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31/03/2021

THIS LETTER IS SPECIALY FOR YOU

My dear reader/member,

Greetings of the Day !

I am inclined to write this letter to you on behalf of our EDITORIAL BOARD / EDITORIAL ADVISORY BOARD to express our thanks for your whole hearted support for bringing out SV issue regularly and successfully.

These are definitely very hard and unassuming days and it becomes very difficult to pull on further due to economic conditions. As you already know, we send FREE PRINTED COPY of each issue to our members / readers as per our mailing list. Out of 400/500, print copies, hardly there remains 10/20 copies as stock. We send copies to our contributors, donors and few copies as complementary copies. Day by day, compose, printing and postal expenses are increasing. At this stage, each issue of the journal with 70/100 pages has a total cost of about Rs. 25000/- for each issue. We also send official certificates to our contributors with offprints for their papers.

We have a mailing list which needs to be updated. Hence, I propose the following to all our readers.

(1) **We definitely need your academic, as well as financial support for our works ahead.**

(2) **From January 2021, we shall stop the practice of sending printed copies to all readers.**

(3) Of course, we shall mail digital copy to you all and also to our contributors with certificates.

(4) Updataion procedure is very badly needed, then and then only we shall be able to send digital copy. Hence, I propose the following.

(4.1) Please send us the following details at your earliest to update our data.

(A) Full name, (B) Residential address, (C) Whatsapp mobile number (D) Email ID

(4.2) **Please note that From January 2021, we shall send Digital copy only to all those who have given us the above information.**

(4.3) **Even if you might have sent your above details earlier, please send it again to update the work.**

(4.4) **Please furnish the above details Latest by 20 April 2021. Otherwise, all our communication can stop immediately.**

(5) You can supply this information to any one of the following persons by sending SMS/email..

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I am sure that you will treat this matter as urgent and give priority to send details eventhough in your busy schedule.

This will help us to update our data and serve you better.

(6) **We want to bring out 4 issues from year 2021 (instead of two issues as now). Of course, this only depends upon our circumstances ahead.**

With love and warm regards.

Yours sincerely,
Sd/-
Dr. B. B. Jani

THIS LETTER IS THE LAST REMINDER TO YOU.

EDITORIAL

BIG DREAMS HAVE SMALL BEGININGS

We are extremely happy to present this issue (NSV 17, March 2021, No. 1) to our readers.

SANKHYA VIGNAN now begins its journey in the 17th year. As already announced earlier from this time onwards, we shall be having Digital copy (D. copy) of the issues, stop printing and posting work and bring out 4 issues in the year 2021 (March, June, September and December)

We express our very sincere thanks to all our contributors, evaluators, readers and well wishers for their continuous and consistent support which has helped us to achieve our goal.

This issue contains a **special lette**r to our readers (repeated), **three research articles, one research study article, one research note, one biography** and **SV News Letter with Readers Forum** as usual. You will find details about the same in the contents.

We are highly indebted to our following referees who have spared no nerves for evaluation of the articles / papers submitted for this issue. **(Names of referees are given one by one in the order of t heir appearance in the journal.)**

(1) A. C. Brahmbhatt	**(2) J. R. Purohit**	**(3) M. N. Patel**
(4) R. G. Bhatt	**(5) H. M. Dixit**	**(6) Shailesh Teredesai**

As you know, we have our website **www.sankhyavignan.org** where you can give your feedback and suggestions.

We have **new editorial board, new editorial advisory board and new research team** from this year. We express our sincere thanks to **Shree Dinesh Darji for DTP work and Shree Ashish Bhatt for website.**

We shall be sending D.copy to all our readers whose email ID / Whatsapp no. are with us. Our contributors will get D.copy and official certificates.

Wish you good health, progress and prosperity.

AHMEDABAD **EDITORIAL BOARD**
Date : 31/03/2021

NOTE: Members of editorial board are in no way concerned with the views, opinions or ideas expressed in this issue. Authenticity responsibility lies solely with the persons presenting them.

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GUJARAT STATISