branches.
- To make a comparison between the productivity among the selected StCBs and rank the banks by considering different variables.

Research Methodology

Research Design

To measure the productivity of StCBs is analytical in nature because the researcher needs to use all the secondary data that could be available to him.

Sample Size

There are 31 StCBs in India. National Federation of State Co-operative Banks Ltd, Mumbai, categorizes these banks in five regions—central, eastern, western, northern, and north-eastern regions. The northern region consists of:

1. The Chandigarh State Co-operative Bank Ltd.
2. The Haryana State Co-operative Apex Bank Ltd.
3. The Himachal Pradesh State Co-operative Bank Ltd.
4. The Jammu & Kashmir State Co-operative Bank Ltd.
5. The Punjab State Co-operative Bank Ltd.
6. The Rajasthan State Co-operative Bank Ltd.

All these six StCBs have been taken into consideration for conducting the present study.

Hypothesis

To cover these objectives, the following hypotheses have been formulated:

H_1: There is no significant difference between the growth rates of business per employee of StCBs of northern region in India during the study period.

H_2: There is no significant difference between the growth rate of business per branch of StCBs of northern region in India during the study period.

Data Collection

The present research paper is based on secondary data collected from websites of National Federation of State Co-operative Banks Ltd., Mumbai and annual reports of the banks under study.

Variables Studied

The productivity performance has been measured in terms of the following parameters:

1. Deposits per employee.
2. Advances per employee.
3. Business per employee.
4. Deposits per branch.
5. Advance per branch.
6. Business per branch.

Statistical Tools Applied

Besides averages and percentages, Average Compound Growth Rate (ACGR) and Friedman Test (non-parametric) are used to give the study an analytical shape.

ACGR:

$$Y = ab^t$$

where:

Y = Dependent variables (like deposits/advances per employee)

a = constant

b = slope of trend lines (growth rates)

t = time

Friedmen's Statistic:

$$F = \frac{12}{nk(k+1)} \times \left(\sum_{j=1}^{k} R_j^2 \right) - 3n(k+1)$$

where:

n = number of years

k = number of sample

R_j = total of ranks assigned to the sample during "n" years

Time Period

The study period is taken from 2002–03 to 2006–07 (five years).

Analysis and Interpretation

Productivity in Terms of Employees

Deposits per employee

Table 1 reveals the performance of StCBs in terms of deposits per employee. As per this parameter, Rajasthan State Co-operative Bank has shown the highest deposit average in terms of absolute amount, that is, Rs 479.32 lakhs while Chandigarh Bank has shown the lowest mean amount of deposits per employees. But, in terms of ACGR, Chandigarh State Co-operative Apex Bank holds the first rank with 8.66% ACGR, whereas Punjab and Rajasthan State Co-operative Banks stand jointly at the fifth spot with 3.86% ACGR.

Table 1: Deposits per Employee of StCBs: 2002–03 to 2006–07

(as on 31 March) (Rs in lakh)

Name of Bank	2002–03	2003–04	2004–05	2005–06	2006–07	Mean	ACGR	Rank
Chandigarh	120.51	153.07	138.72	135.54	182.55	146.08	8.66	1
Haryana	160.43	192.71	197.20	215.97	222.20	197.71	6.73	2
Himachal Pradesh	136.98	150.78	173.75	213.66	180.73	171.18	5.70	3
J & K	128.80	128.80	157.41	163.43	163.43	148.37	4.88	4
Punjab	291.35	185.81	189.51	214.15	239.27	224.02	3.86	5.5
Rajasthan	403.21	440.54	510.88	554.71	487.25	479.32	3.86	5.5

Source: Compiled from NAFSCOB Report.

Advances per employee

As is evident from Table 2 Haryana State Co-operative Apex Bank has achieved 17.25% ACGR to occupy the highest rank whereas at 3.77 ACGR, Jammu & Kashmir State Co-operative Bank occupies the lowest rank among the selected banks. But in terms of the average amount of advances per employee, Rajasthan State Co-operative Bank is on the top with Rs 640.47 lakhs. The lowest position held from this angle is by Chandigarh State Co-operative Bank with Rs 17.71 lakhs per employee.

Business per employee

As per this parameter, as seen in Table 3, Rajasthan State Co-operative Bank has shown the best performance with Rs 1,119.79 lakhs' average amount of business per employee while Chandigarh State Co-operative Bank is the worst with a low average of Rs 163.79 lakhs per employee during the same period. Haryana State Co-operative Bank has achieved 13.52% ACGR to occupy the highest rank followed by Chandigarh State Co-operative Bank with 9.18% growth rate. Jammu & Kashmir State Co-operative bank is at the bottom with 4.77% ACGR.

Table 2: Advances (Outstanding) per Employee of StCBs: 2002–03 to 2006–07

(as on 31 March) (Rs in lakh)

Name of Bank	2002–03	2003–04	2004–05	2005–06	2006–07	Mean	ACGR	Rank
Chandigarh	13.80	12.76	15.61	20.55	25.82	17.71	13.35	3
Haryana	241.88	317.29	373.30	440.73	536.09	381.86	17.25	1
Himachal Pradesh	38.06	56.92	58.25	59.53	80.61	58.67	16.19	2
J & K	31.60	31.60	37.46	39.02	39.02	35.54	3.77	6
Punjab	332.68	369.86	429.97	456.03	586.88	435.08	12.02	4
Rajasthan	452.01	528.60	684.50	770.70	766.55	640.47	11.14	5

Source: Compiled from NAFSCOB Report.

Table 3: Business (Deposits + Advances) per Employee of StCBs: 2002–03 to 2006–07

(as on 31 March)

(Rs in lakh)

Name of Bank	2002–03	2003–04	2004–05	2005–06	2006–07	Mean	ACGR	Rank
Chandigarh	134.31	165.83	154.33	156.09	208.37	163.79	9.18	2
Haryana	402.31	510.00	570.50	656.70	758.29	579.56	13.52	1
Himachal Pradesh	175.04	207.70	232.00	173.19	261.34	229.85	8.35	3
J & K	160.40	160.40	194.87	202.45	202.45	184.11	4.77	6
Punjab	624.03	555.67	619.48	670.18	826.15	659.10	5.77	5
Rajasthan	855.22	969.14	1,195.38	1,325.41	1,253.80	1,119.79	7.95	4

Source: Compiled from NAFSCOB Report.

Branch-wise Productivity

Deposits per branch

Three parameters have been considered to justify the extent of branch expansion. Table 4 reveals the productivity of StCBs in terms of deposits per branch. As per this parameter, Rajasthan State Co-operative Bank has shown the highest average amount with Rs 8,081.72 lakhs followed by HARCO Bank with Rs 7,932.83 lakhs. But highest ACGR is shown by Chandigarh State Co-operative Bank shows the highest ACGR at 10.92%; the lowest ACGR among the six StCBs is that of Jammu & Kashmir State Co-operative Bank (3.01%).

Table 4: Deposits per Branch of StCBs: 2002–03 to 2006–07

(as on 31 March)

(Rs in lakh)

Name of Bank	2002–03	2003–04	2004–05	2005–06	2006–07	Mean	ACGR	Rank
Chandigarh	743.17	1,046.00	947.92	926.17	1,247.42	982.24	10.92	1
Haryana	6,783.86	7,983.86	7,902.21	8,376.50	8,618.07	7,932.83	4.90	4
Himachal Pradesh	907.68	993.68	1,055.31	1,255.57	1,269.86	1,096.42	6.95	2
J & K	1,423.95	1,423.95	1,696.56	1,651.47	1,651.47	1,569.48	3.01	6
Punjab	4,688.09	5,168.86	5,383.64	5,246.67	5,782.29	5,253.91	4.28	5
Rajasthan	7,084.93	7,300.36	8,137.57	8,558.36	9,327.36	8,081.72	5.65	3

Source: Compiled from NAFSCOB Report.

Table 5: Advances (Outstanding) per Branch of StCBs: 2002–03 to 2006–07

(as on 31 March)

(Rs in lakh)

Name of Bank	2002–03	2003–04	2004–05	2005–06	2006–07	Mean	ACGR	Rank
Chandigarh	85.08	87.17	106.67	140.42	176.42	119.15	15.70	2
Haryana	10,228.14	13,444.64	14,959.79	17,094.21	20,792.57	2,611.07	15.25	3
Himachal Pradesh	249.81	375.11	353.80	349.83	566.41	378.99	17.79	1
J & K	349.33	349.33	403.72	394.26	394.26	378.18	2.45	6
Punjab	49,889.60	10,288.82	10,851.46	11,172.83	14,183.00	11,277.14	7.48	5
Rajasthan	7,942.50	8,759.64	10,903.14	11,890.79	14,673.93	10,834	13.06	4

Source: Compiled from NAFSCOB Report.

Advances per branch

Table 5 shows the advances per branch of six StCBs during 2003–07. It reveals that the highest average amount is that of Punjab State Co-operative Bank, that is, Rs 11,277.14 lakhs. The second highest average amount, which is Rs 10,834 lakhs, is of Rajasthan State Co-operative Bank. Himachal Pradesh State Co-operative Bank has achieved 17.79% ACGR to occupy the highest rank followed by Chandigarh State Co-operative Bank with 15.70%. The lowest growth rate, 2.45%, is held by Jammu & Kashmir State Co-operative Bank.

Business per branch

As per this parameter, HARCO Bank has performed well in terms of absolute average amount as well as in terms of growth rate. The average amount of business of HARCO bank is Rs 23,238.5 lakhs while its ACGR is 11.57% followed by Chandigarh State Co-operative bank with 11.44% ACGR. The lowest average amount of business per branch (Rs 1,109.29) is depicted by Chandigarh State Co-operative Bank. Jammu & Kashmir State Co-operative Bank has shown the lowest ACGR (2.90%) as per this parameter.

Productivity can be measured with the help of various indicators. In the present paper, six parameters have been used to analyze the productivity of selected StCBs. Ranks are assigned to the banks on the basis ACGR according to the six parameters. An effort has also been made to measure the aggregate productivity of selected banks on the basis of ranks assigned to banks. Smaller total rank shows higher productivity and vice-versa. Table 7 reveals that Chandigarh State Co-operative Bank has attained the total ranking figure of 11 to reach the highest overall rank followed by HARCO Bank. Himachal Pradesh, Rajasthan, and Punjab State Co-operative Banks hold the third, fourth, and fifth positions, respectively. The productivity of Jammu & Kashmir State Co-operative Bank is the lowest among the selected banks.

Table 6: Business (Deposits + Advances) per Branch of StCBs: 2002–03 to 2006–07

(as on 31 March) (Rs in lakh)

Name of Bank	2002–03	2003–04	2004–05	2005–06	2006–07	Mean	ACGR	Rank
Chandigarh	828.25	1,133.17	1,054.59	1,066.59	1,423.84	1,101.29	11.44	2
Haryana	17,012.00	21,438.14	22,861.00	25,470.71	29,410.64	23,238.5	11.57	1
Himachal Pradesh	1,157.49	1,368.79	1,409.11	1,605.40	1,836.27	1,475.41	9.67	4
J & K	1,773.28	1,773.28	2,100.28	2,045.73	2,045.73	1,947.66	2.90	6
Punjab	14,577.69	15,457.68	16,235.10	16,419.50	19,965.29	16,531.05	6.49	5
Rajasthan	15,027.43	16,060.50	19,040.71	20,449.15	24,001.29	18,915.82	9.82	3

Source: Compiled from NAFSCOB Report.

Table 7: Ranks assigned to State Co-operative Banks on the Basis of Various Variables: Composite Productivity (Total Productivity Index)

(as on 31 March) (Rs in lakh)

Name of Bank	2002–03	2003–04	2004–05	2005–06	2006–07	Mean	ACGR	Rank
Chandigarh	1	3	2	1	2	2	11	1
Haryana	2	1	1	4	3	1	12	2
Himachal Pradesh	3	2	3	2	1	4	15	3
J & K	4	6	6	6	6	6	34	6
Punjab	5.5	4	5	5	5	5	29.5	5
Rajasthan	5.5	5	4	3	4	3	24.5	4

Source: Compiled from results derived in foregoing tables.

Growth Rates of Business per Employee and per Branch of StCBs of Northern Region: Friedman's Test

To test the hypothesis, Friedman's Test has been used. It is a non-parametric test. This test requires less restrictive assumptions concerning the level of data measurement. It is used whenever the number of sample is greater than or equal to 3 (say k). The Friedman's test statistic is:

$$F = \frac{12}{nk(k+1)} \times \left(\sum_{j=1}^{k} R_j^2 \right) - 3n(k+1)$$

In order to calculate the "F" values for this study, ranks are assigned for the growth rates of per employee/branch amounts of business (deposits + advances) of different StCBs of northern region in India. This has been used in the following sequence:

$$F = \frac{12}{4 \times 6\,(6+1)} (13^2 + 19^2 + 15^2 + 12^2 + 11^2 + 14^2) - 3 \times 4\,(6+1)$$

$$= \frac{12}{24\,(7)} (169 + 361 + 225 + 144 + 121 + 196) - 12 \times 7$$

$$= \frac{12}{168} (1216) - 84b = 86.86 - 84 = 2.86$$

Table 8: Business per Employee of StCBs of Northern Region: Friedman's Test Growth Rate of Business per Employee

Year	Chandigarh	Haryana	Himachal Pradesh	J & K	Punjab	Rajasthan	Total Rank (Row Total)
2002–03	–	–	–	–	–	–	–
2003–04	23.47 (5)	26.77 (6)	18.66 (4)	0 (2)	-10.96 (1)	13.22 (3)	21
2004–05	-6.94 (1)	11.86 (4)	11.70 (3)	21.49 (5)	11.48 (2)	23.34 (6)	21
2005–06	1.14 (1)	15.11 (5)	17.75 (6)	3.89 (2)	8.18 (3)	10.88 (4)	21
2006–07	33.49 (6)	15.47 (4)	-4.34 (2)	0 (3)	23.27 (5)	-5.40 (1)	21
Total Rank (Column Total)	**13**	**19**	**15**	**12**	**11**	**14**	**84**

Table 9: Business per Branch of StCBs of Northern Region: Friedman's Test Growth Rate of Business per Branch

Year	Chandigarh	Haryana	Himachal Pradesh	J & K	Punjab	Rajasthan	Total Rank (Row Total)
2002–03	–	–	–	–	–	–	–
2003–04	36.82 (6)	26.02 (5)	18.27 (4)	0 (1)	6.72 (2)	6.88 (3)	21
2004–05	-6.94 (1)	6.64 (4)	2.95 (2)	18.44 (5)	5.03 (3)	18.56 (6)	21
2005–06	1.14 (3)	11.42 (5)	13.93 (6)	-2.60 (1)	1.14 (2)	7.40 (4)	21
2006–07	33.50 (6)	15.47 (4)	14.38 (3)	0 (1)	3.32 (2)	17.34 (5)	21
Total Rank (Column Total)	**16**	**18**	**15**	**8**	**9**	**18**	**84**

$$F = \frac{12}{4 \times 6 (6+1)} (16^2 + 18^2 + 15^2 + 8^2 + 9^2 + 18^2) - 3 \times 4 (6+1)$$

$$= \frac{12}{168} (256+324+22566+64+81+324) - 84$$

$$= \frac{12}{168} (1274) - 84$$

$$= 91 - 84 = 7$$

It is inferred from Table 10 that the calculated value of "F" for the growth rates of per employee and per branch amount of business of StCBs are lower than the table value of x^2 (11.07 at 5% level and 15.09 at 1% level of significance). Hence, from both hypotheses, it can be seen that there is no significant difference in the growth rates of per employee as well as per branch during the period under study. It is also concluded that per employee performance of business as well as per branch performance of business granted by HARCO Bank is best among the selected StCBs during the study.

Table 10: Results of Friedman's Test

Grow Rate of	Calculated Value of F	D.F.	Value of x^2	Result
Business per employee	2.86	5	11.07 (15.09)	Not significant
Business per branch	7	5	11.07 (15.09)	Not significant

Conclusions

The business of all selected StCBs are growing with low to high growth rate in general particularly:

- In terms of deposits per employee and deposits per branch, the Chandigarh State Co-operative Bank has shown better performance among the banks under study.
- HARCO Bank has topped with highest ACGR in term of advances per employee, business per employee, and business per branch. But on the basis of remaining parameters, it has shown average performance.
- Himachal Pradesh State Co-operative Bank has achieved the first, second, third, and fourth ranks on the basis of advances per branch, advances per employee and deposits per branch, deposits per employee and business per employee, and business per branch, respectively.
- Jammu & Kashmir, Punjab, and Rajasthan State Co-operative Banks have shown poor performance among the selected banks in case of all parameters.
- Considering overall productivity of the selected banks, Chandigarh State Co-operative Bank Ltd has topped and is followed by HARCO Bank.

Suggestions

To improve the productivity of employees in particular and productivity of branches in general, policy makers may consider the following improvements:

- The StCBs need to greatly improve their efficiency through introduction of computer, that is, electronic banking technology and improved management skills.
- The policy makers of these banks may consider productive compensation plan which should be matched with performance measures which have been already discussed.
- The banks must study their present process of operations, which they have been following for years in the light of international standards.
- Most of the bank employees face job dissatisfaction because their job is monotonous. They have to handle the same type of job day in and day out. If the seating arrangement of employees is interchanged from time to time, it will reduce frauds and increase their potential.
- In order to motivate employees, a more positive approach for reward is called for.
- Regular meeting between staff and managers should be conducted at a regular interval.
- Inefficiency in delivering the service to customers has a direct bearing on the bank's success. Therefore, all possible efforts should be need to motivate the employees to deliver their best. It is necessary that employees should be empowered so that they feel more involved in increasing the productivity and serving customers better.

References

Arora, Usha and Verma, Richa (2005), "An Analysis of Operational and Productivity Efficiency of Public Sector Banks in India," *Productivity*, 46(2–3, July–December): 384–90.

Ketkar, Kusum W., Noulas Athanasios, G., and Agarwal, Man Mohan (2003), "An Analysis of Efficiency and Productivity Growth of the Indian Banking Sector," *Finance India*, XVII(2): 511–13.

National Federation of State Cooperative Banks Ltd (NAFSCOB) (2003–07), Basic Data.

Pal, Karam and Goyal, Pooja (2008), "Productivity Performance of Banking Industry in India," *Asian Economic Review*, 50(2, August): 249–68.

Subbiah, A. (2000–01), "Comparison of Growth Rates of Per Employee Amounts of Deposits and Advances of Commercial Banks in India," *Prajnan*, XXIV(2): 165–71.

"Take calculated risks that is quite different from being rash."

— George S. Patton

Sources of Finance and Productivity: A Study of Unorganized Manufacturing Sector in India

Pradip Kumar Biswas and Indranil Biswas

Unorganized manufacturing sector of India is found to operate under increasing returns to scale despite the industries being predominantly traditional in nature. Scarcity of capital compels this sector to operate at a sub-optimal level. Scheduled commercial banks plagued with NPAs under directed lending due to information asymmetry and monitoring problems not only restrict supply of loans to this sector but also fail to ensure productive use of the capital advanced to this sector. Informal sources of financing is highly important to this sector and these financers having full information about borrowers are in a position to monitor the functioning of the latter often bundling of financing with other relations and at times through equity participation. Thus, informal financing ensures most productive use of scarce resource, which is reflected in terms of increasing returns to scale. Significantly positive regression coefficient of the value added per enterprise on the proportion of non-institutional finances in total outstanding loan and a negative coefficient of the regression on the share of institutional finances are again manifestations of the differences in the utilization of the finances provided by the two sources.

Dr Pradip Kumar Biswas is Reader at College of Vocational Studies, Delhi University and Indranil Biswas is Scientist at NISTADS (CSIR), New Delhi.

Introduction

It is commonly believed that the unorganized manufacturing sector of industries is starved of capital and since they fail to get access to the organized sources of finance, they borrow from the unorganized credit market often at high interest rates. It is felt that there is urgent need for the state to intervene in order to raise their capital. In response to this demand the state has become quite active over the past few decades in promoting institutional finances for this unorganized sector. Public and private commercial banks and central- and state-level term lending institutions, co-operative societies, etc., are directed/encouraged by the state to provide loans to the unorganized manufacturers at low interest rates. Over the years, the share of these institutional sources in total outstanding loans of the unorganized manufacturing sector has increased steadily. Between 1994–95 and 2000–01 the share rapidly increased from 57.13% to 72.23% (NSSO, 1994–95, 2000–01b). However, the latest NSSO report no. 526 (NSSO, 2005–06b) on unorganized manufacturing sector reveals a major reversal of the trend—the share of the institutional financing declined to 55.70%, even lower than what it was in 1994–95. It is mentioned in the report that the decline was rather unexpected and the reporting authority, after making several cross-checking, verification, and data authentication has confirmed the decline. In fact, the share of small industries in total priority sector lending has declined substantially since 1999 till 2004 (for which latest data are available) although the share of priority sector advances in total advances by scheduled commercial banks did not decline, as may be seen in the data provided in Table 1. The reasons for the steep fall of the share of institutional sources of finance are in itself an important issue of research. Nonetheless, it shows continuing high importance of the informal sources of finance to the small producers. They still depend on moneylenders, friends,

Table 1: Declining Share of Priority Sector Lending to Small Business (%)

Year	Agricultural Advances/ Total Priority Sector Advances	SSI Advances/ Total Priority Sector Advances	Other Priority Sectors' Advances/ Total Priority Sector Advances	Priority Sector Advances/Total Advance by Schedule Commercial Banks
1995	38.05	41.82	20.13	36.56
1997	39.19	39.86	20.91	41.72
1999	37.39	39.81	22.81	43.54
2000	36.14	35.83	28.03	43.63
2002	36.85	29.06	31.38	43.12
2004	35.08	23.72	38.65	43.96

Source: RBI (2005, Annexure 6).

Note: According to the RBI (2005) the share of priority advances in total credit by scheduled commercial banks slightly increased over the years.

and relatives, business partners, etc., for financing (Table 2). The share of financing, however, varies across size categories of enterprises and across rural and urban locations. For long, private moneylenders were discouraged by the state as their terms and conditions are generally onerous to the borrowers. It is only recently that the government has found the worth of these moneylenders and proposed to infuse capital in the unorganized sectors of the economy through them rather than through commercial banks and other financial institutions.

Table 2: Source-wise Distribution of Outstanding Loans of Unorganized Manufacturing Sector, 2005–06 (%)

Enterprise Type	Central and State Level Term Lending Institution	Other Institutional Agencies	Money-lenders	Business Partner	Supplier/ Contractor	Friends and Relatives	Others	All
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Rural								
OAME	45.3	3.5	25.6	0.2	3.0	18.5	4.1	100.0
NDME	69.9	7.8	8.1	0.7	2.9	10.1	0.4	100.0
DME	56.0	19.9	7.7	6.5	1.3	5.9	2.7	100.0
All	**57.3**	**15.9**	**9.8**	**4.7**	**1.8**	**8.1**	**2.5**	**100.0**
Urban								
OAME	33.7	4.2	11.6	1.3	2.1	11.5	35.8	100.0
NDME	19.8	1.9	4.1	0.5	1.2	6.3	66.2	100.0
DME	60.5	4.4	10.2	4.3	2.3	7.7	10.6	100.0
All	**45.9**	**3.6**	**8.3**	**2.9**	**1.9**	**7.5**	**29.9**	**100.0**
All-India								
OAME	38.6	3.8	17.5	0.8	2.4	14.5	22.4	100.0
NDME	28.1	2.8	4.8	0.5	1.5	6.9	55.3	100.0
DME	59.2	8.8	9.5	4.9	2.0	7.2	8.4	100.0
All	**48.9**	**6.8**	**8.7**	**3.4**	**1.9**	**7.6**	**22.7**	**100.0**

Source: NSSO (2005–06a, Statement 21).

Notes: Own-account Enterprise (OAME): An enterprise, which is run without any hired worker employed on a fairly regular basis.
Non-directory Establishment (NDME): An establishment employing less than six workers (household and hired workers taken together) is termed non-directory establishment.
Directory Establishment (DME): A directory establishment is one, which has employed six or more workers (household and hired workers taken together).

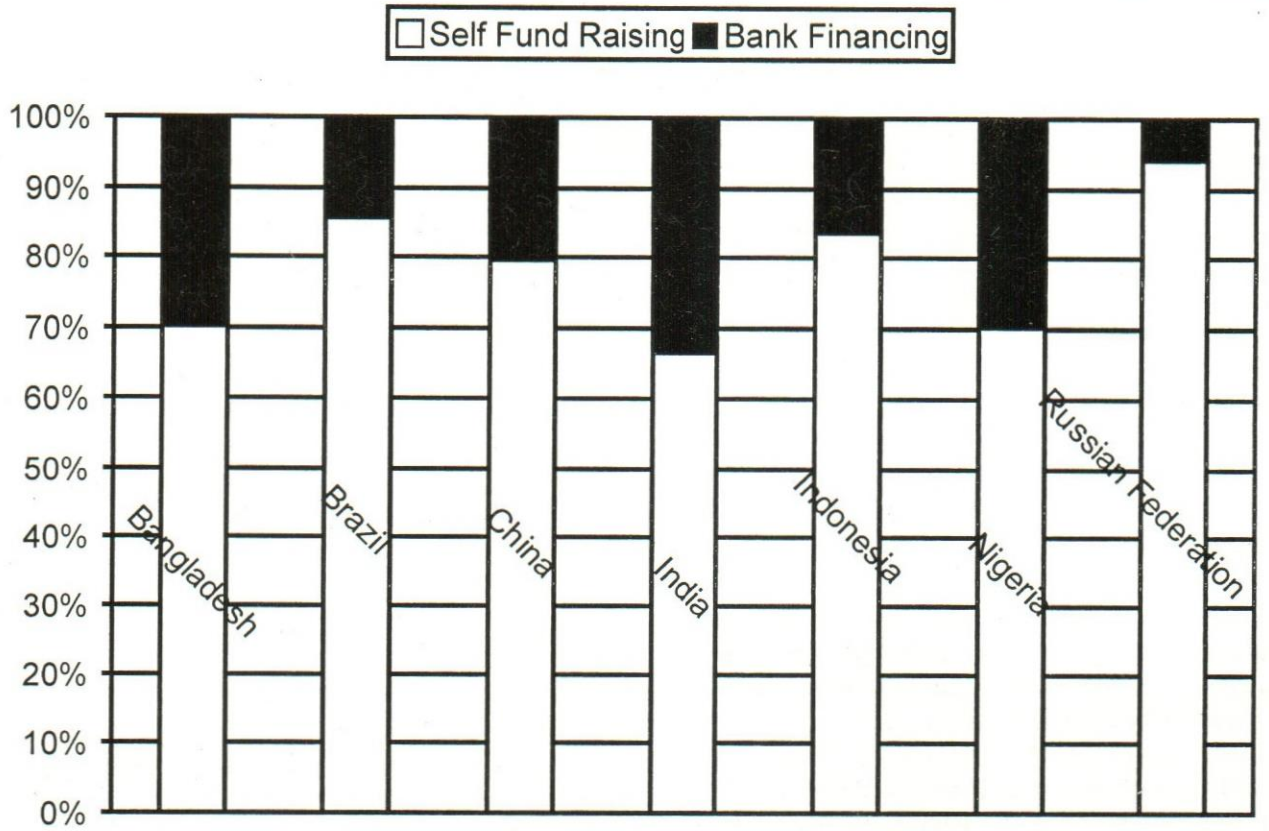


Fig. 1: Percentage Share of Institutional and Non-institutional Finances

Source: Ayyagari et al. (2005)

Predominance of non-institutional finance is not unique to India; it is more widespread. It may be seen in the Fig. 1 that not only in the developing countries but also in more advanced economies like Brazil, Russia, China, the share of self-raised fund, primarily borrowed from non-institutional sources like moneylenders, friends, and relatives, business partners, traders, distributors, profits from business, etc., constitutes more than 65% of the total financing. Strong presence of the informal sources of financing in these countries does indicate their superiority vis-à-vis banking finances in some way or other.

To put it differently, the high level of dependency of the small producers on informal sources of finance would raise several questions: (i) whether the banks are incompetent to deal with the small borrowers; (ii) how moneylenders are more efficient in transacting loans with them; (iii) whether they have special governance mechanism; and (iv) whether the capital provided by moneylenders and other non-institutional sources is more productive than that obtained from institutional sources. In other words, whether the advantages of loan financing by moneylenders are reflected in terms of higher productivity. This paper will focus on the last aspect although the other issues will be discussed.

Among academicians and policy makers in India there has not been much interest in studying any relationship between the sources of fund for investment and the level of productivity of factors,[1] but they used to recommend for expanding the volume of loans to the small producers by commercial banks and for restricting the operations of private moneylenders simply because they charged very high interest rates. A study undertaken by Kui-Wai Li (2003) on Chinese economy for the period of 1984–98 does indicate variations in productivity across sources of investment financing. His study delineated that for the country as a whole, finances raised through private sources

[1]Studies on informal finances focused primarily on the terms and condition of loans such as tied/interlinked transaction, usury, debt trap, etc. (Bhaduri 1973, Bharadwaj 1974, among others). Informal finances are often dubbed as a phenomenon associated with semi feudalism or pre-capitalist system, which restrict the growth of productive forces.

are more productive than that obtained from banks. Using the Cobb–Douglas production function, he found overall constant return to scale (sum of the estimated coefficients of labor and four types of capital equals to 1.0976, which is not significantly different from 1). The four sources of finances for investment in fixed capital formation, namely, state appropriation, self-raised fund, domestic bank loans, and foreign direct investment, together contribute 0.6252 to the aforementioned estimate of the scale parameter. Among the four capital sources, self raised fund has the largest coefficient (0.3676) accounting for 58.80% of the total contribution made by capital. Since self raised fund has a major share (increased from 55.5% in 1981 to 67.4% in 1998) in total investment in fixed assets, Li concluded that it indicated constant returns. The performance of domestic bank loan is rather weak, as the estimated coefficient is 0.0404.

A further study on Chinese economy based on firm level data undertaken by Ayyagari et al. (2005), however, finds results that contradict the study by Li. Although bank financing among the sample firms is much low, firms that receive bank loans are found to grow faster, have higher sales growth, and higher profit reinvestment as compared to those firms that rely on informal finances. Molnar and Tanaka (2007), however, noted that firms with past bank borrowing borrow more from the informal sector in order to supplement:

> The risk avert lending behaviour of the banking sector encourages private enterprises to look for alternative financing sources. Companies and individuals seeking higher return than interest on bank deposits are able to earn higher returns by placing funds in the informal financial sector. This sector thus acts as an alternative intermediary to banks and other formal institutions and also performs the functions of risk management and monitoring. (Molnar and Tanka, 2007)

Under this situation of borrowings from both banks and informal sources it would be difficult to isolate the source-wise contribution to productivity.

The present paper attempts to measure the contribution of different sources of financing capital to productivity based on NSSO data for the Indian unorganized manufacturing industries. The remainder of the paper is structured as follows: the next section provides a framework for measurement and analysis of productivity and data sources, followed by estimation of the returns to scale for various categories of enterprises based on Cobb–Doglas production function, and traces the impact of various sources of finances on productivity across the categories of enterprises and concludes by making suitable policy recommendations.

Methodology

For the measurement of productivity and returns to scale among the informal industries, we have used the Cobb–Doglas production function of the following form:

$$\text{LogQ} = c(0) + c(1)\text{logK} + c(2)\text{logL} + e \qquad (1)$$

where the symbols have their usual meaning.

If c (1) + c (2) exceeds 1, it would be a case of increasing returns to scale (IRS). It is constant returns to scale (CRS) if the sum is equal to 1 and diminishing return to scale (DRS) if less than 1.

In order to study the impact of finances from different sources on productivity the above equational form has been modified as under:

$$\text{LogQ} = c(0) + c(1)\text{logK} + c(2)\text{logL} + c(3)\,X_j + e \qquad (2)$$

If c (3) is positive and significant, it may be said that the capital obtained from jth source has positive impact on the overall productivity.

Data Source and Summary Statistics

Data Source

For the estimation of relevant parameters, we have used 62nd Round of NSSO data (2005–06) on unorganized manufacturing. From this source relevant data are compiled industry wise, which are used as sample points for the purpose of regression. In order to make the sample points representative and unbiased we have dropped those industries for which relevant data are not present or insignificant as mentioned in the Appendix. Regression analysis has been conducted for OAMEs, NDMEs, and DMEs in the rural areas and urban areas separately.

Summary Statistics

Table 3: Distribution of Enterprises in Number

Type of Enterprise	Rural	Urban	All India
OAME	11,108,720 (91.59%)	3,504,186 (70.90%)	14,612,906 (85.60%)
NDME	745,269 (6.15%)	1,025,013 (20.74%)	1,770,282 (10.37%)
DME	274,277 (2.26%)	413,355 (8.36%)	687,632 (4.03%)

Source: NSSO (2005–06a).

Table 4: Gross Value Added per Enterprise and per Worker (Rs)

	Rural		Urban		All	
	GVA per Enterprise	GVA per Worker	GVA per Enterprise	GVA per Worker	GVA per Enterprise	GVA per Worker
OAME	16,946	10,446	26,356	16,300	19,203	11,846
NDME	86,076	26,909	143,460	43,308	119,302	36,543
DME	466,247	41,887	619,734	65,298	558,513	55,052
All	31,355	16,211	100,267	38,167	51,307	24,034

Source: NSSO (2005–06b).

It is shown in Table 3 that OAMEs constitute 86% of all the manufacturing enterprises. Around 91.59% $\simeq$ 92% of the OAMEs belong to the rural areas. However, for this category gross value added per enterprise and per worker are much lower as compared to those of the NDMEs and DMEs (Table 4).

Returns to Scale

In order to measure the returns to scale a set of regressions is run using Equation (1) for different categories of entrepreneurs for rural and urban areas.

Regression results based on industry wise data presented in Table 5, indicate that the unorganized manufacturing sector is witnessing highly increasing returns to scale, that is, the sum of the estimated coefficients of log(K) and log(L) are much greater than one. This is true for individual categories of OAMEs, NDMEs, and DMEs separately irrespective of rural and urban locations. IRS is generally a phenomenon associated with a newly growing industry that has not yet achieved its full potential, for instance, the state of computer industry over the past few decades.

Table 5: Regression Results of value Added per Enterprise on Capital and Labor per Enterprise

Dependent Variable: Log of value added per enterprise					
Item	Intercept (c)	Independent Log(K)	Independent Log(L)	Adjusted R^2	Returns to Scale
Results of the regression across industries					
Rural OAMEs	3.56***	0.58***	1.44***	0.79	IRS
Urban OAMEs	3.14***	0.63***	0.16	0.75	DRS
Combined OAMEs	3.15**	0.59***	1.15***	0.86	IRS
Rural NDMEs	6.83***	0.27***	1.24***	0.57	IRS
Urban NDMEs	5.28***	0.41***	1.14**	0.63	IRS
combined NDMEs	5.60***	0.40***	0.92***	0.74	IRS
Rural DMEs	4.40**	0.54***	0.67*	0.42	IRS
Urban DMEs	3.93	0.53***	0.93	0.23	IRS
Combined DMEs	2.70	0.60***	1.08**	0.24	IRS

Notes: * indicates 85–90% level of confidence
** indicates 90–95% level of confidence
*** indicates 95% and above confidence level sample size 19.

Some of the reasons for the IRS in newly growing industries include, series of innovation, new areas of application, and several externalities leading to cost cutting and/or larger value additions per unit of inputs along with dynamism and rapid growth of the industry, as may be found in any standard text book of undergraduate microeconomics. IRS, therefore, indicates high growth potential of an emerging industry or sector, which over the years would make substantial expansion and gradually enter the phase of CRS and then DRS.

It is, however, difficult to comprehend how IRS can exist in the unorganized manufacturing industries that are generally not new and many are even centuries old. No major innovations are taking place in these industries or other sectors that are related to these industries. In another way of putting the problem is that why, in spite of the presence of IRS, is this sector not growing rapidly? Why are the small producers not making substantial investment that will make them grow fast? The answer probably lies in the nature of financial institutions and the structure of organizations of the small industries. The latter generates IRS and the former restricts rapid investment.

Traditional informal network organizations involving producers, traders, financiers, and other stakeholders enable equity participations in the production process that results in the most productive use of scarce resources (Biswas, 2008). IRS is nothing but a reflection of the best possible use of the resources in situations where resource constraints compel the producers to operate below the optimum scale. The scarcity of resource of these informal networks however restricts investment and the formal institutions are generally reluctant to grant loans to them, as they do not have the collateral against risky loans. Further, whenever they provide loans, they cannot monitor the activities of the borrowers to ensure production and safe repayment. High incidence of NPA under priority sector lending is a testimony of this fact. The priority sector received 43.6% of the credit disbursement by public sector banks in 2000 and 44% in 2004 whereas its share in NPA was 44.5% and 47.5 % in the respective years (RBI, 2005).

Impact of Various Sources of Finances on Productivity across the Categories of Enterprises

As already discussed that the unorganized manufacturing sector has a very high share of outstanding loans from non-institutional sources in spite of efforts made by the government to raise financing by institutional sources and discouraging the former. The presence of the two phenomena, namely, IRS and high incidence of non-institutional loans, would call for a study about the quality of loan capital obtained from different sources especially about their contribution to productivity. A related question is that why institutional finances are not being infused

Table 6: Estimates of the Influence of Institutional and Non-institutional on Productivity per Enterprise in the OAMEs

Dependant Variable	Intercept Value (c)	Log(K)	Log(L)	Non-Institutional Loan	Instittutional Loan	Money-lenders	Adjusted R^2
Combined OAMEs							
Log of value	2.49***	0.64***	1.06***	0.004**	–	–	0.88
added per	2.85***	0.64***	1.06***	–	–0.004**	–	0.88
enterprise	3.09***	0.60***	1.08***	–	–	0.001*	0.85
Rural OAMEs							
Log of value	3.11***	0.60***	1.32***	0.003*	–	–	0.80
added per	3.45***	0.60***	1.32***	–	-0.003	–	0.80
enterprise	2.98***	0.63***	1.02***	–	–	0.006**	0.81
Urban OAMEs							
Log of value	3.51***	0.60***	0.40	-0.003	–	–	0.75
added per	3.21***	0.60***	0.40	–	0.003	–	0.75
enterprise	3.01***	0.62***	0.88**	–	–	-0.01***	0.82

Notes: * indicates 85–90% level of confidence
** indicates 90–95% level of confidence
*** indicates 95% and above confidence level
sample size 19.

adequately in spite of the presence of IRS, what their weaknesses are vis-à-vis non-institutional finances. On the other hand, low penetration and high incidence of NPA of the institutional sources cast doubt about the quality of financial services provided by these institutions. The following section would make an attempt to see whether the non-institutional sources of finance have higher contribution to productivity than the institutional sources.

The regression results indicate that in the case of OAMEs the estimate of value added per enterprise is positively influenced by the extent of non-institutional sources of finance particularly moneylenders as shown in Table 6. Similar regression exercise was carried on separately for rural and urban areas and a similar result was obtained for the rural areas. In the case of urban areas, productivity is much higher in the case of financing from non-institutional sources than institutional sources.

In the case of over all NDMEs, non-institutional sources of finance have a weak positive impact on value added per enterprise while in the rural areas the relation is insignificant (Table 7). In the urban areas non-institutional sources of finance have significant positive impact on the value added per enterprise. It may be seen in Table 8 that for the DMEs no significant relation is found between the sources of finance and the productivity.

A large body of economics literature has also argued that informal institutions possess sufficient information about their borrowers and have a comparative advantage in screening, monitoring, and enforcement capacity over and above the formal institutions (Arnott and Stiglitz, 1991;

Table 7: Estimates of the Influence of Institutional and Non-institutional on Productivity per Enterprise in the NDMEs

Dependant Variable	Intercept Value (c)	Log(K)	Log(L)	Non-Institutional Loan	Instittutional Loan	Money-lenders	Adjusted R^2
Combined NDMEs							
Log of Value	6.67***	0.38***	0.19***	0.004*	–	–	0.65
added per	7.05***	0.38***	0.19***	–	-0.004*	–	0.65
enterprise	6.52***	0.40***	0.25	–	–	-0.003	0.61
Rural NDMEs							
Log of Value	7.02***	0.34**	0.37*	0.0004	–	–	0.25
added per	7.07***	0.34**	0.37*	–	-0.0004	–	0.25
enterprise	6.94***	0.34**	0.32	–	–	0.01	0.30
Urban NDMEs							
Log of Value	3.45***	0.52***	1.21***	0.01***	–	–	0.74
added per	3.96***	0.52***	1.21***	–	-0.01***	–	0.74
enterprise	5.26***	0.41***	1.13**	–	–	0.001	0.61

Notes: * indicates 85–90% level of confidence
** indicates 90–95% level of confidence
*** indicates 95% and above confidence level
sample size 19.

moneylenders are found to have negative impact of productivity. Because of the numerical predominance of rural OAMEs in total OAMEs, the positive coefficient of rural moneylenders' share is reflected in the combined estimate. This reflects that modern financial institutions including commercial banks are ill equipped to deal with these networks, particularly rural networks, thereby depriving the sector realizing it growth potential. It is, therefore, evident that the contribution of capital to the

Stiglitz, 1990). Bundling of financing with other relation is an effective monitoring tool for the moneylender and other informal institutions. Theoretically, the informal institutions have been modeled as both a competitor to their formal counterpart (as in Bell et al., 1997; Jain, 1999; Varghese, 2005) as well as channels of formal funds, where informal lenders who offer credit acquire formal funds to service financing needs of the entrepreneurs (Bose, 1998; Floro and Ray, 1997; Hoff and Stiglitz, 1998). This would eliminate

Table 8: Estimates of the Influence of Institutional and Non-institutional on Productivity per Enterprise in the DMEs

Dependant Variable	Intercept Value (c)	Log(K)	Log(L)	Non-Institutional Loan	Institttutional Loan	Money-lenders	Adjusted R^2
Combined DMEs							
Log of value	1.77	0.62***	1.31*	0.002	–	–	0.19
added per	1.98	0.62***	1.31*	–	-0.002	–	0.19
enterprise	5.04	0.47***	0.91*	–	–	-0.02*	0.31
Rural DMEs							
Log of value	4.78**	0.53***	0.61**	-0.005	–	–	0.42
added per	4.21**	0.53***	0.61**	–	0.005	–	042
enterprise	4.66**	0.50**	0.81*	–	–	-0.007	0.39
Urban DMEs							
Log of value	4.09	0.53***	0.89	-0.001	–	–	0.18
added per	4.01*	0.53***	0.89*	–	0.001*	–	0.18
enterprise	6.25**	0.45***	0.49	–	–	–0.017*	0.30

Notes: * indicates 85–90% level of confidence
** indicates 90–95% level of confidence
*** indicates 95% and above confidence level
sample size 19.

the asymmetric information and monitoring problems of the formal institutions. However, both strands of literature emphasize that informal lenders hold informational and monitoring advantages over the formal lender. This is precisely the reason why deployment of capital provided by non-institutional sources is made most productively even resulting in increasing returns to scale in the relevant range.

Concluding Observations

The unorganized manufacturing sector has been witnessing increasing returns to scale, but its growth has been stunted by the paucity of capital. The informal sources of finance are predominant in the sector and its better utilization leads to IRS though its capacity to expand financing is limited. The formal sources of finance on the other hand are hesitant to provide finances because information asymmetry and monitoring problems and the resultant NPAs while granting loans to this sector (particularly priority sector). It would be more appropriate if the informal institutions are assigned the responsibility of screening and monitory on behalf of the formal sources possibly in line with Floro and Ray (1997), Bose (1998), and Hoff and Stiglitz (1998). This would, on the one hand, channelize adequate capital to the deprived unorganized sector and, on the other hand, enable the banks to do business in a risk free manner with the vast and highly productive sector of the economy.

Appendix

2-digit Industry Groups Selected for the Analysis

NIC Code	Name of the Industry
15	Manufacture of food products and beverages
16	Manufacture of tobacco products
17	Manufacture of textiles
18	Manufacture of wearing apparel; dressing and dyeing of fur
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddler, harness, and footwear
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21	Manufacture of paper and paper products
22	Publishing, printing, and reproduction of recorded media

23	Manufacture of coke, refined petroleum products, and nuclear fuel
24	Manufacture of chemicals and chemical products
25	Manufacture of rubber and plastics products
26	Manufacture of other non-metallic mineral products
27	Manufacture of basic metals
28	Manufacture of fabricated metal products, except machinery and equipment
29	Manufacture of machinery and equipment n.e.c.
31	Manufacture of electrical machinery and apparatus n.e.c.
33	Manufacture of medical, precision and optical instruments, watches, and clocks
35	Manufacture of other transport equipment
36	Manufacture of furniture; manufacturing n.e.c.

References

Arnott, Richard and Stiglitz, Joseph E. (1991), "Moral Hazard and Nonmarket Institutions: Dysfunctional Crowding Out or Peer Monitoring?" *The American Economic Review*, 81(1): 179–90.

Ayyagari, Meghana, Demirgüç-Kunt, Asli, and Maksimovicc, Vojislav (2008), "Formal versus Informal Finance: Evidence from China," World Bank Policy Research Working Paper No. 4465.

Bell, Clive, Srinivasan, T.N., and Christopher, Udry (1997), "Rationing, Spillover and Interlinking in Credit Markets: The Case of Rural Punjab," *Oxford Economic Papers*, (49): 557–85.

Biswas, Pradip Kumar (Forthcoming), "Promoting Competitiveness of Small Enterprises Networks—An Alternative Approach to Intervention," *The Journal of Artificial Intelligence and Society*, Springer.

Bose, Pinaki (1998), "Formal–Informal Sector Interaction in Rural Credit Markets," *Journal of Development Economics*, 56(2): 265–80.

Floro, Maria S. and Ray, Debraj (1997), "Vertical Links Between Formal and Informal Financial Institutions," *Review of Development Economics*, 1(1): 34–56.

Hoff, Karla and Stiglitz, Joseph E. (1998), "Moneylenders and Bankers: Price-Increasing Subsidies in a Monopolistically Competitive Market," *Journal of Development Economics*, 55(2): 485–518.

Jain, Sanjay (1999), "Symbiosis vs. Crowding-Out: The Interaction of Formal and Informal Credit Markets in Developing Countries," *Journal of Development Economics*, 59(2): 419–44.

Li, Kui-Wai (2003), "China's Capital and Productivity Measurement using Financial Resources," Central discussion paper, pp. 1–20, Yale University.

Molnar, Margit and Kensuke, Tanaka (2007) "What is Different about Monitoring by Informal Financial Institutions? Financing of Private Firms in China," Opening and Innovation on Financial Emerging Markets, March, Beijing, China.

National Sample Survey Organisation (NSSO) (1994–95), "Assets and Borrowings of the Unorganised Manufacturing Enterprises in India," Report No. 435.

National Sample Survey Organisation (NSSO) (2000–01a), "Unorganised Manufacturing Sector in India 2000–2001," Report No. 478.

National Sample Survey Organisation (NSSO) (2000–01b), "Unorganised Manufacturing Sector in India 2000-2001," Report No. 479.

National Sample Survey Organisation (NSSO) (2005–06a), "Unorganised Manufacturing Sector in India 2005–2006," Report No. 525.

National Sample Survey Organisation (NSSO) (2005–06b), "Unorganised Manufacturing Sector in India 2005–2006," Report No. 526.

Reserve Bank of India (RBI) (2005), "Draft Technical Paper by The Internal Working Group on Priority Sector Lending."

Stigltiz, Joseph E. (1990), "Peer Monitoring and Credit Markets," *World Bank Economic Review*, (3): 351–66.

Varghese, Adel (2005), "Bank–Moneylender Linkage as an Alternative to Bank Competition in Rural Credit Markets," *Oxford Economic Papers*, 57(2): 315–35.

"Nothing will ever be attempted if all possible objections must first be overcome"

— Samuel Johnson

Feature

Rural Product and Urban Market

D. Subramaniam and K. Shyamasunder

Majority of the Indian population lives in rural areas. The typical rural India is still engaged in agricultural activities. Most of the rural workforce consists of illiterates who have no knowledge about marketing their own produce, but they have expert skill to make a particular product. Also the product they produce does not have a market in their own rural area despite having a market in the urban area. This invariably creates a "gap" between the producer and the buyer and the rural workforce has to depend upon the middlemen who have the skill to identify a market for the product produced in the rural side. The causes for the existence of such a "gap" are due to the difference in the environment prevailing in urban and rural areas. This paper makes an attempt to study what can bridge this "gap" that exists between the rural producers and the urban buyers.

D. Subramaniam is Research Scholar and the current Campus Head of ICFAI National College, Kanchipuram and Dr K. Shyamasunder is the Director of Velammal College of Management and Computer Studies, Chennai.

Introduction

Many of the marketing textbooks have described the various strategies that can be adopted to market a product keeping the profile of the people in general. Of late advances have been made and books have been written based on the profiles of the consumer behaviors of the urban and rural populations. Marketers have found the necessity to understand the varying needs of the urban and rural buyers in order to succeed in their endeavor. Very recently it has been established that the urban market is reaching a saturation level and the producers have felt the necessity to penetrate the rural population. Especially in India with over 70% of the population living in the rural areas (Table 1), they see a huge potential for their future markets in rural India.

Table 1: All India Population Distribution

Distribution	Population	Population (%)
Rural	741,660,293	72.22
Urban	285,354,954	27.78
Total	**1,027,015,247**	**100**

Source: National Council for Applied Economic Research (2002).

It is also established that marketing strategies that have clinched success in urban India is not yielding the same result in rural India where they encounter severe challenges. A common sense approach will reveal that this difficulty is faced mainly because the profile of the rural buyer differs from that of the urban buyer in terms of:

- their literacy level,
- awareness level,
- income level, and
- social environment and culture.

So, one has to have a proper understanding of the rural buyer's need before trying to market the product in that sector in order to succeed.

Similarly the rural producers, while trying to enter the urban market, also need to have a proper understanding of the needs of buyers in the urban sector before entering the urban segment. The kind of rural producers as evidenced by their pattern of occupation is presented in Table 2.

Table 2: Occupation Pattern

Occupation	Proportion of Rural Population (%)
Cultivators	50
Agriculture labourers	27
Trading and craftsmanship	10
Non-agriculture labourers (livestock, forestry, fishing, hunting, plantations, etc.)	10
Salary earners	3
Total	**100**

Source: K.S. Habeeb ur Rahman (2004, p.22).

But there are many an item produced in the rural sector that does not have much of market in the rural side but has huge potential in the urban sector. This is an interesting aspect which calls for the understanding of the urban mindset for these products and accordingly devises the marketing strategies. For example, a handicraft mainly produced in the rural side does not have much potential in the rural sector as such. However, it has a better market potential in the urban side as urbanites can afford and also have a taste for such items. Many of the agricultural products are similarly making their way into the urban side for better profit realization. Some of the commonly used items both in rural as well as in urban, but produced mainly in the rural side, also have succeeded commercially when branded. For example, the commonly used "butter" has made a huge headway as "Amul" from the rural side to many of the urban centers all over the country. Similarly "Aavin" has succeeded as a milk sachet at the regional level in Tamilnadu though it now has many competitors.

Urban vs Rural Divide in Business Approaches

It has been found that many firms have tasted success in rural areas when they found the urban market getting saturated for their products. It has been comparatively easier for these firms as they were able to understand the needs of the customer and accordingly devise their marketing strategies.

This is not the case when a rural business tries to enter an urban sector as the rural producers lack such an expertise. This is because they only have skill to produce but not the skill to market. This necessitates the role of a middleman to fill this gap. If only the rural producer was equipped to acquire the skill to market and to manage the business they will be able to succeed easily. It is more easily said than done.

Skill Gap

The negatives of rural businessmen are as follows:

- They are generally illiterates.
- They lack business acumen.
- They lack money for investment.
- They lack infrastructure.
- They lack access to information.

While the positives of rural businessmen are:

- They have the creative skill to produce.
- They are generally low cost and qualitative.
- They have enough time at their disposal.
- Cheap labor.

Bridging the Gap

If this mismatch in skill is identified and facilitated for their removal the rural products can easily reach the urban sector. This will also enable rural producers to understand the urban buyer's expectation and attain the ability to reach them. The so-called "gap" between the rural producers and urban buyers can thus be bridged. This will transform the rural economy in specific and the whole country in general.

The responsibility of bridging the skill can best be handled by the government; the government can also take the help of NGOs as it calls for massive involvement, plan, and resources. It also requires different approaches at different places and situations but the ultimate goal remains the same.

One important task is to identify the linkages of various variables that have an impact on factors leading to the removal of the negatives as listed earlier or strengthen the positives of the rural businessmen.

For example, rural literacy is a function of rural income; urban expenditure is a function of rural income; the role of technology in information sharing and rural development for infrastructure and rural development; investment and rural development; government and private investment.

In today's economic scenario where "recession" is setting in "global economy" many countries are resorting to massive investments in infrastructure. For example, the Chinese government has announced a package of $ 586 billion investment in infrastructure and public welfare to boost the economy and revive employment opportunities.

The multiplier effect is supposed to set in and bring growth to the economy. This is one possible action the government can take. This will not only improve the infrastructure but also improve the income in general and rural income in specific. This action addresses some of the concerns listed under the negatives as earlier.

Further one has to understand that mere increased spending in infrastructure cannot bring in results as such spending has to take place in projects that can help stimulate growth. Hence, spending has to take place with increased focus. Also it has to strike a balance between projects that yield quicker results and the projects that are likely to take longer time to yield results. For example, spending on rural education is an important action that can benefit the rural economy in the long run. But one has to wait for it to bring success in the long run. The elimination of ignorance and enriching the rural folk with knowledge will lead to bridging the skill gap that is currently depriving this section of India's population of success. This will eliminate the dependence on the middlemen and enable them to be independent.

Third, the power of information has to be understood in the proper context for achieving success in any business. Today, many companies are spending a lot on information management as they help in qualitative decision-making; they thereby get a competitive edge in the market. The Enterprise Resource Planning (ERP) is one such investment which will enable capturing information at the source and provide consistent information at all levels of the management hierarchy for decision-making. Also the role of technology has to utilize fully to exploit information power. While the type of technology to be used may vary, an appropriate use of technology is inevitable. For example, the use of ERP may be appropriate for an established business in the urban area; it may be too much for asking for a small or medium business of the rural side. But still the business in the rural side also has to use an appropriate IT tool to succeed in their venture. For example, the power of "Internet" is exceptional for any upcoming business. This enables a rural educated youth to exploit the opportunities in the market.

Here, opportunities exist for both the government and private sector to invest in ITES sector in the rural side. Many firms have tasted success by establishing e-kiosks in the rural side. For example, ITC, a big corporate of India was able to taste success by going in for large scale IT investment (e-choupal scheme) in the rural side and by providing the required training to the rural youth they were able to taste success in their business. The technology helped in better sourcing of agricultural products, monitoring of agricultural production, monitoring of their price patterns and planning of logistics, etc. Also, recently, Confederation of Indian Industry (CII) has signed a memorandum of undertaking with Khadi and Village Industries Commission (KVIC) and Ministry of Panchayati Raj to promote a new concept of Rural Business Hubs (RBHs). These RBHs enable direct business linkage between industry and rural business community. It helps farmers, artisans, and rural business enterprises to establish market linkages enabling knowledge transfer, enabling reduction in logistics costs, etc. The buyer also benefits by way of reduction in procurement cost and standardized sources of supply.

This initiative will bridge the skill gap and make the rural entrepreneur to be independent.

Fourth, the importance of training can never be over emphasized. Here again the initiatives can come from both the government and private sectors. NGOs can also actively contribute. There have been many instances of rural arts disappearing over a period of time due to lack of support for those arts and the younger generation has not been able to inherit the art from their fore fathers. For example, Crafts Council of India has initiated a venture to help rural handicraft artisans in acquiring skills. The government of India's Ministry of Textiles in their annual report 2000–01 has also listed many initiatives taken for revival of languishing arts like "Bamboo Etching" in Megalaya, "Scroll Painting" of Manipur, etc.

Schemes as these can again bridge the skill gaps as listed earlier.

Also, there is a linkage between the income levels of urban to the increased manufacturing activity at the rural side especially if the rural product depends upon urban market for its survival.

The rural product in such a situation has to depend upon the urban market to have higher income levels more specifically higher personal disposable income for its success. It has been established in several studies that the rural economy is growing faster than urban economy due to higher income level among the urbanites. A study carried out by Roopa Purushothaman, a US-trained economist in their research paper "Is Urban Growth Good for Rural India" has listed the following revelations:

- A 10% increase in urban expenditure has led to 4.8% increase in rural non-farm employment.
- A Rs 100 increase in urban spending resulted in increase of Rs 39 in rural income.

- The rural economy has grown at 7.3% average when compared to just 5.4% in the urban economy.
- The study also reveals quoting central statistical figures indicating the contribution of rural economy as 49% of GDP in 2000 indicating a high increase in contribution compared to 46% of the period 1993–94.
- There is a declining trend in the process of urbanization as a result of economic growth.
- The rural agricultural employment growth was as low as 1% during 2000 and 2005 whereas the non farm jobs have grown by 20% for the said period.

The other factor that can bring about success for a rural product is that if the rural location is visited by outsiders such as urban buyers, tourists, floating population, etc. This is possible if the rural location happens to be a tourist destination. This will enable direct contact between the buyer and the rural seller. For example, many miniature versions of "Taj Mahal" are made using marble stones which are available locally in Agra. Since the place is visited by many tourists the rural manufacturers of this product are able to sell it directly to buyers visiting as tourists.

All these linkages clearly establish the various levels of impact on the rural economy and help in reducing the skill gaps as mentioned in this paper.

Conclusion

The product produced in rural side has to reach the urban hands as necessitated by the market forces. In order for the transaction, as mentioned earlier, to take place certain skill gaps have to be bridged which act as a bottleneck. Government has a very vital role to play in removing such an obstacle and so also others like private players, NGOs, etc. Schemes like investment in infrastructure improvement, creating a conducive environment for rural investment, rural education, and information accessibility and training opportunities are aimed at addressing these obstacles so that rural economy flourishes.

References

Habeeb ur Rehman, K.S., Rural Marketing in India—2004. ICFAI.

Hawkins, Dell I., Roger J. Best, Kennet, A. Coney, and Mookerjee, Amit, *Consumer Behaviour-Building Marketing Strategy,* 9th edition. The McGrawHill Companies.

Kazmi, Azhar, Business Policy and Strategic Management, 2nd edition. Tata McGrawHill.

Nair, N. Rajan and Sanjith, R. Nair (1993), Marketing, 7th edition. Sultan Chand & Sons.

Sherlekar, S.A. Marketing Management. 13th revised edition. Himalaya Publishing House.

http://apparel.indiamart.com/annual- report/handicrafts.html

www.rbh.in

http://knowledge.wharton.upenn.edu/india/article.cfm

"Knowing is not enough; we must apply. Willing is not enough; we must do."

— Johann Wolfgang von Goethe

Feature

Planning of Engineering College Machine-shops: Need, Proposals, and Economic Benefits

Karan Sakhuja, Malyaj Srivastav, Samir Sharma, Soumya Sharma, and Abid Haleem

Ensuring effective learning among students is vital in the context of India's ever-growing technical education sector and its contribution to our economic development. The role of proper planning of machine shop floors, a priority in all commercial manufacturing units, is often ignored while setting-up of engineering colleges. The paper proposes a four-pronged approach to improve the learning outcome of students. This will guarantee massive monetary savings for all the stakeholders in any technical institution—the government, college promoters (in case of private colleges), parents, and, primarily, the industry which recruits these students. The proposal of buffer scheduling will also lead to environmental conservation by preventing metal wastage in college machine shops.

Karan Sakhuja, Malyaj Srivastav, Samir Sharma & Soumya Sharma are final year students of B. Tech. (Mechanical Engineering), Faculty of Engineering & Technology, Jamia Millia Islamia, New Delhi and Dr. Abid Haleem is the Head of Department of Mechanical Engineering, Jamia Millia Islamia University, New Delhi.

Introduction

Current Technical Education Scenario in India

With the unprecedented growth of the Indian economy, there is an exponential growth of technical education in India in order to meet the technical human resource requirement of the Indian industry. India has one of the highest growth rates of graduate engineers in the world as evident from Fig. 1 (National Science Foundation USA, 2008).

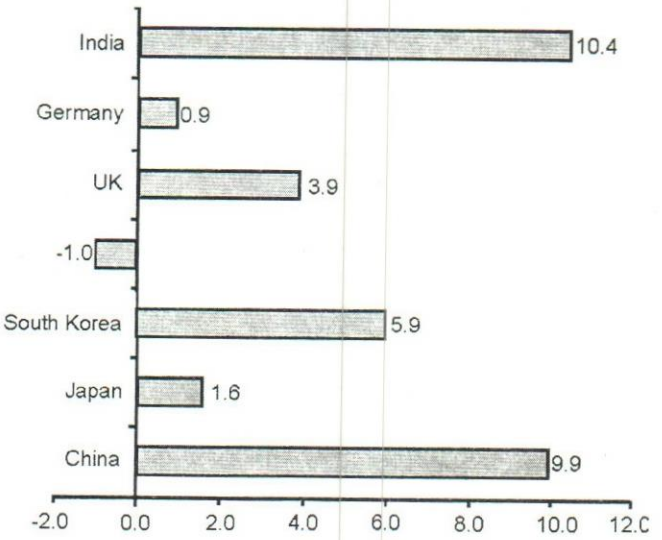


Fig. 1: Growth Rate of Graduate Engineers for Different Countries (2004 or the most recent year)

The surge in demand for technical graduates sets reflex action towards the growth of student intakes in technical institutions to geometric proportions. This in turn puts tremendous pressure on the infrastructure of existing technical institutions, apart from the need for establishing new technical institutions.

In the recent past, enrolment of students in engineering courses has witnessed a virtual explosion. During 1990 and 2004, the intake of Bachelors Degree students in Mechanical Engineering rose from 22,354 to 50,908 (Table 1) (AICTE, 2004–07). In 2007–08, out of 1,645 engineering colleges in India (which only numbered 571 in 1998), about 85% are privately-owned, 10% are government

Table 1: Student Intake in Engineering Colleges at Bachelor's level (excluding IITs & NITs)

Year	No. of Student enrolled
2004	265416
2005	439689
2006	499697
2007	653290

colleges, while others are part of universities which may be wholly or partly funded by the government. Almost 88% of students graduate from private engineering colleges (UGC, 2001–08). During 2006, Computer Science and Information Technology accounted for 34% of the total engineering graduates, 39% for Electronics and Electrical Engineering, 12% for Mechanical Engineering, and 4% for Civil Engineering as shown in Fig. 2 (Banerjee and Muley, 2008).

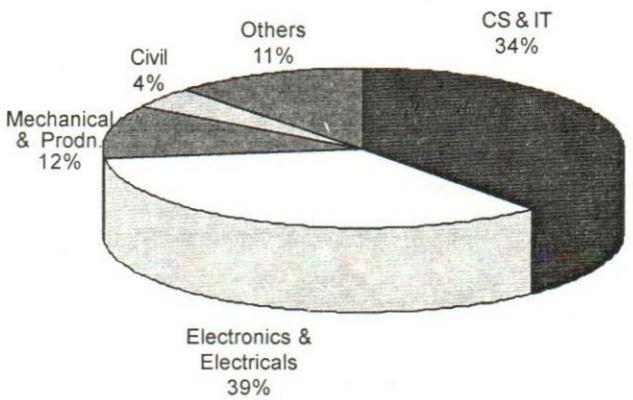


Fig. 2: Discipline wise Break-up of Sanctioned Intake for Engineering Bachelors in India in 2006

As per the All India Council for Technical Education (AICTE, the statutory body of the Government of India mandated for approval and development of technical education in India) guidelines, Bachelors-level Mechanical Engineering students at various engineering colleges across India have machine shop training several times throughout the duration of their degree course. Students of all other engineering disciplines (like Civil, Computers, Electronics, Electrical, IT, etc.) undertake the same only during their first year.

Problem of "Unemployable Engineering Graduates"

Although the demand–supply gap of the technical manpower is continuously shrinking, industry leaders complain about the absence of trained quality engineers for their industries. They have consistently highlighted their dissatisfaction with the high costs incurred in training fresh engineering graduates before they were equipped to handle the jobs they were recruited for. As a result, significant unemployment rates are observed amongst graduating engineers.

Unemployability is a bigger crisis than unemployment. Poor quality of skills/education show up in low incomes rather than unemployment; 58% of graduates makes less than Rs 75,000 per year (Team Lease Services, 2007).

The stress is more on written instruction, or theory, and written testing systems, with little applicability to practical workplace situations. Skills shortage is accompanied by unemployability in industry due to lack of requisite skill levels. Of the total students having a Bachelor's Degree in any Engineering discipline, only 25% are in a sense employable (NASSCOM, 2007). It is estimated that the Indian Information Technology (IIT) industry will spend $ 1.1 billion or 3% of its revenue on training fresh graduates in 2008–09 (NASSCOM, 2007). Though it is believed that the situation in the infrastructure, construction, and core-engineering (ICE) sector is slightly better, it is no doubt bleak. Across all 36 sectors of Indian industry, "there are tremendous knowledge and skill gaps at all levels of jobs" (CII, 2007). Besides the money spent by the industry in training engineering graduates to make them employable, a lot of productive employment time is also wasted. Since the recruited graduates are not "first day, first hour productive," public sector undertakings involved in core-engineering operations (public sector undertakings) like NTPC, Indian Oil, etc., have complete one-year training programs while paying the trainees a stipend between Rs 12,000–15,000 (NTPC, IOCL, 2009).

In Andhra Pradesh (the state churning out maximum engineers in India—131,000 graduates in 2008), only slightly over 38% were found readily employable. The annual funding requirements for their employability-focused training initiatives will be of the order of Rs 650 crores (CII and IMaCS, 2008). It is estimated that about 30% of the fresh engineering graduates are unemployed even one

year after graduation (Institute of Applied Manpower Research, 2004–07).

The problem is not limited to the data highlighted earlier. Approximately 70% of all Indian Institute of Management (IIM) graduates in 2004 were engineers. But, the irony is that most of them do not want to work for manufacturing companies. Statistics bear this trend out. In 2004, 28% of all IIM students preferred to be in the Banking, Finance, Securities, and Insurance (BFSI) sector, while 29% preferred jobs with IT companies, 11% took up consulting assignments, while the others preferred to work in marketing functions (Krishnan, 2005). The only plausible explanation for this can be the lack of interest in technical engineering subjects and perhaps even incompetency as engineers.

Industry representatives feel that the academia, therefore, has to be responsive to industry's future manpower and special training needs and focus on specialized laboratory training to improve the student's technical know-how.

Problem of Students Disinterested in Pursuing Higher Education (Master's and PhD) in Engineering Disciplines

Another consequence of ineffective technical learning in engineering colleges is that the number of graduate engineers opting for higher education remains alarmingly low despite mushrooming of new institutions across the country. In 2006, about 2.3 lakh students graduated in engineering, but only 20,000 Master Degrees and 968 PhDs were awarded in the same year (Banerjee and Muley, 2008). In higher education institutions, including the Indian Institutes of Technology (IITs) and the Indian Institute of Science (IISc), only 1% of students graduating in BTech opt for an MTech and only 2% students graduating with MTech opt for PhD (Banerjee and Muley, 2008). China produced more than 5,000 PhD holders compared to India's 1,000 in the same year (Banerjee and Muley, 2008). The percentages of doctorate degrees to engineering degrees is much higher for most of the other countries studied-9% USA, 10% UK, 8% Germany, and 3% Korea-(Banerjee and Muley, 2008). Also, India has 119 researchers per million of population as compared to Japan with 5,287 and 4,484 in the US (Agarwal, 2006).

A direct consequence of this problem is a severe crunch of qualified faculty in technical institutions. The Ministry of Human Resource Development (MHRD) has initiated steps to motivate youth to pursue higher education by such schemes as Early Faculty Induction Programme, etc.

Role of Machine-shops in Students' Overall Learning Outcome

It is observed that the main bottlenecks in the path of effective learning (practical-oriented) arise due to inappropriate infrastructure design of the laboratory facilities, improper design of laboratory experiments, and lack of involvement of student, teacher, and laboratory personnel in the process of teaching and learning. Significant improvements can be obtained if these points can be addressed properly. We have examined the aforementioned points from the workshop facility point of view, since it is the largest and one of the most expensive setup in any engineering college.

Proposals and Recommendations: To Ensure Optimal Learning Outcome in College Machine-shops

Our objective of ensuring efficient learning is achieved by working upon four key areas:

- Optimal Machine-shop Layout Planning (using the SLP approach)
- Scheduling:
  - Buffer Inventory Scheduling
  - Students' Batch Scheduling
  - Scheduling of Teaching Staff/Instructors
- Design of learning-centric job observation sheets
- Improving manufacturing process awareness by:
  - Inclusion of maintenance of machines by students in their internal evaluation.
  - Curriculum design.

Optimal Layout Planning

Optimal layout planning has the following elements under focus:

- Student to machine ratio (incorporating recommended student-teacher ratio).
- Material handling/transportation time (non-intersecting process flows mean reduced bottlenecks).
- Job completion time (machining time + learning time + quality inspection + post-job analysis).
- Effective utilization of floor space (reduction of congestion-achieved by layout planning).
- Causes of randomness (leading to ineffective learning).
- Maintain flexibility of operation (batch scheduling).

- Maintenance of machines (alignment tests + overhauling + training of student batches).
- Provide for student and staff safety, convenience, and comfort.

Machine-shop Layout Problem: An Overview

The plant layout problem, being a shop floor design problem, is fundamentally different from an optimization problem. We tend to "satisfy," rather than "optimize" so that the layout performs at or above minimum acceptable levels of criteria. Design of "optimum plant layout" is a problem of great magnitude and, hence, we define the overall system as a collection of components/sub-systems and attempt to obtain "optimum" solutions for the sub-systems. The result will be a sub-optimum solution, but it will be better than that which would otherwise be obtained.

By having a layout in which there is an efficient utilization of floor space, the problem of congestion due to incoherent placement of machines is solved. As a result, the maintenance of machines is easier, faster, and safer.

Being more concerned with job organization, an engineering school machine-shop may seem to be more of a *process-focused* system. A college machine shop has certain features of both the product focused system (Martinich, 2006) and the process focused system, but it cannot be explicitly classified as either of them.

More than 50% of tool shops that polled in a survey in the US indicated that their first priority is to implement advanced technology (MoldMaking Technology, 2008). Survey analysis (Cimatron) revealed that many of these implementations have failed to solve the problems for which they were acquired. While machining did speed up, it created new bottlenecks throughout the process and ultimately fell short of reducing overall delivery times, because the layout was not optimal (MoldMaking Technology, 2008). Similar inference, regarding the importance of efficient layout design, can be drawn for a college machine-shop. Hence, procurement of advanced machinery by college administration may not lead to a better understanding of machining processes by the students.

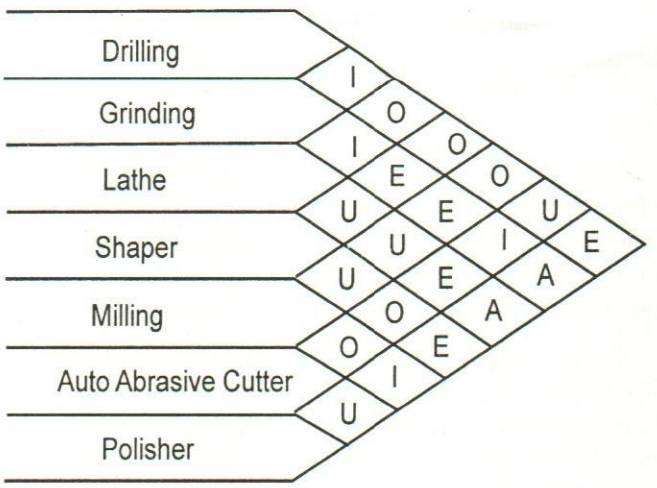
Systematic Layout Planning (SLP) approach (Francis et al., 2004, p. 37):

Different techniques involved in SLP procedure are:

- Flow Analysis Approach, Flow Matrix (quantitative measure of flow) and Process Charts.
- Activity Relationship Charts (REL) (also known as Proximity Chart).
- REL Diagrams (to estimate flow between work-centers).

Here, the fundamental question addressed is of "relative location of facilities." The locations will depend on the need for one pair of facilities to be adjacent (physically close) to each other relative to the need for all other pairs of facilities to be similarly adjacent to each other. Locations must be allocated based on the relative gains and losses for the alternatives and seek to minimize some indicative measure of the cost of having non-adjacent locations of facilities.

In the REL chart, depending on the magnitudes of material flows, activities having the greatest pair-wise flow are located next to one another; the relative locations of pairs of activities having smallest flows are of little importance. Hence, a "closeness rating" to each pair of activity is assigned (Fig. 3).



Symbol	Meaning	Reason for relative imporance
A	Absolutely Important	Convenience • Heavy Traffic (material & instructor) • Easy Supervision
E	Especially Important	Convenience
I	Important	Easy Supervision
O	Ordinary	No known relation
U	Unimportant	Absolutely no movement between machines

Fig. 3: REL Chart for College Machine-shops

The ideal procedure for a plant layout is to build the layout around the productive process and then design the building around the layout. But, this is not always possible—the engineering college building/campus may already be existing, as may be the workshop complex, or the site layout may not permit the construction of a building to house the productive processes.

Here, it is important to note that the SLP approach for machine-shop layout planning is applied keeping in mind the fact that at Bachelor's Degree level, a particular job is completed at a single major-machine (like lathe, mill, drill, or shaper). Often, machining a single job at more than one major machine is not exercised.

Scheduling

Buffer Inventory Scheduling

As per the AICTE norms, workshop practice is compulsory for all branches in engineering during the first and second semesters (includes carpentry, fitting, smithy, welding, sheet metal, foundry, and elementary machine-shop) (AICTE, 2009). Students of Mechanical Engineering Degree program have to undertake machine-shop practice in one semester each (it can be during odd or even semester) during second and third years (AICTE, 2009).

Buffer Inventory (as defined in context of college machine-shops) is an inventory/store of work pieces made available when student requirements vary, causing sudden increases in demand. It acts as a cushion against the complete depletion of work-piece stock in the machine-shop.

Certain conditions need to be accounted for smooth functioning of a machine-shop. The most important of them is work-piece shortages. When students run out of work pieces to be machined in the machine shop (say, cylindrical job for lathe or MS plates for drilling operation, or solid metal block for shaping/milling operation), valuable time is spent in preparing a suitable work piece from raw materials, though they have already learnt how to prepare such work pieces in the fitting shop in the first semester. This problem can be effectively remedied by Buffer Inventory Scheduling, that is, timing the storage as per the academic curriculum of students. It can be implemented as follows:

- First year students in the first semester should prepare specific dimension work pieces, as required by second and third year students, in the metal-fitting shop. It is then stored in the buffer inventory (space for which is planned in the layout).
- Specific dimension work pieces prepared by first year even semester students in the metal-fitting shop will also act as a buffer for them when they themselves come to the second semester of the first year. A schematic is given in Fig. 4.

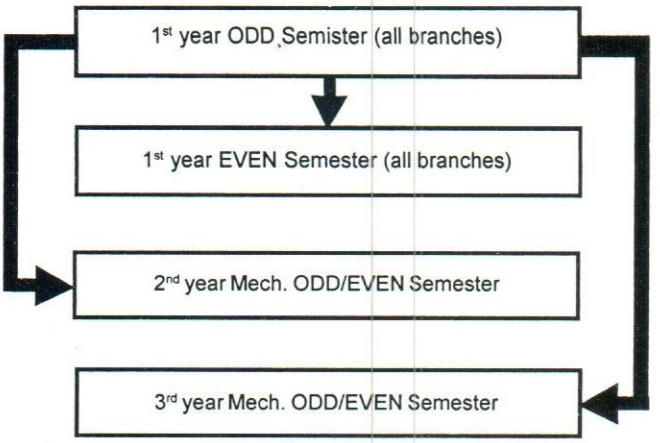


Fig. 4: Flow of Workpieces (through Inventory)

A model for preventing metal wastage (and also saving money) has been developed as an example and given in the Appendix.

This model has three major benefits:

- Saves the second and third year students a lot of productive lab-learning time and eliminates work-stoppages leading to efficient learning.
- Wastage of metal work pieces reduces significantly, contributing to mineral resource conservation, reduced scrap metal-waste, and, hence, environmental preservation.
- Certain amount of cost-cutting, though small, due to reduced metal consumption.

Scheduling of Students-batches

Basic objective is to avoid congestion points/bottlenecks during the training of students in the machine-shop. Crowding in any education-facility is the biggest cause of inefficient learning.

There has to be a consistent *cyclic training schedule* in the machine-shop without material shortage (involves use of Buffer Inventories and In-process Inventories).

As stated earlier, Mechanical and Production Engineering students undertake machine-shop practice in one semester each (whether odd or even) during second and third years as courses on Production Processes I and II with a minimum

Assuming 5 engineering branches in the college, with 60 students per branch

proposal: The work pieces of specific dimensions, as required by second & third year students, shall be prepared by first semester students during their turn in the Fitting Shop.

This way, number of work pieces that the first semester students of all branches (at 2:1 student to job ratio), will produce = 60 x 5 x $^1/_2$ = 150

Requirement by . . .	Number of work pieces required (at 4:1 student to job ratio, 15 work pieces per branch)
Second semester students of all branches	60 x 5 x $^1/_4$ = 75
Second year Odd/Even semester mechanical engineering students	60 x $^1/_4$ = 15
Third year Odd/Even semester mechanical engineering students	60 x $^1/_4$ = 15

Cost of work piece material:

CI Cube (for Shaping & Miling operations)	MS Plate in the form of flats (for Drilling operations)	MS Round Bar (for operations on Lathe)
Rs. 95 per standard cube of 1200g	Rs. 35 per kg	Rs. 40 per kg

MS = Mild Steel
C1 = Cast Iron

Source: Local Supplier rates, Delhi NCR, April 2009

For Drilling buffer:
(work piece required: MS plate)

A 80 x 64 x 6 mm work piece MS plate weighs around 450 gm
It, therefore, costs around Rs. 15.75 per work piece
Hence,
Monetary saving from the proposal = 15.75 x 105 = *Rs. 1653.75*
Amount of Mild Steel saved = 450 gm x 105 = *47.25 kg*

For Lathe buffer:
(Work piece required: MS round-bar)

A 165 mm long x 25 mm diameter MS round bar cut for turning operation
will weigh around 640 gm
(As per Local supplier rates in Delhi, a 25 mm diameter MS round bar weighs 3.85 kg/m)
It, therefore, costs around Rs. 25.6 per work piece
Hence,
Monetary saving from the proposal = 25.6 x 105 = *Rs. 2688*
Amount of Mild Steel saved = 640 gm x 105 = *67.2 kg*

Fig. 5: How Buffer Inventory Scheduling Prevents Metal Wastage

12 periods (12 X 50 minutes = 600 minutes) = 6 weeks, that is, duration of machine-shop training = 100 minutes per week (AICTE, 2009). But, for first year students of all branches, the duration of machine-shop training = 200 minutes per week.

Now, the ideal student:instructor ratio in machine-shops = 10:1 (AICTE, 2009).

The class should be divided into two batches (A and B) of 30 students each (AICTE, 2009). Batch A is now split-up into three groups (A1, A2, and A3), with each group of 10 students assigned to a different machine. Similarly, Batch B is divided into three groups (B1, B2, and B3).

Lathe, shaper, milling, and sensitive-drill are the four major machines on which students are trained in most machine-shops (the rest like grinders and automatic cutters are used in course of use of these machines). Ideally, a student learns the basics of machine operation (required at that level of the degree program) in two periods (of 100 minutes each), that is, two weeks (AICTE, 2009).

A corresponding batch-schedule for second and third year Mechanical Engineering Degree program is shown in Table 2.

Table 2: Students' Batch Schedule during a Semester

Weeks	LATHE	SHAPER	MILLING	DRILLING
1 and 2	A1	A2	A3	-
	-	B1	B2	B3
3 and 4	-	A1	A2	A3
	B3	-	B1	B2
5 and 6	A3	-	A1	A2
	B2	B3	-	B1
7 and 8	A2	A3	-	A1
	B1	B2	B3	-

In-process Inventories are required in the machine-shop for temporary storage of the work pieces being machined by different student-batches over the week.

Scheduling of Teachers/Instructors

As per the AICTE norms, the ratio between the foremen (lecturer rank) to workshop instructor may be 1:5. For machine-shop it can be 1:3. For a workload of about 25 hours/week in a workshop, one instructor is recommended. However, the number will also vary based on different trades: one instructor is recommended for one trade.

In a college machine-shop, there are six workstations: lathe, shaper, drilling, milling, grinding, cutting, and polishing (cutting operations performed by first year students according to specified dimensions and prepared work piece stored in Buffer Inventory).

We propose that each instructor should be supervising one major machining operation (like the lathe or milling or shaper or drilling) and one minor trade (like grinding or polisher or power supply monitoring).

In any trade, the instructors should schedule students' training in the following order:

Machine internals → Performing machining operations → Finishing operation on the job → Analysis of chips and finished-machined surface (for machining parameters like D-Cut, Feed, Speed)

Most of the *personnel-scheduling* problems can be solved as linear programming models.

In an odd or even semester, there are second year and third year students of Mechanical Engineering Degree program, being trained at the machine-shop. The corresponding scheduling is presented in Table 3.

Table 3: Instructor's Schedule during a Semester

C. Weeks	LATHE Instructor	SHAPER Instructor	MILLING Instructor	DRILLING Instructor
1 and 2	3rd yr-A1 2nd yr-A1	3rd yr-A2 2nd yr-A2	3rd yr-A3 2nd yr-A3	- -
	- -	3rd yr-B1 2nd yr-B1	3rd yr-B2 2nd yr-B2	3rd yr-B3 2nd yr-B3
3 and 4	- -	3rd yr-A1 2nd yr-A1	3rd yr-A2 2nd yr-A2	3rd yr-A3 2nd yr-A3
	3rd yr-B3 2nd yr-B3	- -	3rd yr-B1 2nd yr-B1	3rd yr-B2 2nd yr-B2
5 and 6	3rd yr-A3 2nd yr-A3	- -	3rd yr-A1 3rd yr-A1	3rd yr-A2 2nd yr-A2
	3rd yr-B2 2nd yr-B2	3rd yr-B3 2nd yr-B3	- -	3rd yr-B1 2nd yr-B1
7 and 8	3rd yr-A2 2nd yr-A2	3rd yr-A3 2nd yr-A3	- -	3rd yr-A1 2nd yr-A1
	3rd yr-B1 2nd yr-B1	3rd yr-B2 2nd yr-B2	3rd yr-B3 2nd yr-B3	- -

Design of Learning-centric Observation Sheets

It is the approach to technical learning that differentiates between engineering graduates, diploma holders, and ITI passouts. In the industry, ITI passouts and diploma holders are required to concentrate their skill and learning on job production and machine operation.

Mechanical engineers, on the other hand, are required to handle the quality aspects of production like analyzing the mechanical properties of the job and tool during and after machining, chip formation, surface finish, dimensional accuracy, etc. Their role is to take a product from an idea to the marketplace, for which a broad range of skills are needed. He/she needs to understand the forces and the thermal environment that a product, its parts, or its sub-systems will encounter; to design them for functionality, aesthetics; and to determine the best way to manufacture them and ensure they will operate without failure. They are required to plan and develop more efficient production setups. Perhaps the one skill that is the mechanical engineer's exclusive domain is the ability to analyze and design objects and systems with motion. Hence, there has to be a compulsory incorporation of comprehensive post-job analysis during their machine-shop training in college (Table 4).

Table 4: Parameters to be Included in Lab Observation Sheets

Chip study	Machining Parameters
• Thickness • Length • Curvature • Colour	• Feed • Speed • Depth of Cut • Material Removal Rate

A model observation table to be filled in by students while performing machining operations is suggested in Table 5.

Maintenance of Machines by Students as Part of Internal Assessment Marking

In case of mechanical failures, defects in machine components, or tool break, considerable delay occurs as time is spent on corrective repairs. Maintenance/ overhauling of the machines should be made an integral part of students' workshop curriculum. Each group will perform maintenance of machine that they just finished working on as a weekly tutorial under the instructor-in-charge of the trade. This minimizes chances of machine/ tool breakdown and even if that happens, it can be brought back into running condition by the students themselves.

Table 5: Model Observation Sheet

Description of Operation	Shop	Machine Used	Tool Standard/ Special	Jigs/fixtures/ Gauges used if any	Time analysis			
					Machining time	Handling time	Setup time	Cycle Time

Temp. measurement of tool (using thermocouple)

To ensure due attention to this cause, a certain percentage of internal evaluation marks should be allocated to this.

Curriculum Design

There is a huge scope in India to propel manufacturing sector's contribution in the Gross Domestic Product (GDP). But, in recent years, service sector growth has been the focus of the government and industry.

The most effective way to achieve the former is by improving competency of the graduate engineers in Product Design. Besides increasing students' visit to the industries so that they can see their theoretical knowledge in action, learning manufacturing design, and process design also has to be an integral part of the degree level curriculum. The machine shop has to provide not only an environment for experimentation, but also facilitate innovation in product and tool development.

Every state has its own body to regulate the technical education institutions in the state (including both state government colleges and private institutes). These are state-wise technical universities (like Punjab Technical University, UP Technical University, etc.). Although, they are all under the purview of the AICTE, more steps need to be taken to ensure competency in teaching, syllabi content, and practical training at a national benchmark.

Economic Benefits of Machine Shops having Optimal Learning Outcomes: Implications of the Study

There are four stakeholders in the technical education sector. The manner in which each of them will be benefited through implementation of these proposals are detailed further:

- ***Government:*** It runs and funds higher educational institutes throughout the country. Highly skilled engineering graduates will make immense contributions to the country's GDP. Currently public sector, or government, investment in education is less than 3% of GDP, including a share of higher education at 0.4%). The central government spends slightly more than 25% of total public expenditure and the state governments spend the remaining three quarters (Agarwal, 2006, p. 6). The National Policy on Education 1986 has set a goal of 6% of GDP as total expenditure on education. This would include 1.5% for higher and technical education (Agarwal, 2006, p. 6). As the number of students taking up Master's and PhDs increases (a direct consequence of improved technical learning), we shall have more engineering-based research and development activities, indigenous technology, and patents. An indirect consequence could also be the government overcoming the faculty shortage problem in colleges, and also stemming the "brain-drain" to technically advanced nations.
- ***College promoters (in case of privately-run colleges)***: Enrolment pressure, rising unit costs of higher education, and competing pressures on public finances have encouraged growth of the private sector in education sector. Declining public sector expenditures, poor facilities, and a lack of capacity also build a strong case for a greater role for the private sector. Moreover, the public sector higher education system displays a lack of flexibility in supply response for meeting the rapidly-changing needs of a fast-growing Indian economy. Better placed students in the industry will improve the brand image of their college as a centre for excellence in technical learning.
- ***Parents:*** Bearing the rising cost of quality higher education, their chief concern is the employability of their children. The household sector, or parents, contributes Rs 18,675 crores of the estimated aggregate spending of Rs 37,675 crores (0.4% of GDP) annually (Agarwal, 2006, p. 6). Appropriate return on parents' investment in their wards' education can only

be ensured by their becoming competent professionals, and not mere degree-holders.

Industry: The industry and, more so the production/manufacturing sector and power sector will be the chief beneficiaries of the above proposals. One percent of jobs in industries require skill plus knowledge-based workers which includes engineers, technologists, etc. Total cost of un-employability repair in India is Rs 485,640 crores (Team Lease Services, 2007). Hence, implementation of the proposals of this paper can lead to a saving of Rs 4,856.40 crores (0.1% of GDP).

Cost of Implementing Proposals

While layout planning, observation sheets, and incorporation of machine maintenance in internal assessment markings have no cost inputs; as a result, Buffer Inventory Scheduling will incur some cost. Implementing the concept of Buffer Inventory in a machine-shop would require adequate number of storage cupboards inside the facility. In addition, a minimal amount will be required for cataloguing the inventory, both Buffer as well as In-process for a faster retrieval of work pieces. The cost to implement the these proposals is not very significant, vis-á-vis the tremendous potential of monetary savings.

Other Facilities for Improved Technical Learning

The factors to be taken care of in machine-shop layout design are not crisp. Hence, fuzzy logic may be employed. Also, dedicated software can be used for designing optimal shop floor layouts.

The colleges can also open their machine-shops (and other laboratories of various engineering disciplines), on a part-time basis, for commercial use like machining, assembly, fabrication services, and design assistance in support of research projects and instructional laboratories. Besides revenue generation, it will provide the students with greater exposure to industrial manufacturing practices. This practice is already being followed at the universities in the USA.

Senior faculty members should also teach certain portions of the syllabi to the first year students to inculcate advanced observation-skills and research-oriented reasoning in them.

Most of the mentioned proposals (like optimal layout planning, batch scheduling, learning-centric lab-observation sheets, can be extended to the laboratories of all the engineering disciplines in any college, because ultimately it helps in achieving the objective of any educational facility: effective practical learning/training of students. Lab-specific proposals (be it a lab for electronics or electrical or civil engineering students) can be developed by analyzing the working of that laboratory.

All possible efforts must be made to revitalize the structure of laboratory-based learning at degree level technical education in India.

The issue of professional graduates as unemployable is not specific to India. On an average only 13% of fresh professional graduates were employable. Finance and accounting graduates did better with 19% of them found to be employable, and the rest engineers (17%), life science researcher (14%), analyst (15%) (*McKinsey Quarterly No.* 3, 2005).

Conclusion

There is a need for the industry, government, and academia to work together for formulating a strategy to improve industrial employment readiness of engineering and technology graduates in India. We must ensure that the output of the human resource establishment has a set of abilities that they can then build upon if the opportunity so arises. To put it another way, we should not attempt to estimate the requirement of number of engineers, etc., that a fast growing economy would require. Instead we need to build in a very basic foundation in each person, such that in case a particular opportunity opens up in a specific sphere, an individual can quickly add occupation specific skills on to his set of basic skills. Effective lab-learning is a vital tool for empowering the engineering students with competitive technical knowledge-base to tackle real world problems to be faced by them in the industry.

The direct significance of the above proposals is improved learning outcome among engineering students. Cost-reduction in material expenditure (for machine-shops) incurred by the institutions and environmental preservation through reduced metal use are the secondary advantages.

But the most notable and significant benefit, though an indirect result, is the monetary savings made by the industry, due to a massive reduction in cost of training the fresh recruits and making them technically competent.

Appendix

How Buffer Inventory Scheduling Prevents Metal Wastage

Assuming five engineering branches in the college, with 60 students per branch

Proposal: The work pieces of specific dimensions, as required by second and third year students, shall be prepared by first semester students during their turn in the fitting shop.

This way, number of work pieces that the first semester students of all branches (at 2:1 student to job ratio), will produce = 60 x 5 x ½ = 150

Number of Workpieces required

Requirement by... (at 4:1 student to job ratio, 15 work pieces per branch)

Second semester students of all branches 60 x 5 x ¼ = 75

Second year Odd/even semester mechanical engineering students 60 x ¼ = 15

Third year Odd/Even semester mechanical engineering students 60 x ¼ = 15

Now, this requirement will be met entirely from the buffer inventory created by the first semester students of all branches.

Therefore, number of work pieces saved (that would have been prepared again by the abovementioned three categories of students before starting their respective jobs) = 75 +15 +15 = 105

Cost of Workpiece Material:

CI Cube (for Shaping and Milling Operations)	MS Plate in the Form of Flats (for Drilling Operations)	MS Round Bar (for operations on Lathe)
Rs 95 per standard cube of 1,200 g	Rs 35 per kg	Rs 40 per kg

Source: Local Supplier rates, Delhi NCR, April 2009.

Notes: MS = Mild Steel
CI = Cast Iron

For Drilling buffer:

(Work piece required: MS plate)

An 80 x 64 x 6 mm work piece MS plate weighs around 450 g

It, therefore, costs around Rs 15.75 per work piece

Hence:

Monetary saving from the proposal

= 15.75 x 105 = Rs 1,653.75

Amount of Mild Steel saved = 450 gm x 105 = 47.25 kg

For Lathe buffer:

(Work piece required: MS round-bar)

A 165 mm long X 25 mm diameter MS round bar cut for turning operation will weigh around 640g

(As per Local supplier rates in Delhi, a 25 mm diameter MS round bar weighs 3.85 kg/m)

It, therefore, costs around Rs 25.6 per work piece

Hence:

Monetary saving from the proposal

= 25.6 x 105 = Rs 2,688

Amount of Mild Steel saved = 640 g x 105 = 67.2 kg

References

Agarwal, Pawan (2006), "Higher Education in India—The Need for a Change," Working Paper no. 179, Indian Council for Research on International Economic Relations (ICRIER), May 2006 and CII report titled "Towards Excellence-Higher Education in India."

AICTE Norms and Standards for Engineering Technology degree programs, Staff Norms, available at http://www.aicte.ernet.in/8staff.htm#04 (accessed on June 30, 2009)

AICTE Norms and Standards for Engineering Technology degree programs, Norms for infrastructure, available at http://www.aicte.ernet.in/12norms_engineering.htm#03_6 (accessed on June 30, 2009).

All India Council for Technical Education (AICTE) (2004-07), *Hand Book for Approval Process.* Ministry of Human Resource Development (MHRD), Government of India, available at http://www.aicte.ernet.in/

Banerjee, Rangan and Vinayak, P. Muley (2008), *Engineering Education in India.* Department of Energy Science and Engineering, Indian Institute of Technology, sponsored by Observer Research Foundation, p. 34.

Cimatron, Survey analysis conducted for MoldMaking industry, available at http://www.cimatron.com/NA/homepage.aspx?FolderID= 850&=en (accessed on June 30, 2009).

Confederation of Indian Industries (CII) (2007), "National Committee on Skills and Human Resources," available at http://www.cii.in/

CII and ICRA Management Consulting Services Limited (IMaCS) (2008), "Study on Mapping of Human Resources and Skills in Andhra Pradesh—2015."

Francis, Richard L., Leon F. McGinnis Jr, and John, A. White (2004), *Facility Layout and Location—An Analytical Approach,* 2nd edition. Prentice Hall of India, p. 37.

How to Achieve Tool Shop Optimization, MoldMaking Technology Online, available at http://www.moldmakingtechnology.com/articles/0406shop1.html (accessed on June 30, 2009).

Institute of Applied Manpower Research (2004–06), "Annual Technical Manpower Reviews," New Delhi, State-wise review report.

Krishnan, Sanjay (2005), "B-school Grads Shunning Jobs at Manufacturing Firms," June 8, Mumbai, available at http://www.rediff.com///money/2005/jun/08spec.htm (accessed on June 30, 2009).

Martinich, Joseph S. (2006), *Production and Operations Management-An Applied Modern Approach*, 3rd edition. John Wiley & Sons, Inc.

McKinsey Quarterly No. 3. (2005), "Sizing the Emerging Global Labour Market," survey with HR experts.

National Association of Software and Services Companies (NASSCOM) 2007, Press Release.

National Science Foundation USA (2008), "Science and Engineering Indicators 2008," available at http://www.nsf.gov/statistics/seind08/

NTPC and INDIAN OIL recruitment advertisements, available at http://www.ntpcjobs.net/advertisement.php and http://www.iocl.com/PeopleCareers/OMPanipatRefinery_new.pdf (accessed on June 30, 2009).

University Grants Commission (UGC) (2001–08), *Annual Reports.* Ministry of Human Resource Development (MHRD), Government of India, available at http://www.ugc.ac.in/

Team Lease Services (2007), "India Labour Report 2007: The Youth Unemployability Crisis," p. 3

"Our greatest glory is not in never falling but in rising every time we fall."

—Confucius

Feature

Productivity Improvement through Application of "MOST" in Switchgear Company

Neelesh P. Sirdeshmukh, Y.M. Puri, I.K. Chopde, and A.D. Pundlik

Increased market competition has moved companies more towards "customization" of their products and services. Therefore, it has become the norm rather than exception for companies to update their operations continuously. Predetermined Motion Time Systems (PMTS) have become attractive and an useful evaluation tool in this endeavor. BasicMost and MiniMOST, as examples of PMTS systems, were applied to the assembly of 4P RCCB product. Using results from MOST study sheet lean principles are applied such as work balance, suggesting workstation-wise improvements, and the differences between Present, MOST, and Lean MOST output are presented.

Neelesh Pandharinath Sirdeshmukh is student of M.Tech. (Industrial Engineering); Dr Y.M. Puri is Assistant Professor in the Mechanical Engineering Department; Dr I.K. Chopde is Professor in Mechanical Engineering Department, Visvesvaraya National Institute of Technology, Nagpur, India; and A.D. Pundlik is Assistant General Manager, Engineering and Industrial Engineering.

Introduction

Today, every company has a great concern over improving quality and decreasing cost, which leads to improved system productivity. In order to remain competitive, processes must be designed to run at maximum efficiencies. Maynard Operation Sequence Technique (MOST) is computerized by MOST Data Acquisition Technique (MDAT) which made it easier to learn, faster in determining standard, and more capable of mass data update. The latter made these systems economically advantageous to meet frequent changes in processes to meet the ever-changing customer needs. This industry is India's largest manufacturer of low tension switchgear including modular devices unit. Presently it is facing various problems, specifically, 4P RCCB. The main problems are fulfillment of increased demand and excess manpower. According to current production data Effective Work Time (EWT) is 165 minutes. EWT indicates current average engagement time of a person. This paper utilizes MOST as a scientific approach for work measurement. At the RCCB 4P line operations are analyzed by using MiniMOST and Basic MOST applications. Comparison of present o/p, MOST o/p, and Lean MOST o/p are provided at the end of paper.

Literature Review

There are many reasons why one wants to know the amount of time a particular task should take to be completed. It is for any of three reasons:

1. To accomplish planning.
2. Determine performance.
3. Establish costs.

PMTS is a work measurement technique that utilizes tables of standard times, assigned to basic motions of an activity. The total of the times for these basic motions is the time for the activity.

MOST: Primary Considerations

1. Work is done only when an object is moved. Movements of objects follow consistently repeating patterns.
2. Body motions are organized into "Sequence Models" which describe activities required for movement of an object.

Type of MOST (Zandin, 2003, pp. 1–29)

1. ***BasicMOST***: is the most commonly used version of MOST. Typically used for activities that are "medium cycle" (that take a few seconds to approximately 10 minutes). These are repetitive and non-repetitive activities.
2. ***MiniMOST***: produces a very detailed, precise analysis. Typically used for activities that are "short cycle" (that take approximately 20 seconds or less). These are highly repetitive activities and occur frequently. These feature very little variation.
3. ***MaxiMOST***: Typically used for setups, heavy assembly, maintenance, or utilities of "longer cycle" activities (that take 2 minutes to more than several hours). These are activities that are non-repetitive or vary widely from cycle to cycle variations.

Factors that influence system selection for type of MOST are the following:

1. Type of activities
2. Length of the cycle
3. How frequently the activity occurs
4. How much variation is involved
5. Use of standards

BasicMOST System

BasicMOST system (Zandin, 2003, pp. 1–29), compared to other PMTS systems, concentrates on the movement of "objects" rather than the basic motions of the "worker." This lead to using fewer elements in describing operations that consequently made the technique simpler to use, faster to implement, and more economical to use when compared to other PMTS systems. The fewer elements used in describing the operation, together with the smaller number of parameters used with these elements, made the system less susceptible to applicator's deviations. In that regard it can be looked at as an enhancement to other exiting PMTS systems. BasicMOST is one of three available modules in the family of MOST.

BasicMOST (Zandin, 2003, pp. 1–29) is recommended for operation time that extends from few seconds to 10 minutes, with 0.5–3.0 minutes being a typical time.

Sequence Models of BasicMOST: In BasicMOST, an operation is broken down into sub-operations, which are in turn broken down to activities and sub-activities. Each activity (method step) is represented by a "sequence model" and the sub-activities are represented by "parameters" of the model. Each parameter is associated with (and followed by) an "index" that represents the "time" that it will take to perform this sub-activity. Partial list of the parameters are included in Table 1. BasicMOST has three types of sequence models: General Move; Controlled Move; and Tool Use. With the proper combinations of these models, any operation can be modeled.

Table 1: Partial List BasicMOST Parameters

Parameter	Symbol	Definition
Action distance	A	Covers all spinal movement or action of finger, hands, and/or feet either loaded or unloaded. Any control of these actions by the surroundings requires the use of other parameters.
Body action	B	Refers to either vertical motions of the body or the actions necessary to overcome an obstruction or impairment to body movement.
Gain control	G	Covers all manual motins (mainly finger, hand, and foot) employed to obtain complete manual control of an object and to sequentially relinquish that control. The G parameter can include one or several short-move motions whose objectives is to gain full control of the object(s) before it is to be moved to another location.
Place	P	Refers to action at the final stage of an object's displacement to align, orient and/or engage the object with another object(s) before the control of the object relinquished.

The General Move Sequence is characterized by a sequence of unrestricted spatial displacement of an object under manual control. It is described as:

1. Use one or two hands to reach the object(s) at a distance. The body movement might be used as appropriate in order to help the movement of the object.
2. Gain manual control of the object.

3. Move the object with a distance to the target point of placement. The body movement might be used as appropriate in order to help the movement of the object(s).
4. Place the object in a required position.
5. Return to workplace or in the normal working position.

These five steps can be represented by five parameters in three distinct phases as:

Get	Put	Return
Ax By Gz	Ak Bl Pm	An

Table 2: Index Values for Parameter

Index "x" (x10)	Parameter A "Action Distance"
0	≤ 2 in
1	Within reach
3	1–2 steps
6	3–4 steps
19	5–7 steps
16	8–10 steps

The indexes (subscripts x, y, etc.) associated with each parameter are catalogued on data cards. Table 2 shows a representative column from data card for the values of index "x," in Time Measurement Units (TMU).

In the BasicMOST software, there are dropdown lists of indexes values for all parameters. The time of the activity that is represented by the model is determined by adding the values of the indexes (x, y, etc.). As shown in Table 2, the value of the index will depend on the description of the parameter. Therefore, it becomes necessary for the user to understand the different descriptions of each parameter, as it will affect the calculated time of the model and, hence, the accuracy of the sub-operations and operations. The same applies for both the Controlled Move and the Tool Use sequence models. MiniMOST technique having general Move and Controlled Move sequence models. Details on these modules can be found in Zandin (2003, pp. 1–29).

Methodology

Following are the initial data collected:

1. Product list
2. Process operation and flow chart
3. Current allocation of workforce
4. Layout
5. Equipment and work center list with capacities

Table 3: MOST Sheet

MOST Estimation Sheet Industrial Engineering Department	**Operation Group: NEELESH** Study done by Neelesh Sirdeshmukh	**Additional Information**

Operation: 1 PMR SOLDERING-RCCB 4 POLE

Work Center: RCCB RCCB Date: 10 April, 2009

Total Cycle time (Secs): 49.40 Work Content (Secs): 49.40

Sr. No.	Sub Operation/Element Description	Frq	Div	Off	CT (Secs)	Men	CW(Secs)
1	COLLECTION OF RCCB IN BIN	1	30	1	22.32	1	22.32
NEELES 3.1	COLLECTION OF RCCB IN BIN-PMR SOLDERING RCCB				0.74		0.74
	1 STAND FROM CHIAR WITH ADJUSTMENTS						
GM Freq. Simo	A0 B10 G0 A0 B0 P0 A0	1	1	No	3.60	1	3.60
	2 MOVE 8–10 STEPS, BEND & ARISE, GET GET LOADED BIN OF RCCB, MOVE 8–10 STEPS, PUT IT ON TABLE						
GM Freq. Simo	A16 B6 G3 A16 B0 P1 A0	1	1	No	15.12	1	15.12
	3 SIT WITH ADJUSTMENT ON CHAIR						
GM Freq. Simo	A0 B0 G0 A0 B10 P0 A0	1	1	No	3.60	1	3.60

Table 4: Comparison of Present and MOST O/P for RCCB 4P

Sr. No.	Description	Present o/p per Shift	MOST Cycle Time in sec.	MOST o/p	MOST PI %	MOST minute	Productivity Improved
1	PMR soldering	240	49.4	559	43	198	133
2	Bottom plate riveting	1,000	15.93	1,733	58	266	73
3	Knob spring rivet fitting & knob lever link riveting	1,400	14.12	1,955	72	329	40
4	Latch lever assembly & lever link	1,600	14.59	1,892	85	389	18
5	Latch rotor bunch assembly	1,144	20.96	1,317	87	400	15
6	Center riveting	2,600	5.77	4,783	54	250	84
7	Latch assembly	272	34.17	808	34	155	197
8	Latch top plate riveting	568	18.67	1,478	38	177	160
9	PMR & latch fitting	448	23.95	1,152	39	179	157
10	Relay calibration	180	73.43	376	48	220	109
11	Test knob fitting	500	30.54	904	55	255	81
12	Cover fitting	480	20.91	1,320	36	167	175
13	HV testing	800	17.69	1,560	51	236	95
14	Sensitivity testing	320	46.18	598	54	246	87
15	Cover screw insertion & screw tightening	496	17.23	1,602	31	142	223
16	Final test on test bench	200	110.43	250	80	368	25
17	Cleaning of job with liquid & apply DUCO paint	400	48.8	566	71	325	41
18	Single box packing	368	23.49	1,175	31	144	219
19	Varton packing (per piece time)	40	148.5	186	22	99	365
20	Pad printing (CE/Specification/LOGO) 3 set up	2,000	5.84	4,726	42	195	136
21	Pad printing(ON/OFF on knob print)	2,000	4.9	5,633	36	163	182

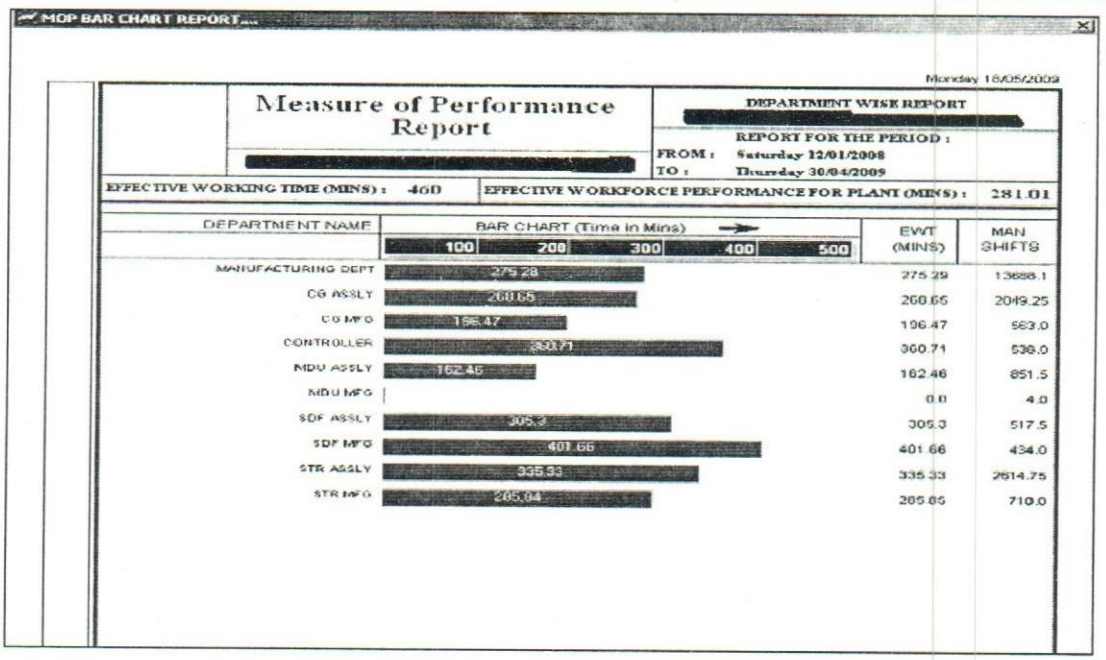


Fig.1: Measure of Performance Report from MDAT

6. Work instruction or standard operating procedure of each operation
7. Pictures and videos of methods

After data collection from various sources, we arrived at final database in MDAT software, which was further enhanced by attaching pictures and videos of each operation. These visual aids would help us identify NVA and waste and also in training quality and safety. Table 3 gives MOST sheets applied over relay soldering operation. Table 4 gives Cycle Time calculated by MOST, comparison with present CT and MOST PI, MOST minutes, improve in productivity, etc.

Performance Control System

MDAT not only produces shopfloor wise graphical report, but it can also provide line wise, operator wise, and workstation wise performance graph. It simplifies the tracking and controlling of performance and detecting various reasons of less output. Daily Job Time Booking Card (JTBC) is used for recording daily performance of worker. Fig.1 shows Measure of Performance (MOP) report from MDAT software.

Implementation

Lean is the set of "tools" that assists in the identification and steady elimination of waste, improvement of quality, and production time and cost reduction. To enhance productivity, a company must use continuous improvement strategy. In this work some workstation wise improvements and layout changes are proposed which leads to reducing cycle time of operations.

Work Balancing

Fig. 2 shows the present situation of work balance and proposes a new concept of work balancing. Work also uses multiactivity chart and suggests one operator for two test benches. It also records the present rejection quantity and identifies key operations where rejection is very high.

Results

Table 5 shows final comparison of present output, MOST o/p, and output after implementing lean concept. Fig. 3 shows the graphical comparison of present, MOST, and Lean MOST output.

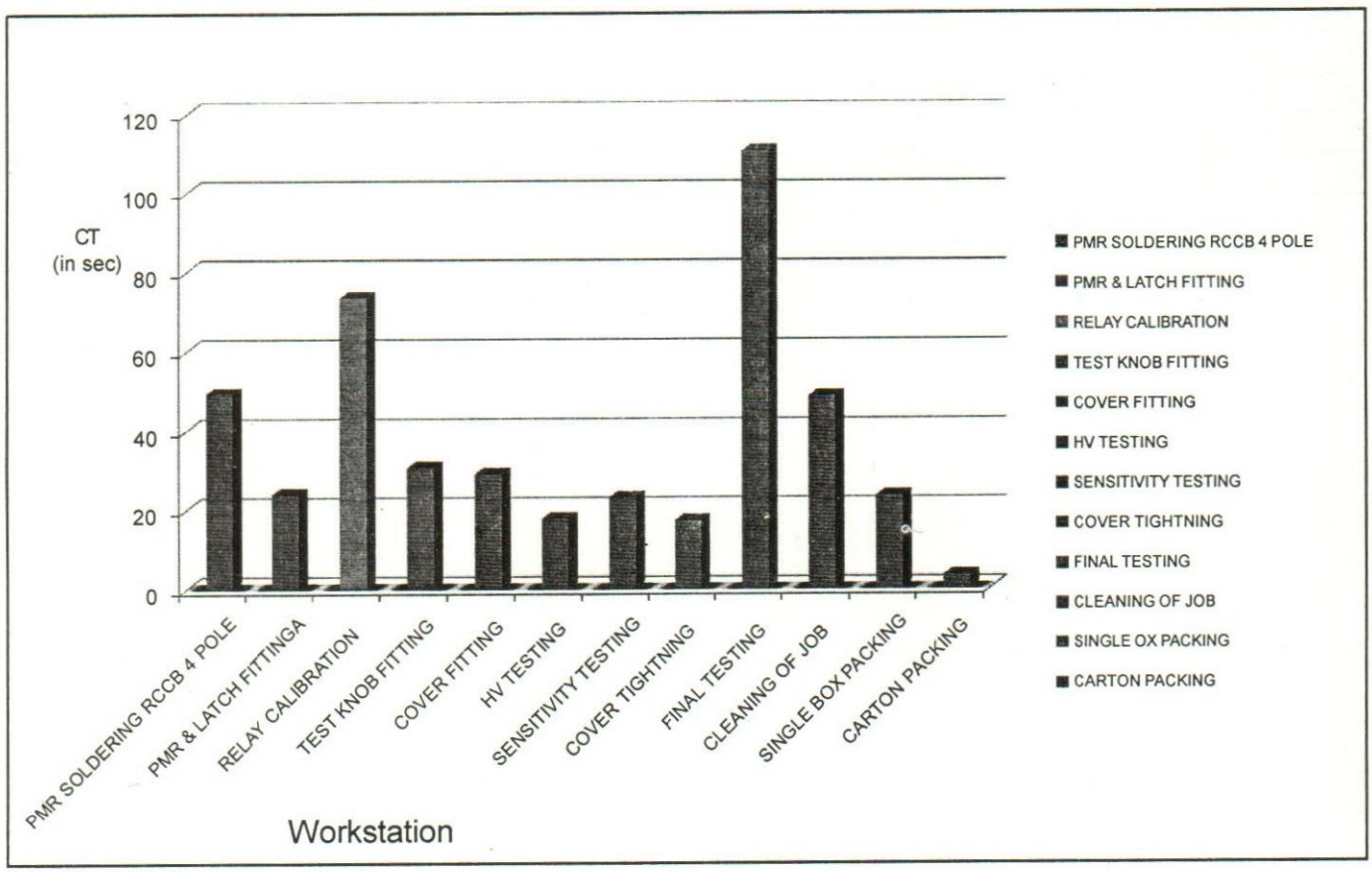


Fig. 2: Present Work Balance for RCCB 4P

Table 5: Comparison of Present, MOST, and Lean MOST Output

Sr. No.	Description	Present o/p Shift	MOST Cycle Time in sec.	MOST o/p	Lean MOST C.T.	Lean MOST o/p
1	PMR soldering	240	49.4	559	49.4	559
2	Bottom plate riveting	1,000	15.93	1733	11.43	2415
3	Latch knob link rivet riveting	2,600	8.46	3262	7.2	3833
4	Latch lever link riveting	2,600	7.73	3571	7.2	3833
5	Latch lever assembly & lever link	1,600	14.59	1892	14.29	1931
6	Latch rotor bunch assembly	1,144	20.96	1317	20.96	1317
7	Center riveting	2,600	5.77	4783	5.77	4783
8	Latch assembly	272	34.17	808	34.17	808
9	Latch top plate riveting	568	18.67	1478	14.17	1948
10	PMR & latch fitting	448	23.95	1152	23.95	1152
11	Relay calibration	180	73.43	376	36.72	752
12	Test knob fitting	500	30.54	904	18.43	1498
13	Cover fitting	480	20.91	1320	10.4	2654
14	HV testing	800	17.69	1560	17.69	1560
15	Sensitivity testing	320	46.18	598	46.18	598
16	Cover screw insertion screw tightening &	496	17.23	1602	17.23	1602
17	Final test on test bench	200	110.43	250	55.22	500
18	Cleaning of job with liquid & apply DUCO paint	400	48.8	566	48.8	566
19	Single box packing	368	23.49	1175	23.49	1175
20	Carton packing (for 45 boxes)	40	148.5	186	148.5	186
21	Pad printing (CE/Specification/LOGO) 3 set up	2,000	5.84	4726	5.84	4726
22	Pad printing(ON/OFF on knob print	2,000	4.9	5633	4.9	5633

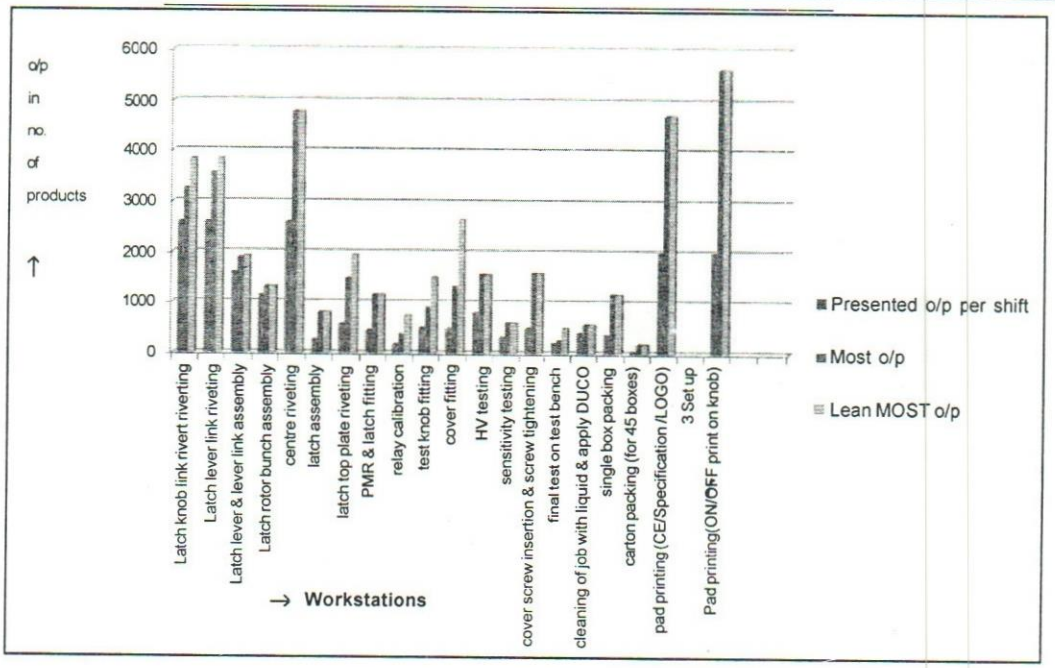


Fig. 3: Comparison of Present, MOST, and Lean MOST Output

Conclusion

It was thus found that the company under study was using time standards formulated eight years back. After MOST implementation on RCCB line, it was observed that time standards used were not appropriate for current processes. The current production data shows EWT is 222 minutes as compared to available 460 MOST minutes. To utilize current resources effectively, it is required to implement MOST standards. MOST implementation, work balancing, and improving workstation wise operations are required to fulfill the demand of 300,000 RCCB per year.

References

Barnes, Ralph M. (2002), *Motion and Time Study Design and Measurement of Work*, 7th edition. Wiley Publication.

Kanawaty, George (2007), *Introduction to Work Study*, 4th edition, pp. 329–36. ILO: Universal Book Corporation.

Meyers, Fred E. and Jim, R. Stewart (2002), *Motion and Time Study for Lean Manufacturing*, 3rd edition. Prentice Hall Publication.

Rabie, A. (2001), "Evaluation of the Accuracy of Basic Most," Prceedings of IERC, May 20–23, Dallas, Texas.

Rabie, Abdurrahman, "Application of Basic Most in Lock's Assembly," Integrated Science & Technology Dept, James Madison University, Harrisonburg, USA.

Zandin, Kjell B. (1999), *Fundamentals of Work Measurement Coursebook*, 2nd edition, pp. 30–112. Maynard and Company, Inc.

Zandin, Kjell B. (2003), *MOST Work Measurement Systems*, 3rd edition (Revised and Expanded). HB Maynard.

"Great spirits have always encountered violent opposition from mediocre minds."

— Albert Einstein

Feature

GA Framework for Job Shop Scheduling Problem with Due Dates

Pankaj Chandna and Ashwani Dhingra

The job shop problem is a well-known NP-hard scheduling problem of combinatorial optimization and has a very wide engineering background. These are computationally complex problems which often have highly domain dependent features and thus tend to need highly domain specific optimization algorithms. Genetic Algorithm (GA) provides a way of separating the optimization algorithm from domain knowledge which has led to promising and useful results in the areas of job shop scheduling. In this paper a novel GA framework to job shop scheduling problems is presented, in which the chromosome is a fixed length string, encoding a schedule in such a way that crossover and mutation always produce valid schedules. The authors have suggested three new due date related performance measures for NP-hard job shop scheduling problems. Experiments are conducted for example problems, and the results confirm the viability of the suggested fitness functions.

Pankaj Chandna is Assistant Professor in the Department of Mechanical Engineering, NIT Kurukshetra and Ashwani Dhingra is Lecturer in the Department of Engineering and Technology at Maharishi Dayanand University, Rohtak.

Introduction

Sequencing and scheduling is a form of decision-making that plays a crucial role in manufacturing and service industries. In the current competitive environment effective sequencing and scheduling has become a necessity for survival in the market place. It has been concluded from the literature survey that scheduling improves productivity, increases throughput rate, reduces WIP, maximizes machine utilization, meets over due rates, satisfies production constraints, and achieves further business objectives.

The job shop problem is a well-known NP-hard scheduling problem of combinatorial optimization and has a very wide engineering background. A general job shop scheduling problem (JSSP) considered in this paper is described as follows: A set of n jobs (J_1, J_2, J_3..... J_n) must be processed on M machines (M_1, M_2, M_3..... M_n) and each job consist of exactly M operations. Each operation uses one of the M machines for fixed duration. The sequence of these operation processed on the machines is restricted by a pre-set job routing. Each machine can process at most one operation at a time and once an operation initiates processing on a given machine, it must complete on that machine without interruption. The operations of a given job have to be processed in a given order. The problem consists in finding a schedule of the operations on the machines.

Since the 1980s much interest has been devoted to the development and application of the meta heuristic algorithm the Genetic Algorithm (GA), inspired by the process of Darwinian evolution and has been recognized as a general search energy also an optimization method which is useful for attacking combinatorial optimization problems. As opposed to other optimization methods, GA works with a population of solutions instead of just a

single solution. GA assigns a value to each individual in the population according to a problem specific objective function. A survival of the fittest step selects individual from the old population. A reproduction step applies operators such as crossover or mutation to these individuals to produce a new population that is fitter than the previous one. GA is an optimization method of searching based on evolutionary process. In applying GA, we have to analyze specific properties of problem and decide on a proper representation, an objective function, a construction method of initial population, a genetic operator, and a genetic parameter. Job shop scheduling are highly computationally complex problems which often have highly domain dependent features and thus tend to require highly domain specific optimization algorithms. GA provides a way of separating the optimization algorithm from domain knowledge which has led to promising and useful results in the areas of job shop scheduling. Davis (1985) proposed the first GA based technique to solve job shop scheduling problems JSSPs.

In this paper a novel GA framework to JSSPs is presented, in which the chromosome is a fixed length string, encoding a schedule in such a way that crossover and mutation always produce valid schedules. First, fitness function used in this work is the total weighted squared tardiness. This has been selected as it is a compromise of the two due-date related performance measures, that is, maximum tardiness and total weighted tardiness and also a comprehensive measure of due-date performance. The second case considered here is when all jobs have been assigned a common due date, then the fitness function is to minimize the sum of squares of deviations of job completion times from the given common due date. Third case suggested fitness function is to minimize the product of number of tardy jobs and total weighted squared tardiness. Experiments are conducted for example problems, and the results confirm the viability of the suggested fitness function.

Due Date Performance

In the light of increasing global competition, companies are required to deliver customized products in a shorter lead-time and on schedule. As a result production planning is under constant pressure to shorten lead times and meet customer due dates. Lack of success in meeting due dates can result in the loss of customer and market competitiveness. The scheduling theory has not evolved to consider the consequences of missing due dates because of the reason that these consequences are very fuzzy and are almost impossible to measure with much precision, thus most companies assign precise due dates to every job because assigning it is very easy. Then they rely upon the production scheduler to know the consequences of missing every due date and to somehow produce a schedule that balances these consequences. Due date performance can be quantitatively measured by the conformity of a schedule to the assigned due dates. Particular measures are functions of jobs flow time and assigned due date such as job lateness, job tardiness, and job earliness.

Most production scheduling problems are computationally intractable in terms of an optimal solution and as a result myopic dispatching rules are often used. Tasgetiren et al. (1995) stated that not only priority rule but also due date arrangement method affect the job shop performance. Therefore, to produce better results specific due date assignments methods for specific performance measures must be used. Job shops with the total weighted tardiness as objective have been the focus of a number of studies Anderson and Nyiernda (1990) showed two kinds of rules that combine two dispatching rules to minimize tardiness in a job shop. He et al. (1996) considered a generalized JSSP with due dates with the objective of minimizing tardiness. On the other hand, Singer and Pinedo (1998) presented a branch and bound algorithm for minimizing the total weighted tardiness in job shops. Pinedo and Singer (1999) also worked on a heuristic, which is based on the shifting bottleneck procedure (SBP). Asano and Ohta (2002) developed a heuristic algorithm based on the tree search procedure to minimize the total weighted tardiness with job-specific due dates and delay penalties in a job shop. They reduced the computational time for finding sub optimal solution to a great extent.

Performance Measure

It is not easy to state objectives in scheduling. They are numerous, complex, and often conflicting. Previous research on scheduling has concentrated mainly on regular performance measures in which the objective functions are non-decreasing in completion time. Recently researchers have begun to study objective functions that are not regular. Commonly used such measures are total earliness plus total tardiness and total weighted earliness plus total weighted tardiness in which the weight associated with the earliness of job may be different from the weight associated with the tardiness of the job.

In the literature it has been noticed that mostly heuristics are based upon the intuition of the structure of a near optimal

schedule in a job shop with maximum flow time and total completion time as the performance measures (Applegate and Cook, 1991; Brucker et al., 1994; Carlier and Pinson, 1989; Park et al., 2003; Pinedo, 2001; Ponnambalam et al., 1999; Tavakkoli and Daneshmand, 2005; Van Laarhoven et al., 1992). As tardiness problem is becoming more and more important as compared to the make—span problem, in certain practical situations other performance measures for due date performance such as job lateness, job tardiness, and job earliness are drawing more attention (Rajendran and Parthasarthy, 1997; Shanthikumar, 1983).

Some researchers have also suggested algorithms considering dual criteria or multiple objective functions. Gupta and Ramnarayanan (1996) considered static single machine scheduling problem with the objective of minimizing the maximum tardiness of any job subjected to the constraint that the total number of tardy jobs is minimum. Duffua et al. (1997) proposed an algorithm for one machine scheduling problem with the objective of minimizing the mean tardiness subjected to maintain a prescribed number of tardy jobs. Ovacik and Uzsoy (1997) presented an excellent treatise of the application of decomposition methods and shifting bottleneck techniques to large-scale job shops with several objectives. Chakravarthy and Rajendran (1999) considered scheduling in a flow shop with the bicriteria of make span and maximum tardiness minimization. Onwubolu and Mutingi (1999) considered three different objective functions for a flow shop-scheduling problem: minimizing total tardiness; minimizing number of tardy jobs; and minimizing two functions simultaneously for a flow shop-scheduling problem. Thiagarajan and Rajendran (2005) presented dispatching rules in order to minimize the sum of weighted earliness and weighted tardiness of jobs also used the objective function of minimization of the sum of weighted earliness, weighted tardiness and weighted flow time of jobs in a job shop.

GA Framework: Representation

In this paper a novel approach to JSSPs is presented, in which the chromosome is a fixed length string, encoding a schedule in such away that crossover and mutation always produce valid schedules. The idea of representation is as follows: the genotype for a j x m problem we use is a string containing j x m chunks (genes), each chink being large enough to hold the largest job number (j). It provides instructions for building a legal schedule as follows. The string of chunks a, b, c... means the following: put the first untackled task of the ath uncompleted job into the earliest place where it will fit in the developing schedule. Then put the first untackled task of the bth uncompleted job into the earliest place where it will fit in the developing schedule, and so on. The task of constructing an actual schedule is handled by a schedule builder, which maintains a circular list of uncompleted jobs and a list of untackled tasks for each such job. Thus, the notion of "'ath uncompleted"' job is taken modulo the length of the circular list to find the actual uncompleted job. In this paper we investigate the general JSSPs, which are mostly based on the assumptions considered by Conway et al. (1967).

Fitness Functions

The fitness function used in this work is the total weighted squared tardiness, which is defined as follows:

If C_j be the completion time of a job "'j"' having due date d_j then the tardiness is given by:

$$T_j = \{C_j - d_j\} \text{ if } C_j - d_j \geq 0$$

$$= 0 \qquad \text{otherwise.}$$

Then fitness function is given as:

$$\text{minimize} \quad \sum_{j=1}^{n} w_j T_j^2 \tag{1}$$

where w_j is the weight attached to the job.

This measure of due date performance has been selected over the other due date based performance measure for the reasons discussed in the next paragraph.

One of the common due date performance is the total weighted tardiness defined as:

$$T = \sum_{j=1}^{n} w_j T_j \tag{2}$$

The problem with measure in Equation (2) is that a single job may contribute the majority of the tardiness without regard to how overall tardiness is distributed. Also using Equation (2) would give undesirable scenario if: (i) tardiness represent an important attribute to service quality and (ii) the assertion holds that a customers dissatisfaction tends to increase quadratically with the tardiness as proposed in Taguchi's loss function. Another commonly used due date performance measure is maximum tardiness (T_{max}) defined as:

$$T_{max} = \max w_j T_j \quad (3)$$

This does not distinguish between tardiness that occurs in all jobs versus a single job as long as the maximum weighted tardiness is the same. Due to these facts the total weighted squared tardiness is used as objective function in this problem formulation as this is a compromise of the two due date related performance measures mentioned above and is comprehensive measure of due date performance.

The second case arises when all the jobs have been assigned a common due date, then the fitness function reduces to minimize mean of squares of deviations of job completion times from the given common due date.

If C_j be the completion time of a job "'j'" having a common due date "'d'" then the deviation is given by:

$$D_j = \{C_j - d\} \quad \text{if } C_j - d_j \geq 0$$
$$= 0 \quad \text{otherwise.}$$

Then fitness function is given as:

$$\text{minimize} \sum_{j=1}^{n} w_j D_j^2 \quad (4)$$

where w_j is the weight attached to the job.

The third case suggests fitness function takes care of the most commonly used performance measure also, that is, the number of tardy jobs and is defined as the minimization of product of number of tardy jobs (N_T) and total weighted squared tardiness:

$$\text{minimize } N_T \sum_{j=1}^{n} w_j T_j^2 \quad (5)$$

where $n \geq N_T \geq 1$.

Schedule Builder

When generating a schedule the most common way is to choose an operation from a set of scheduleable operations one at a time and assign a start time to each. A scheduleable operation is an operation whose preceding operations have been completed. The schedule builder has considered all the four cases for any feasible schedules, that is, inadmissible, semiactive, active, and non-delay schedules. The number of inadmissible schedule or schedule with excess idle time is infinite and of no interest in schedule generation because it is useless under any measure of performance. A semi-active schedule contains no excess idle time. A semi-active schedule can also be improved if we can shift it by skipping some operations to the front without causing other operations to start later that the original schedules. The optimal schedule is guaranteed to fall within the active schedules; the active schedule is also a superset of non delay schedules. In a non-delay schedule, a machine is never kept idle if some operation can be processed. The active schedules are generally the smallest dominant set in the job shop problem and best schedule is necessarily an active schedule. The non-delay schedules are a subset of active schedules, so the numbers of them are smaller than those of active schedules; however, they are not dominant though the average solution quality may be better than the active schedule.

Results

Experiments are conducted for a number of example due date JSSPs with all the three suggested fitness functions. Results obtained confirm the viability of the suggested fitness functions. Input and output for one 6×6 example due date JSSP shop has been described in detail. Table 1 gives due date matrix for 6×6 example JSSP for different due dates; as all the jobs can not be taken up at the same priority levels, a weighting coefficient is allotted to each job along with due date so that they can be simultaneously dealt with for minimization of objective function. Each job can have arrival time, that is, the time after which the job becomes able to be scheduled. Table 2 gives the processing times of each job on each machine. Tables 3 and 4 give the same input data for 6×6 example JSSP having a common due date for all the jobs. This input has been used for minimization of second objective function defined earlier. Input for third fitness function is

Table 1: Due Date Matrix for 6×6 Example JSSP for Different Due Dates

Job	Due Date	Arrival Time	Weight Coefficient
1	30	0	1
2	35	0	1
3	40	0	1
4	45	0	1
5	50	0	1
6	55	0	1

Table 2 : Processing Time Matrix for 6×6 Example JSSP for Different Due Dates

Machine? → Job ↓	1	2	3	4	5	6
1	3	6	1	7	6	3
2	10	8	5	4	10	10
3	9	1	5	4	7	8
4	5	5	5	3	8	9
5	3	3	9	1	5	4
6	10	3	1	3	4	9

Table 3: Due Date Matrix for 6×6 Example JSSP for a Common Due Date

Job	Due Date	Arrival Time	Weight Coefficient
1	40	0	1
2	40	0	1
3	40	0	1
4	40	0	1
5	40	0	1
6	40	0	1

Table 4: Processing Time Matrix for 6×6 Example JSSP for a Common Due Date

Machine? → Job ↓	1	2	3	4	5	6
1	3	6	1	7	6	3
2	10	8	5	4	10	10
3	9	1	5	4	7	8
4	5	5	5	3	8	9
5	3	3	9	1	5	4
6	10	3	1	3	4	9

same as described in Tables 1 and 2. The program was run in the LINUX environment. Output of the program for the 6×6 example JSSP has been shown in Tables 5, 6, and 7 for three suggested performance measures.

Conclusion

In the literature it has been noticed that mostly heuristics are based upon the intuition of the structure of a near optimal schedule in a job shop with maximum flow time and total completion time as the performance measures. As tardiness problem is becoming more and more important as compared to the make span problem, due date related performance measure such as job lateness, job tardiness and job earliness are drawing more attention. However, previous research in the JSSP has provided several insights into the development of both job shop scheduling heuristics and due date assignment heuristics. The past scheduling practice does not support responding to above competitive demand. In this paper the authors have suggested three new due date related performance measures for NP-hard job shop scheduling problem JSSPs. First measure, that is, total weighted squared tardiness is a compromise of the two most widely used due date related performance measures, that is, maximum tardiness and total weighted tardiness and also a comprehensive measure of due date performance. The second measure can be used for a special problem when all the jobs have been assigned a common due date, the fitness function is to then minimize mean of squares of deviations of job completion times from the given common due date. Initially, minimizing number of tardy jobs was also the most commonly used objective to measure for JSSPs. Because of its limitations when using it as an individual objective function, researchers used this function as one of the performance measure when dealing with multiple objective functions JSSPs. Third suggested fitness function here is to minimize the product of number of tardy jobs and total weighted squared tardiness. Experiments are conducted for example problems, and the results confirm the viability of the suggested fitness functions.

Table 5: Output of the Program for Fitness Function 1

Value of Fitness Function 1: 383.00
Generation : 501

Job	1	2	1	3	3	2	1	3	5	2	4	1	6	4	1	6	5	4	1	3	2	4	4	3	6	2	3	4	2	6	5	5	6	5	6	5
Machine	3	2	1	3	4	3	2	6	3	5	2	4	2	1	6	4	2	3	5	1	6	4	5	2	6	1	5	6	4	1	5	6	5	1	3	4
Start	1	1	2	2	7	9	9	11	14	14	15	15	20	20	22	23	23	25	25	25	25	30	33	34	35	35	41	44	45	45	48	53	55	57	59	60
Finish	1	8	4	6	10	13	14	18	22	23	19	21	22	24	24	25	25	29	30	33	34	32	40	34	43	44	47	52	48	54	52	56	58	59	59	60

Table 6: Output of the Program for Fitness Function 2

Value of Fitness Function 2: 161.40

Generation: 501

Job	1	2	1	3	3	2	4	3	6	4	5	2	6	1	3	6	5	4	5	3	4	6	2	1	4	1	6	2	5	6	1	4	5	2	3	5
Machine	3	2	1	3	4	3	2	6	2	1	3	5	4	2	1	6	2	3	5	2	4	1	6	4	5	6	5	1	6	3	5	6	1	4	5	4
Start	1	1	2	2	7	9	9	11	14	14	14	14	17	17	19	20	23	23	26	28	28	29	29	31	31	39	39	39	42	43	43	46	49	49	49	53
Finish	1	8	4	6	10	13	13	18	16	18	22	23	19	22	27	28	25	27	30	28	30	38	38	37	38	41	42	48	45	43	48	54	51	52	55	53

Table 7: Output of the Program for Fitness Function 3

Value of Fitness Function 3: 1732.00

Generation: 502

Job	1	2	1	3	3	2	1	3	5	2	4	1	6	4	1	5	6	4	1	3	2	4	5	3	2	5	3	6	4	5	2	5	6	4	6	6
Machine	3	2	1	3	4	3	2	6	3	5	2	4	2	1	6	2	4	3	5	1	6	4	5	2	1	6	5	6	5	1	4	4	1	6	5	3
Start	1	1	2	2	7	9	9	11	14	14	15	15	20	20	22	23	23	25	25	25	25	30	31	34	35	36	36	40	43	45	45	49	49	51	59	63
Finish	1	8	4	6	10	13	14	18	22	23	19	21	22	24	24	25	25	29	30	33	34	32	35	34	44	39	42	48	50	47	48	49	58	59	62	63

References

Anderson, E.J. and Nyirenda, J.C. (1990), "Two New Rules to Minimize Tardiness in a Job Shop," *International Journal of Production Research*, 91: 99–117.

Applegate, D. and Cook, W. (1991), "A Computational Study of the Job Shop Scheduling Problem," *ORSA Journal on Computing*, 13: 149–56.

Asano, M. and Ohta, H. (2002), "A Heuristic for Job Shop Scheduling to Minimise Total Weighted Tardiness," *Computers & Industrial Engineering*, 42: 137–47.

Brucker, P., Jurisch, B., and Sievers, B. (1994), "A Branch and Bound algorithm for the Job Shop Problem,", *Discrete Applied Mathematics*, 49: 107–27.

Carlier, J. and Pinson, E. (1989), "An Algorithm for Solving the Job Shop Problem," Management Science, 35: 164–76.

Chakravarthy, K. and Rajendran, C. (1999), "A Heuristic for Scheduling in Flowshop with the Bicriteria of Makespan and Maximum Tardiness minimization," Production Planning and Control, 10: 707–14.

Conway, R.W., Maxwell, W.L. and Miller, L.W. (1967), *"Theory of Scheduling,"* Addison Wesley Publishing Company.

Davis, L. (1985), "Job Shop Scheduling with Genetic Algorithm," Proceedings of the International Conference on Genetic Algorithms and their applications, 136–49. Hillsdale: Lawrence Erlbaum.

Duffua, S.O., Raouf, A., Ben-Daya, M., and Makki, M. (1997), "One-Machine Scheduling to Minimize Mean Tardiness with Minimum Number Tardy," *Production Planning and Control*, 8: 226–30.

Gupta, J.N.D. and Ramnarayanan, R. (1996), "Single Facility Scheduling with Dual Criteria: Minimizing Maximum Tardiness Subject to Minimum Number of Tardy Jobs,"*Production Planning and Control*, 7: 192–96.

He, Z., Yang, T. and Tiger, A., (1996), "An Exchange Heuristics Imbedded with Simulated Annealing for Due-Dates Job Shop Scheduling," *European Journal of Operational Research*, 91: 99–117.

Onwubolu, C. Godfrey and Mutingi, M. (1999), "Genetic Algorithm for Minimizing Tardiness in Flow Shop Scheduling," *Production Planning and Control*, 10: 462–71.

Ovacik, I.M. and Uzsoy, R. (1997), *"Decomposition Methods for Complex Factory Scheduling Problems,"* Kluwer Boston: Academic Publisher.

Park, B. J., Choi, H.R., and Kim, H. S. (2003), "A Hybrid Genetic Algorithm for the Job Shop Scheduling Problems," *Computers & Industrial Engineering*, 45: 597–13.

Pinedo, M. and Singer, M. (1999), "A Shifting Bottleneck Heuristic for Minimising the Total Weighted Tardiness in a Job Shop," *Naval Reasearch Logistics*, 46: 1–12.

Pinedo, M. (2001), "*Scheduling Theory, Algorithms and Systems*' 2nd edition. New Jersey: Englewood Cliffs, Prentice Hall.

Ponnambalam, S.G., Jawahar, N., and Aravindan, P. (1999), "A Simulated Annealing Algorithm for Job Shop Scheduling," *Production Planning and Control*, 10: 767–77.

Shanthikumar, J.G. (1983) "Scheduling N-Jobs on One Machine to Minimize the Maximum Tardiness," *Computers and Operations Research*, 10: 255–67.

Singer, M. and Pinedo, M. (1998), "A Computational Study of Branch and Bound Techniques for Minimising the Total Weighted Tardiness in Job Shops," IIE Transanctions, *Scheduling and Logistics*, 30: 109–18.

Tasgetiren, M.F., Cedimoglu, Y.H., and Ince, B. (1995), "A Investigation on Due Date Assignment Methods," Proceedings of the 1995 Operation Research and Industrial Engineering Conference, METU, Ankara, July 10–11.

Tavakkoli-Moghaddama, R. and Daneshmand-Mehr, M. (2005), "A Computer Simulation Model for Job Shop Scheduling Problems Minimizing Makespan," *Computers and Industrial Engineering*, 48: 811–23.

Thiagarajan, S. and Rajendran, C. (2005), "Scheduling in Dynamic Assembly Job-shops to Minimize the Sum of Weighted Earliness, Weighted Tardiness and Weighted Flowtime of Jobs," *Computers and Industrial Engineering*, 49: 463–03.

Van Larhoven, P.J.M., Arts, E.H.L., and Lenstra, J.K. (1992), "Job Shop Scheduling by Simulated Annealing," *Operation Research*, 40: 113–25.

"Production is not the application of tools to materials, but logic to work"

— Peter F. Drucker

Feature

Total Factor Productivity Growth in Indian Manufacturing Sector in an Era of Economic Liberalization: A Review

Dipayan Datta Chaudhuri

The objective of this paper is to provide an overview of the recent studies on Total Factor Productivity (TFP) growth rate of the Indian manufacturing sector in the reform period (from early 1990s) and to address issues relating to broad contours of methodology of estimation of TFP growth rates and data sources taking stock of the major studies carried out in this area. The methodology, study period, and nature of data (that is, time-series or cross-section) have to some extent contributed to divergent results.

Dipayan Datta Chaudhuri is Associate Professor at the Indian Institute of Management Indore.

Introduction

There has been a paradigm shift in economic policy regime in 1991—a move from controlled regime of earlier decades towards liberalization and reliance on market forces. Some of the reform measures on the trade front have included reduction and rationalization of the tariff rates, removal of quantitative restrictions on imports, and, largely, market determined exchange rate. Industrial policy and policies relating to foreign direct investment and foreign technology imports are also liberalized. The policy of import liberalization is expected to have favorable impact upon industrial productivity as it provides firms greater and cheaper access to imported capital and intermediate goods. In the context of this shift in policy, it is appropriate to question how far has import liberalization contributed to the better productivity performance of Indian industry in the post-1991 period.

Objective

A number of studies have examined whether there has been a significant acceleration in the productivity growth rate in Indian manufacturing sector in post-1991 period compared to the earlier years. The findings of these studies based on industry-level as well as firm-level time-series and cross-section data are mixed. The objective of this paper is to provide an overview of the recent studies on Total Factor Productivity (TFP) growth rate of Indian manufacturing sector in the reform period (that is, from early 1990s). This study will also address the issues relating to broad contours of methodology of estimation of TFP growth rates and data sources taking stock of the major studies carried out in this area. The methodology, study period, and nature of data (that is, time- series or cross-section) have to some extent contributed to divergent results.

Methodology

The studies on TFP growth of Indian industry have broadly followed either the *growth accounting method* or the *production function approach*. Both the methods have their own limitations. The TFP indices such as Kendrick Index, Solow Index, and Translog Index under the growth accounting method are derived on the basis of assumptions of constant returns to scale, perfect competition, and payment to factors according to marginal product. The advantage of the production function approach is that such assumptions are not required to derive the TFP growth rate. However, in this case, there are problems of identification of the production function (at any level of aggregation) and of simultaneity between output and input decisions; time-series estimation of the production function is also plagued by serial correlation and multicollinearity problems (Rao, 1996).

Output or value added can be taken for the measurement of productivity. In the measurement based on output, usage of raw materials or inputs should be taken into consideration along with the capital stock and labor. If the productivity is measured on the basis of value added, then care should be taken to ensure proper deflation to arrive at value added. According to Balakrishnan and Puspangadan (1994) the productivity growth should be measured following the double-deflation method where output and material inputs are deflated separately by their respective price indices instead of the single deflation method.

Industry-level Studies

There have been a number of studies on TFP growth in the manufacturing sector. Some notable studies are by Ahluwalia (1991), Balakrishnan and Pushpangadan (1994, 1995, 1996), Dholakia and Dholakia (1995), and Rao (1996). These studies debated on the issue whether there is a "'turnaround"' in the TFP growth rate during 1980s compared to the earlier period. It appeared that the method of deflation of value-added—single or double—influences the estimates of TFP growth rate to a great extent. These studies are not taken up for discussion here as the focus of this paper is the productivity performance of the Indian manufacturing sector in the 1990s.

The study of Trivedi et al. (2000) has provided the estimates of productivity by using the gross output (TP) function, single (TFPS), and double (TFPD) deflation methods of value added. The rates of growth of TP, TFPS, and TFPD are found to be 1%, 2.6%, and 4.4% per annum, respectively during 1981–98. All the estimates of productivity have indicated deceleration in the growth rates between 1981–90 and 1990–1998 (Table 1). Five industries—textile, metal, machinery and transport equipment, chemical, and leather—are selected on the basis of their contribution to India's export earnings. It is observed that textile, machinery and transport equipment, and chemical industries are the better performers, whereas metal and leather industries are the worst performers. In all industries, barring the metal industry, input prices have risen faster than output prices. So, the stabilization of input prices, in a situation where output prices are getting stabilized due to import liberalization, is necessary. The study concludes that with the pressure mounting on India to adhere to labor and environmental standards, Indian industries will have to prepare strategies for economizing the use of inputs and curtailing costs so as to remain competitive in the global trading environment.

Goldar and Kumari (2003) in a disaggregate study have examined how far the import liberalization contributed to the better productivity performance of Indian manufacturing sector in the post-1991 period. The TFP growth rate is estimated using a three-input framework following the study of Jorgenson et al. (1987). This study has observed that the rate of growth of TFP had declined from 1.89% per annum to 0.69 % per annum between 1981–91 and 1990–98 (see Table 1). Capacity utilization is found to be a significant factor influencing productivity growth in industries and there is an increase in capacity utilization in manufacturing in the 1980s and a fall in the 1990s. After making corrections for changes in capacity utilization, the TFP growth estimates for the 1990s are found to be about the same as in the previous decade.

In this study, the growth rates of TFP computed for the 17 two-digit industries for the period 1981–82 to 1997–98 are pooled for the regression analysis. The explanatory variables for the regression analysis are growth rate of output in an industry, the Effective Rate of Protection (ERP) accorded by tariff to an industry, the extent of Non-Tariff Barriers (NTB) on imports in an industry, the ratio of recently made investments to existing capital stock (IKR) in an industry, the Real Effective Exchange Rate (REER), the growth rate of agricultural output, and a dummy variable for the post-liberalization period (taking value one for 1991–92 onwards and zero for earlier years). The coefficients of output growth, agricultural growth, and REER are found to be positive and statistically significant. The coefficient of the NTB is found to be positive but not significant. The

Table 1: Total Factor Productivity Growth Rates (% per annum)

Study	Sectors	1973–80	1980–90	1990–98	1981–98	Remarks
Trivedi et al. (2000)	Manufacturing^{S} Manufacturing^{D} Manufacturing^{O}	1.04 2.00 0.57	3.60 7.63 1.66	1.97 3.76 0.95	2.6 4.4 1.0	Declines
Goldar and Kumari (2003)		1981–91	1990–98	1981–98		Declines
	Manufacturing	1.89	0.69	1.40		
Unel (2003)		1979–90	1990–91	1991–97		Increases
	Manufactuing[1] Manufactuing[2]	1.8 3.2	-8.8 -7.2	2.5 4.7		
TSL (2003)		1981–93	1993–2000			Increases
	Manufacturing	0.68	0.97			
Goldar (2004)		1979–91	1991–98			Declines
	Manufacturing	2.14	1.00			
Das (2004)		1980–85	1986–90	1991–95	1995–2000	Overall Decline in 90's over 80's
	Intermediate Goods	-1.26	1.17	-0.39	1.76	
	Capital Goods	0.34	2.23	0.62	-0.51	
	Consumer Goods	0.79	1.03	1.43	-5.06	
Virmani (2004)		1950–64	1965–79	1980–91	1992–2003	Increases
	Manufacturing	0.4	-0.8	1.3	2.8	
Goldar (2006)		1981–89	1990–97	1981–97		Declines
	Manufacturing^{S}	4.52	1.86	3.36		
	Manufacturing^{D}	8.97	2.92	5.79		
	Manufacturing^{O}	2.13	0.90	1.49		
Banga and Goldar (2007)		1981–90	1991–2000	1981–2000		Declines
	Manufacturing with Services[3]	0.88	0.26			
	Manufacturing with Services[4]	1.3	0.5	0.8		Declines
	Manufacturing without Services[4]	0.5	1.1	0.7		Increases
Sidhu (2007)	Industry	1983–93	1993–2003			Declines
		4.47	2.80			

Notes: 1 TFP calculated assuming the actual labor shares equal to the labor elasticity.
2 TFP calculated assuming a constant labor elasticity of 0.6.
3 Based on the data from 148 three-digit-level industries.
4 Based on the data from 41 industry groups.
Manufacturing^{S}: Single deflated value added.
Manufacturing^{D}: Double deflated value added.
Manufacturing^{O}: Gross output function (three-input model).

coefficients of IKR and ERP are found to be negative and significant. The variable IKR is included to capture the effect of gestation lags on productivity. The negative coefficient of ERP indicates the productivity enhancing effect of tariff reform through increased competitive pressure on domestic manufacturing sector.

Unel (2003) has concluded that TFP growth rates in aggregate manufacturing and many sub-sectors have accelerated after the 1991 reforms. The growth rate of TFP in aggregate manufacturing is estimated as 1.8% per annum for the period 1979–90 and 2.5% per annum for the period 1991–97. The estimate is based on the value-added function framework, taking value added as output, and labor, and capital as inputs. Unel has presented a second estimate of TFP growth, by assuming the elasticity of output (value added) with respect to labor to be 0.6 rather than taking the elasticity to be equal to the income share of labor. According to this estimate, the average annual growth rate in TFP in Indian manufacturing is 3.2% during 1979–90 and 4.7% during 1991–97. Both estimates indicate higher TFP growth rate in Indian manufacturing in the post-1991 period as compared to the pre-1991 period.

A relatively faster growth in TFP in Indian manufacturing in the post-1991 period as compared to the pre-1991 period has been reported in a study undertaken by the Tata Services Limited (TSL), Department of Economics and Statistics (2003). In the TSL study, TFP estimates have been made for the organized manufacturing sector for the period 1981–82 to 1999–2000. Estimation of TFP growth has been carried out by using the gross output function framework, rather than the value-added function framework. The estimated average annual growth rate of TFP in manufacturing is 0.68% for the pre-1991 period (1981–82 to 1992–93) and 0.97% for the post-1991 period (1993–94 to 1999–2000).

Goldar (2004) has identified certain shortcomings in the methodology of these two studies and has provided an alternative set of estimates of TFP growth following by and large the methodology of input and output measurement adopted in the studies of Unel and TSL. The starting year of the series on gross fixed capital formation (GFCF) used by Unel is 1970–71. Thus, for computing net fixed capital stock for 1979–80, the base year of the study, the real fixed investment series for the previous 10 years has been used. This appears to have caused a significant underestimation of capital input for the base year of the study, affecting thereby the estimate of growth rate of capital input and hence of TFP. Unel has not used a long enough investment series prior to base year to get a good estimate of base year capital stock. While making comparison of productivity growth performance between the pre- and post-1991 periods, the TSL study has taken TFP growth in 1991–92 and 1992–93 as a part of the productivity growth performance in the pre-1991 period. According to Goldar, rather than including 1991–92 and 1992–93 in the pre-1991 period, it perhaps would have been better to leave out these two years from both the pre-1991 and post-1991 periods while making inter-period comparison of TFP growth rates. The data for aggregate factory sector for 1998–99 and 1999–2000 have been used along with such data for earlier years without making adjustment for differences in industrial coverage. This has given rise to a problem of data incomparability, affecting the estimates of TFP growth for the post-1991 period. While making an estimate of real value of intermediate inputs used by manufacturing, the study does not take into account the fact that besides materials, power, and fuel, the manufacturing units use other intermediate inputs. Since deflated value of materials, power, and fuel are used to measure intermediate inputs, this has led to an underestimation of the growth rate of intermediate inputs in the post-1991 period, thus affecting the TFP estimates upwards. Moreover, the expenditure on materials, power, and fuel has been deflated by the price index for manufactured products. Thus, the price index used for deflating the value of materials an energy inputs is the same as that used for deflating gross output. This is another limitation of the study.

Goldar has derived the implicit deflator for GFCF for registered manufacturing from the data on GFCF in registered manufacturing at current and constant prices given in the National Accounts Statistics (NAS). The deflator series is constructed for the period 1959–60 to 1999–2000.Gross fixed investment for the years 1971–72 to 1999–2000 is computed from the Annual Survey of Industries (ASI) data. The series is extrapolated backwards to 1959–60 with the help of the series on GFCF in registered manufacturing (current prices) given in the NAS. According to Goldar, the TFP growth rate is 2.14% for the period 1979–91 and much lower at 1% for the period 1991–98.

Das (2004) using the ASI data from 75 three-digit industries from 10 sectors has examined the productivity performance of Indian manufacturing under different trade regimes. The sectors taken for the study are cotton textiles, textile products, leather and leather products, basic chemicals, rubber, plastics and petroleum products, basic metals, metal products, non-electrical machinery, electrical machinery, and transport equipment. These sectors seem to be the beneficiaries of the tade and industrial policy changes of the 1980s and 1990s. While analyzing the productivity growth, the growth accounting methodology is adopted. The TFP growth for each industry is calculated using the Tornqvist index. The study period is divided into

four phases such as 1980–85 (the emergence of thinking about the need for change in trade policies), 1986-90 (the long-term fiscal policy and simplification of the tariff structure), 1991–95 (comprehensive changes in trade policy), and 1996–2000 (Exim Policy of 1997-2000 aiming at simplified procedures and rationalized tariff rates). The TFP growth rates of the use-based sectors, namely, Intermediate Goods, Capital Goods, and Consumer Goods during four phases are shown in Table 1. This study has observed that there is a marked fall in the growth rate of TFP in the 1990s from that in the 1980s. The contribution of TFP to output growth has declined from 7.3% during 1980s to –0.18% during 1990s.

The primary focus of Virmani's (2004) paper is to estimate the trends of TFP growth for the economy as a whole. An effort is also made to estimate TFP growth for all sectors of the economy. Virmani showed that there are two statistically distinguishable phases of growth: (i) Indian version of socialism (1950–51 to 1979–80) and (ii) market reforms (1980–81 to 2003–04). It has also highlighted four sub-phases : IA quest for commanding heights (1950–51 to 1964–65), IB legislative-bureaucratic socialism or a socialist rate of growth (1965–66 to 1979–80) , IIA modest reforms (1980–81 to 1991–92) and IIB broader reforms (1992–93 to 2003–04). The study has observed that the TFP growth rates in the manufacturing sector are 0.4%,-0.8%, 1.3%, and 2.8% during the sub-phases IA, IB, IIA, and IIB, respectively. So, the TFP growth rate in the manufacturing sector has accelerated in the 1990s in comparison with 1980s. The TFP growth rate has reached its peak at 3% in the manufacturing sector in the year 1993–94. The contribution of the manufacturing sector in total TFP growth rate increased from 8% to 11% between the sub-periods IIA and IIB.

After analyzing the existing studies, Goldar (2006) presented new estimates of productivity growth in Indian manufacturing for the period of 1981–82 to 1997–98. The study period is divided into two sub-periods, that is, 1981–82 to 1989–90 and 1990–91 to 1997–98. It is observed that between these two sub-periods, the estimated growth rate of TFP has declined from 4.52% per annum to 1.86% per annum in the case of single deflated method, from 8.97% to 2.92% per annum in the case of double deflated method, and from 2.13% per annum to 0.90% per annum when gross output function is used instead of the value added function. So, the TFP growth rate in Indian manufacturing sector has decelerated during 1990s in comparison with 1980s. According to Goldar, there is considerable potential for productivity improvement in the beginning of the 1980s, for example, an overhung of employment existing by the end of the 1970s. This potential is used for attaining a rapid growth in productivity. As this source of productivity growth got exhausted, it became difficult to maintain a rapid growth in productivity in the 1990s. Another possible explanation is as there is a spurt in investment activity in the 1990s in response to economic reforms, the adverse effect on productivity is attributed to gestation lags. In that case, one could expect a pick-up in productivity growth in the coming years.

Goldar has also provided estimates of TFP growth rates for two-digit industries. Among 17 industrial sectors at two-digit level, TFP growth rate declined in 11 sectors during 1990–97 compared to 1981–89. Sectors such as jute textiles, paper and paper products, leather and leather products, basic metal and alloys, metal products, and transport equipments have experienced increase in the TFP growth rate during 1990s.

Banga and Goldar (2007) have analyzed the growing use of services as input in Indian manufacturing sector during 1990s. The study period is 1980–81 to 1999–2000, divided into two sub-periods, that is, 1980– 81 to 1989–90 and 1990–91 to 1999–2000. The study has estimated the KLEMS (or Capital–Labour–Energy–Materials–Services) production function using ASI data for 148 three–digit–level industries. It has been observed that the TFP growth rate has decelerated from 0.88% per annum to 0.26% per annum between the two sub-periods (see Table 1). The growth rate in services as input in the manufacturing sector has accelerated from 0.42% per annum during 1980s to 15.78% per annum during 1990s. In order to evaluate the contribution of services as an input to the growth of TFP in the manufacturing sector, a multilateral total factor productivity index (MTFPI) is constructed for 41 major industry groups for the period 1980–81 to 1999–2000, with and without services as a separate input. The growth rate of MTFPI has decelerated from 1.3% per annum during 1980s to 0.5% per annum during 1990s when services are taken as input (see Table 1). However, there is an acceleration in MTFPI growth rates from 0.5% per annum to 1.1% per annum between the two sub-periods when services are not included in the measurement of the index. It is, therefore, observed that any study on the productivity of Indian manufacturing sector for the post-reforms period would overstate TFP growth rate if services are not taken as input.

Sidhu (2007) has examined TFP growth rate in Indian industry at the disaggregated level based on ASI data for the period 1973–2003, divided into four sub-periods of 1973–83, 1983–93, 1993–2003, and 1983–2003.The manufacturing units are classified as unincorporated enterprises, corporate sector, cooperative societies, *khadi* and village industries, handloom industries, and others. Unincorporated enterprises include individual proprietorship, joint family (HUF) establishments, and partnership firms. The corporate sector consists of public limited companies, private limited companies, government department enterprises, and public corporations. The study has observed a decline in the TFP growth rate from 4.47% per annum to 2.80% per annum between 1983–93 and 1993–2003 (see Table 1). The TFP growth rate has declined for unincorporated enterprises and *khadi* and village industries, handloom, and others but has increased for the corporate sector and co-operative societies between 1983–93 and 1993–2003. However, the growth rate of the capital stock is overestimated in this study since the capital stock of the benchmark year was taken at historical cost instead of at the replacement cost new.

Inter-state Studies

The study of Trivedi (2004) has focused on a comparison of productivity growth process not only at inter-state level but also at disaggregated industry level in each state. This study is based on ASI data from 1980–81 to 2000–01. Five industry groups, namely, textile and textile products, metal and metal products, machinery and transport equipments, chemical and chemical products, and leather and leather products are selected for the purpose of the study. The states selected for this study are Andhra Pradesh, Bihar (including Jharkhand), Gujarat, Karnataka, Madhya Pradesh (including Chattisgarh), Maharashtra, Rajasthan, Tamilnadu, Uttar Pradesh (including Uttaranchal), and West Bengal. TFPG rates are estimated both by the growth accounting method and the production function method. In the case of five industry aggregate, Madhya Pradesh, Maharashtra, and Karnataka are the toppers, and Bihar, West Bengal, and Uttar Pradesh are the poor performers in terms of TFP. There are inter-state differences in productivity levels within each industry. The inter-state differences in TFPG have increased in all sectors except for the metal industry. Among all sectors, only the metal industry has recorded acceleration in TFPG during the post-1991 period.

Veeramani and Goldar (2005) have analyzed the various dimensions of investment climate (IC) in determining TFP in the manufacturing sector across the major Indian states. The period of study is from 1992–93 to 1997–98. States are grouped under various categories according to the nature of IC, based on the World Bank's "Firm Analysis and Competitiveness Survey" (FACS), 2002. The indicators for IC are POWER (average number of days required to get a new power connection in the state), TELE (average number of days required to get a new telephone connection in the state), MANDAYS (number of mandays lost per employee in industrial disputes), MTR (percentage of the management's time spent with government officials of regulatory and administrative issues), E/L (electricity sales for industrial use as a proportion of total persons engaged in the state's registered manufactured sector), and C/K (real industrial credit by the scheduled commercial banks as a proportion of capital stock). The study shows that most of the "good IC" states have recorded higher TFP levels as compared to the "poor IC" states. All indicators of IC have significant influence upon TFP of the states. The simulation process indicates that the percentages of output lost are the highest in West Bengal and Kerala because of poor IC.

Conclusion

We have reviewed in this paper the trends in TFP growth in the manufacturing sector in India in the post-1991 period. The central question in this paper is whether there has been a significant acceleration in TFP growth rate in the Indian manufacturing sector in the post-1991 period . The survey of literature does not provide any conclusive evidence in this regard. Most of the studies, however, cannot find any significant acceleration in the TFPG rate in the manufacturing sector during 1990s compared to 1980s. The nature of data used, time-period, and methodology followed have influenced the results of these studies. The regression analysis has shown that factors such as the growth rate of industrial production, agricultural growth rate, the movement of the real effective exchange rate, gestation lags in investments, capacity utilization, and reduction of the effective rate of protection have influenced TFPG rate in the industrial sector in India. Studies have also observed the existence of inter-state disparity in the productivity growth rates. This disparity increased in most of the sectors during 1990s. The level of TFP was found to be higher in the states with better industrial climate.

References

Ahluwalia, I.J. (1991), *Productivity and Growth in Indian Manufacturing*. Delhi: Oxford University Press.

Balakrishna, P. and Pushpangadan, K. (1994), "Total Factor Productivity Growth in Manufacturing Industry: A Fresh Look," *Economic and Political Weekly*, July 13, 29(31): 2028–35.

Balakrishna, P. and Pushpangadan,K.(1995), "Total Factor Productivity Growth in Manufacturing Industry," *Economic and Political Weekly*, March 4, **30** (9).

Balakrishna, P. and Pushpangadan, K.(1996), "TFPG in Manufacturing Industry," *Economic and Political Weekly*, February 17, 31(7).

Banga, R. and Goldar, B. (2007), "Contribution of Services to Output Growth and Productivity in Indian Manufacturing : Pre- and Post-Reforms," *Economic and Political Weekly*, June 30–July 6, 42(26), 2769–77.

Das, D.K. (2004), "Manufacturing Productivity under Varying Trade Regimes, 1980–2000," *Economic and Political Weekly (Review of Industry and Management)*, January 31, 39 (5): 423–33.

Dholakia, B.H. and Dholakia, R.H. (1995), "Total Factor Productivity Growth in Indian Manufacturing," *Economic and Political Weekly*, July 15, 30(28).

Goldar, B. (2004), "Productivity Trends in Indian Manufacturing in the Pre- and Post-Reform Periods," Working Paper No. 137, ICRIER, New Delhi, June.

Goldar, B. (2006), "Productivity Growth in Indian Manufacturing in the 1980s and 1990s," in S.D. Tendulkar et al. (eds.), *India: Industrialisation in a Reforming Economy.*, New Delhi: Academic Foundation, New Delhi.

Goldar, B. and Kumari, A. (2003), "Import Liberalization and Productivity Growth in Indian Manufacturing Industries in the 1990s," *The Developing Economics*, December 4, XLI: 436–60.

Jorgenson, D., Gollop, F.M., and Fraumeni, B. (1987), *Productivity and U.S. Economic Growth* ., Cambridge: Harvard University Press.

Rao, J.M. (1996), "Manufacturing Productivity Growth: Method and Measurement," *Economic and Political Weekly*, November 2, 31(44).

Sidhu, H. (2007), "Total Factor Productivity: A Sectoral Analysis of Indian Industry," *Productivity*, July–September, 48(2): 172-81.

Trivedi, P. (2004), "An Inter-State Perspective on Manufacturing Productivity in India: 1980-81 to 2000-01," *Indian Economic Review*, 34(1): 203–37.

Trivedi, P., Prakash, A., and Sinate, D. (2000), "Productivity in Major Manufacturing Industries in India: 1973–74 to 1997–98," Development Research Group Study No. 20, Department of Economic Analysis and Policy, Reserve Bank of India, Mumbai.

Tata Services Limited (2003), *Reforms and Productivity Trends in Indian Manufacturing Sector*, Mumbai: Department of Economic Analysis and Policy, Tata Services.

Unel, B. (2003), "Productivity Trends in India's Manufacturing Sectors in the Last Two Decades," WP/03/22 , International Monetary Fund.

Veeramani, C., and Goldar, B. (2005),"Manufacturing Productivity in Indian States: Does Investment Climate Matter?" *Economic and Political Weekly*, June 11, 40(24): 2413–20.

Virmani, A. (2004), "Sources of India's Economic Growth: Trends in Total Factor Productivity," Working Paper No.131, ICRIER, New Delhi.

"Nothing great was ever achieved without enthusiasm."

— Ralph Waldo Emerson

Feature

Trends in and Determinants of Agricultural Productivity: A Study on Chittoor District, Andhra Pradesh

S. Venkatanarayana Reddy and K. Satyanarayana Reddy

Agriculture as a basic industry plays a prominent role in the process of economic development of every country. Agricultural production has played a crucial role in the determination of agricultural labor wages also. In emphasizing the role of the agriculture in the development of Indian economy, it is observed, if one sector limits the growth of the other, it is more likely to be a case of agricultural growth, limiting non-agricultural sector than vice-versa. Chittoor district is no exemption from this. There are a number of studies on the agricultural sector of the district. So the type of studies, "trends in and determinants of agricultural productivity," is very rare and helps to the successful implementation of several programs to improve the agricultural productivity in the district. A positive and significant increasing trend was found in agricultural productivity. In view of determinants of agricultural productivity it was found that it may increase the agricultural productivity by increasing certain variables which are positively associated with agricultural productivity in the Chittoor district.

Dr S. Venkatanarayana Reddy is Lecturer at St Joseph Collage of Education, Rachana Palli, Anantapur, Andhra Pradesh and K. Satyanarayana Reddy is Professor in Department of Economics, Yogi Vemana University, Kadapa, Andhra Pradesh.

Introduction

So long as it continues to feed and clothe the world, agriculture continues to assume the role of a basic industry in some degree or the other in every country. Agriculture as a basic industry plays a prominent role in the economic development of the country. But the contribution of the agricultural sector to overall economy varies from country to country depending upon the level of economic development. Economic development may be defined as "transformation of economy which is predominantly agricultural and traditional in to one largely industrial and modern." As quoted by the German economist and national protectionist, Frederich List, "almost all of the developed economies moved from the savage stage to the take-off stage of economic development," that is, "agricultural, manufacturing and commercial stage of economic development throughout the path of agricultural stage." In the early stages of economic development of modern advanced states, a high rate of agricultural production has played a crucial role in furthering overall economic growth. In the case of less developed countries, substantial progress in the most backward part of the economy (that is, agricultural sector) was a prerequisite for a successful development of the economy as a whole. In emphasizing the role of agriculture in development of Indian economy, it is observed, if one sector limits the growth of the other, it is more likely to be a case of agricultural growth, limiting non-agricultural sector than vice-versa.

Generally agricultural productivity may be defined as "the average yield per hector of land." After the introduction of modern agricultural technique along with the adoption of hybrid seeds, extension of irrigation facilities, and application of intensive methods of cultivation in India, yield per hector of crops has recorded a steep rising trend. Agricultural productivity in India has undergone an abrupt change in the post-Green Revolution period. Agricultural

productivity, which is composed of both productivity of land and labor, is among the lowest in the world despite increase in the yield. Average yield per hector in India is quite below the world's average in all crops. It shows the backwardness of the Indian agricultural sector. It is said to be a gamble of monsoons and other natural calamities, which affect agricultural productivity in India. The increase in production and productivity of agricultural sector are influencing the wages. The Chittoor district is no exemption from this. The wage level and agricultural productivity are very low in the district as compared to other districts in the state. As a result, the Chittoor district was selected to study the causes and circumstances, which are influencing the low agricultural productivity and to give suggestions to improve the agricultural productivity in the district.

Profile of the District

Chittoor district is located in the Rayalaseema region of Andhra Pradesh. The district, constituted on April 1, 1911, derived its name after the headquarter town of Chittoor. According to 2001 census figures the district has a population of 5,311,817 people. The literacy rate in the district is 48.28%. The rate of literacy among males is 58.4% whereas female literacy rate is 36.3%. But the rural literacy rate is only 18.54%. There is a need to improve the rural literacy rate, especially that of the females. The total cultivated area of the district was recorded at 1,788.003 acres in 2007–08. But the irrigated area is only 263,524 acres. Potato is the main crop. The drought visits the district at least thrice in a decade.

Review of Literature

The study of V.T. Raju (1974), based on the data collected from the Benchmark and Assessment Surveys of the IADP, West Godavari, conducted in 1967–68 to 1970–71, reveals that there was a significant increase in both the money wages and real wages for hired labor from 1967–68 to 1970–71 in the district.

V.N. Misra and S.B.L. Gupta (1974), in their study of Gujarat while accounting factors affecting inter-district wage differentials for 1968–69, found that the availability of pump-sets and agricultural labor turnout was significant and has a positive sign for its coefficient. Land concentration ratio and availability of tractors assumed a negative sign and contributed to significant variation to wage rates. Though the extent of irrigated area assumed a positive sign, it failed to significantly contribute to wage rates.

The study of P. Prudhvikar Reddy (1988) in Andhra Pradesh shows the HYV technology in paddy crop, which was initially confined to canal irrigated areas, has later spread to other irrigated areas. It is of interest to examine the impact of this on the trends in agricultural wages in different agro-climatic zones. The analysis reveals that real wages of all categories of labor have increased at the state as well as zonal levels though its magnitude differed from zone to zone. It also indicated continuous persistence of zonal variations in wages.

P.S. Sarma (1966) made an attempt to study the relative association per acre productivity (20 crops) with rainfall, irrigation, holding-size, land concentration ratios, pure tenancy, workers per acre, area up to 5 acres, mixed tenancy, and hired workers in crop zones and state zones all over India in the period from 1959–60 to 1961–62. The study examines the relative impact of nine independent variables on per acre productivity. On this basis, it has been possible to isolate crop zones and state zones having positive or negative marginal labor productivity.

R.K. Rana's (1990) study of land productivity differentials in India attempted to examine the inequality in land productivity among different states of India. This was based on cross-sectional data. He observed that the role of rainfall is significant due to untimely nature, that is, inadequacy of rain. The per capita cropped area and interest rate are also insignificant on productivity. The quality of soil shows significant effect on land productivity. He suggested five policy measures that would help reduce the variation in land productivity among the states and also help to achieve greater optimality in resource use.

The study conducted by Bardhan in rural West Bengal during 1977–78 revealed that casual farm wage rate was positively influenced by productivity-enhancing factors like age, normal rainfall, lower deficit in actual rainfall, use of nitrogenous fertilizers, primary education of the laborer, and the relative bus season of October–December. The wage rate was also lower for low-cast workers. The negative coefficient for the food cost index was surprising.

Objectives

The following are objectives of the present study:

1. To study trends in agricultural productivity.
2. To study the relative association of agricultural productivity with selected independent variables.

Methodology

The analysis was carried out division wise. The same methodology was used for all three divisions and then the entire district as a whole. To study the first objective trends in agricultural productivity for the entire district for the period of 1988–89 to 2007–08, the following regression model adopted:

$$Y = a+bt$$

where:

y = agricultural productivity
t = time in years
a and b are the constants

To estimate the linear growth rate in agricultural productivity the following formula was adopted

$$LGR = \frac{\hat{b}}{Y} \times 100$$

To study the second objective, that is, determinants of agricultural productivity, the multiple regression analyses is taken out:

$$Y=f(x_1, x_2, x_3, x_4, x_5, x_6, x_7)$$

Specifically:

$$Y=a_0+a_1x_1+a_2x_2+a_3x_3+a_4x_4+a_5x_5+a_6x_6+a_7x_7.$$

where a_1, a_2, a_3, a_4, a_5, a_6, and a_7 are the coefficients of independent variables and a_0 is the constant.

The combined effect of independent variables on agricultural productivity is carried out by multiple correlations coefficient and is tested for its significance by the F-test statistic and t-test statistic also calculated for significance of each independent variable on productivity.

The specifications of the variables are given as follows:

Agricultural productivity (Y): Initially six major crops were selected: (i) Paddy; (ii) Jowar; (iii) Bajra; (iv) Ragi; (v) Groundnut; and (vi) Sugarcane. The production of each crop in each *mandal* was first collected; then the crop production was multiplied by average price of the particular crop. The average productivity of the crop in each *mandal* is computed with the help of the following equation:

$$Y = \frac{\sum_{i=1}^{6} \text{total agricultural production of each crop x average price}}{\sum_{i=1}^{6} \text{total area under the crops}}$$

X_1—*Agricultural annual rainfall (in mms)*: Generally the positive relation is expected between Y variable and x_1 variable.

$_2$—*Percentage of irrigated area*: There is a positive relation between x_2 and Y variables. The formula is:

$$x_2 = \frac{\text{Gross area irrigated}}{\text{Gross area shown}}$$

X_3—*Average size of operational holdings*: It is expected that there is negative relation between Y and x_3 variables;

$$x_3 = \frac{\text{Net area shown}}{\text{No. of agricultural holdings}}$$

X_4—*Land concentration ratio*: Theoretically positive relation is expected between x_4 and Y variables:

$$x_4 = \frac{\text{Net area shown}}{\text{Total population}}$$

X_5—*Workers-area ratio*: It is assumed that there is a positive relation between x_5 and Y variables:

$$x_5 = \frac{\text{Total workers}}{\text{Net area shown}}$$

X_6—*Percentage of hired workers*: A positive relation is expected between the x_6 and Y variables;

$$x_6 = \frac{\text{Hired workers}}{\text{Total agricultural workers}} \times 100$$

X_7—*Fertilizers and pesticides consumption per acre*: Generally there is a positive relation is expected between x_7 and Y variables:

$$x_7 = \frac{\text{Total consumption of fertilizers and pesticides}}{\text{Gross area shown}}$$

Here, the variable Y is dependent while x_1 to x_7 are independent variables.

Data

The present study is depended on both primary and secondary data. The primary data is collected by field survey conducted in 2007-08. The secondary data is gathered from *Hand Book of Statistics* issued by chief planning officer, Chittoor, and unpublished records of the same office for the period of 1988-89 to 2007-08.

Analysis

Trends in Agricultural Productivity

Generally in agricultural sector, productivity is "total output divided by the land units." This is also known as average yield per unit of land. In the present study trends in agricultural productivity is calculated by simple regression analysis considering the time factor (years) as independent variable and productivity (rupees) as dependent variable.

The estimated linear equation of agricultural productivity in Chittoor district is:

$$Y = 301.16 + 337.9*t$$

(21.8687)

r = 0.9662 LGR = 9.18

(Notes: * Significant at 5% probability level.
Figure in parentheses is standard error.)

From this equation, the coefficient of "t," that is, the value of "b" is 337.9. It is positive and significant. There is an increasing trend in agricultural productivity in Chittoor district. It means on average Rs 337.9 of agricultural productivity increased every year during the study period. This increment is significant. The effect of time on agricultural productivity is 0.9662 (r). It shows that 96.62% of variation is observed by the time factor. The linear growth rate is 9.18% and shows average annual increase in agricultural productivity. The value of intercept term is 301.16.

Determinants of Agricultural Productivity

There are many factors affecting the agricultural productivity in the district. So, some important factors (variables) are taken into account in the present study. To calculate the combined effect of all explanatory variables on explained variables the regression equation for each division of the district taken and analyzed accordingly.

Chittoor Division

The estimated regression equation for the division is:

$$Y = 192.4515 - 1.2741*x_1 + 15.9234*x_2 + 1577.6547*x_3 +$$
$$(0.1078) \quad (1.4467) \quad (78.7934)$$
$$249.1199*x_4 - 57.0737x_5 - 99.5297*x_6 - 7.3059*x_7$$
$$(17.2032) \quad (74.4144) \quad (2.1837) \quad (0.1058)$$
$$R^2 = 0.3814 \quad F = 3.4300*$$

(Notes: * Significant at 5% probability level.
Figures in parentheses are standard error.)

The estimated coefficient of the variables annual rainfall (x_1), percentage of hired workers (x_6) and fertilizers, and pesticides consumption per acre (x_7) have a negative and significant association with agricultural productivity (y). It reveals that an increase in x_1, x_6, and x_7 will decrease agricultural productivity significantly. The coefficient of the variable workers area ratio (x_5) has a negative and insignificant association with the dependent variable, agricultural productivity (y). It reveals that an increase in x_5 will reduce agricultural productivity insignificantly. Similarly, the coefficient of the variables percentage of irrigated area (x_2), average size of operational holding (x_3), and land concentration ratio (x4) have a positively significant relation with agricultural productivity. It reveals that an increase in x_2, x_3, and x_4 will increase agricultural productivity significantly.

The multiple correlations coefficient (R^2) is the collective effect of all independent variables on dependent variable. The value of R^2 is 0.3814. It means, 38.14% of variation is observed in agricultural productivity. From F-test statistic this percentage of variation is 3.43 and is significant.

Tirupathi division

The estimated regression equation for the Tirupathi division is:

$$Y = 202.4936 - 7.3851*x_1 - 51.7501*x_2 - 1062.2149*x_3$$
$$(0.0294) \quad (0.7167) \quad (39.7585)$$
$$-778.1399*x_4 - 1353.0625*x_5 + 71.4346*x_6 + 6.4509*x_7$$
$$(11.7702) \quad (18.0569) \quad (1.0177) \quad (0.4989)$$
$$R^2 = 0.9046 \quad F = 4.5040*$$

(Notes: * Significant at 5% probability level.
Figures in parentheses are standard error.)

The estimated coefficient of the variables actual annual rainfall (x_1), percentage of irrigated area (x_2), average size of operational holding (x_3), land concentration ratio (x_4), and workers area ratio (x_5) have a negatively significant association with agricultural productivity (y) significantly. Similarly, the coefficient of the variables percentage of hired workers (x_6) and consumption of fertilizers and pesticides per acre (x_7) have a positively significant association with agricultural productivity (y). It reveals that an increase in x_6 and x_7 will increase Y significantly.

The value multiple correlation (R^2) is 0.9046, which means a 90.46% variation is observed in agricultural productivity. F-value is 4.5040 and is significant.

Madanapalli division

The estimated regression equation for Madanapalli division is:

$$Y = 93.6903 - 0.4247*x_1 - 40.3496*x_2 - 1337.4312*x3$$
$$(0.0217) \quad (0.4532) \quad (8.0739)$$
$$- 909.7139*x_4 + 47.8601*x_5 + 77.0246*x_6 + 9.6504*x7$$
$$(9.2226) \quad (22.4053) \quad (0.6609) \quad (0.1562)$$
$$R^2 = 0.4517 \quad F = 1.1876*$$

(Notes: * Significant at 5% probability level.
Figures in parentheses are standard error.)

The coefficient of the variables actual annual rainfall (x_1), percentage of irrigated area (x_2), average size of operational holdings (x_3), and land concentration ratio (x_4) have a negatively significant relation with agricultural productivity (Y). It reveals that an increase in x_1, x_2, x_3, and x_4 will decrease agricultural productivity (Y) significantly. Similarly, the coefficient of the variables workers-area ratio (x_5), percentage of hired workers (x_6), and consumption of fertilizers and pesticides per acre (x_7) have a positively significant association with agricultural productivity (Y). It

reveals that an increase in x_5, x_6, and x_7 will increase agricultural productivity (Y) significantly.

The value of multiple correlations (R^2) is 0.4517, which means a 45.57% variation is observed in agricultural productivity (Y). This value is insignificant by F- test at 1.1876.

Chittoor District

The estimated regression equation for the entire district is:

$$Y = 2143.9614 - 7.5046*x_1 - 11.3370*x_2 - 1124.4717*x_3$$
$$(0.0183) \quad (0.3369) \quad (8.6856)$$
$$-351.5408*x_4 - 2544.3893*x_5 - 93.4706*x_6 - 5.5959*x_7$$
$$(4.0161) \quad (14.6257) \quad (0.6409) \quad (0.0547)$$
$$R^2 = 0.5932 \qquad F = 4.4980*$$

(Notes: * Significant at 5% probability level.
Figures in parentheses are standard error.)

The coefficient of the variables actual annual rainfall (x_1), average size of operational holdings (x_3), land concentration ratio (x_4), workers–area ratio (x_5), and consumption of fertilizers and pesticides per acre (x_7) have a negatively significant association with agricultural productivity (Y). It reveals that an increase in x_1, x_3, x_4, x_5, and x_7 will decrease agricultural productivity (Y) significantly. Similarly, the coefficient of the variables the percentage workers (x_6) have a positively significant association with agricultural productivity (Y). It reveals that an increase in x_2 and x_6 will increase agricultural productivity (Y) significantly.

The value of multiple correlations coefficient (R^2) is 0.5932. It means 59.32% of variation is observed in agricultural productivity. From F test, R^2 value is 4.4980 and is significant.

Inter-divisional Comparison

The estimated coefficient of actual annual rainfall (x_1) is negative and significance in all the three division and in the district as a whole. It reveals that the observed relation between x_1 and Y variables is negative and runs in an opposite direction to the expected relationship. So, there is no scope to raise the agricultural productivity by raising x_1. The coefficient of percentage of irrigated area (x_2) is positive and significant in Chittoor division and in the entire district as a whole. It reveals that an increase in x_2 will lead to an increase in agricultural productivity significantly. But x_2 has a negative and significant relation with agricultural productivity (Y). It shows that an increase in x_2 will decrease the agricultural productivity significantly. The coefficient of average size of operational holdings (x_3) has a positive and significant relation with agricultural productivity (Y) in Chittoor division only. It reveals that an increase in x_3 will lead to an increase in agricultural productivity significantly in the division. But in Tirupathi and Madanapalli divisions, as well as in the entire district, the coefficient of x_3 has a negatively significant relation with agricultural productivity (Y). It reveals that the increase in x_3 will decrease the agricultural productivity significantly.

The coefficient of land concentration ratio (x_4) has a positive association with agricultural productivity (Y) only in Chittoor division. It reveals that an increase in x_4 will cause a decrease in agricultural productivity significantly. Similarly, the coefficient of land concentration ratio (x_4) has a negative association with agricultural productivity in Tirupathi and Madanapalli divisions, as well as in the district as a whole. It reveals that an increase in x_4 will decrease agricultural productivity (Y) significantly. The coefficient of workers-area ratio (x_5) has a negatively insignificant association with agricultural productivity (Y). It reveals that an increase in x_5 will decrease agricultural productivity (Y) insignificantly. So, there is some scope to raise x_5 to raise agricultural productivity (Y). But in Tirupathi and Madanapalli divisions as well as in the entire district as a whole the coefficient of workers-area ratio (x_5) has a negatively significant association with agricultural productivity (Y). It reveals that there is no scope to raise Y by raising x_5.

The coefficient of the percentage of hired workers (x_6) has a negatively significant association with agricultural productivity (Y) only in Chittoor division. But in Tirupathi and Madanapalli as well as the district as a whole x_6 variable has a positively significant association with agricultural productivity (Y). The negatively significant association in Chittoor division reveals that there is no scope to increase Y by increasing x_6. Contradictorily, in remaining divisions and the entire district there is a large scope to raise significantly agricultural productivity (Y) by raising the percentage of hired workers. The coefficient of consumption fertilizers and pesticides per acre (x_7) has a positively significant association with agricultural productivity (Y) in Tirupathi and Madanapalli divisions. This positively significant association reveals that an increase in x_7 variable, that is, consumption of fertilizers and pesticides per acre will increase agricultural productivity (Y). Significantly, but in Chittoor division and entire the district as a whole, it is in opposite direction, which means having a negatively significant association with agricultural productivity (Y). It reveals that an increase in x_7 will cause a decrease in agricultural productivity (Y).

Summary and Suggestions

Agricultural productivity is the average yield per one unit of input land. Productivity of all crops recorded a step rising

trend after the Green Revolution. Trends in and determinants of agricultural productivity are studied in the present study. The summary and suggestions are given in subsequent paragraphs. A positive and significant trend is observed in agricultural productivity in entire Chittoor district. The average annual increase in agricultural productivity is approximately Rs 338. In agricultural productivity a linear growth rate of 9.18% is recorded in agricultural productivity by the time factor in the study period.

In the view of determinants of agricultural productivity, in case of Chittoor division the variables, actual annual rainfall, percentage of hired workers, workers-area ratio, and consumption of fertilizers and pesticides per acre are due to a negatively significant association. There is no scope to raise the agricultural productivity by raising said the mentioned variables except the variable workers-area ratio due to a negatively insignificant association. This negative and insignificant association reveals that an increase in x_5 will decrease the agricultural productivity insignificantly. But there is some scope to increase the agricultural productivity by increasing the variables percentage of irrigated area, average size of operational holdings, and land concentration ratio in Chittoor division. So, it is suggested that there is no scope to increase the agricultural productivity by increasing x_1, x_5, x_6, and x_7 variables. But there must increase the agricultural productivity by increasing the x_2, x_3, and x_4 variables in the division.

In Tirupathi division there is no scope to raise agricultural productivity by raising all variables except x_6 and x_7 because of a negatively significant relation with agricultural productivity. But there is a large scope to raise agricultural productivity by raising x_6 and x_7 alone to have a positively significant association. So, it is suggested to improve the agricultural productivity, the consumption of fertilizers, and pesticides per acre which are cause to improve the agricultural productivity in the division.

In Madanapalli division, the variables, actual annual rainfall, percentage of irrigated area, average size of operational holding, and land concentration ratio are due to having a negatively significant association with agricultural productivity; there is no scope to raise agricultural productivity; by increasing the said mentioned independent variables. But it is possible to raise agricultural productivity by raising the variables, workers-area ratio, percentage of hired workers, and consumption of fertilizers and pesticides per acre due to a positively significant association. So, it is suggested to improve agricultural productivity by increasing x_5, x_6, and x_7 variables. In the district as a whole there is no scope to raise agricultural productivity by raising actual annual rainfall, average size of operational holdings, land concentration ratio, workers-area ratio, and consumption of fertilizers and pesticides per acre due to a negatively significant association with agricultural productivity in the district. But it is possible to raise agricultural productivity significantly by raising the variables, percentage of irrigated area and percentage of hired workers due to a positively significant association with agricultural productivity.

It may be concluded by saying that in Chittoor division it is possible to increase agricultural productivity by increasing only percentage of irrigated area, average size of operational holdings. Similarly, in Tirupathi division it is possible to increase the agricultural productivity significantly only by increasing workers-area ratio, percentage of hired workers, and consumption of fertilizers and pesticides per acre. In Madanapalli division, it is possible to increase the agricultural productivity significantly only by increasing the workers-area ratio, percentage of hired workers, and consumption of fertilizers and pesticides per acre in the division.

References

Bardhan, Pranab K., "Wages and Unemployment," in *Development Economics*, pp. 47–72. New Delhi: Oxford University Press.

Misra, V.N. and Gupta, S.B.L. (1974), "Productivity, Wages and its Determination in Gujarat Agriculture: An Inter-District Analysis," *Indian Journal of Agricultural Economics*, XXIX(3, July–September).

Raju, V.T. (1974), "Impact of Green Revolution on Wages and Incomes of Hired Labor in IADP District, West Godavari," *Indian Journal of Agricultural Economics*, XXIX(3, July–September).

Rana, R.K. (1990), "Land Productivity Differentials in India: An Empirical Study," *Indian Journal of Agricultural Economics*, 45(1, January–March): 51–55.

Reddy, P. Prudvikar (1998), "Trends in Agricultural Wages: An Inter-Regional Analysis in Andhra Pradesh," *Economics and Political Weekly* March 28, XXXIII(13): A.15–A.19.

Sarma, P.S. (1966), "Impact of Selected Aspects of Labor and Land on per Acre Productivity," *Indian Journal of Agricultural Economics*, XXI(1, January–March): 31-43.

"We are still masters of our fate. we are still captains of our souls."

— Winston Churchill

Registered with Registrar of Newspapers REGD. NO. 4757/59

Productivity

Announces

a

Special Issue

Vol. 50, No. 3,

October - December, 2009

on

Water Resource Management

Place your orders with :

MD Publications Pvt Ltd
"MD House", 11, Darya Ganj
New Delhi-110 002
Telephone : 91-11-45355555
E-mail : contact@mdppl.com
website : www.mdppl.com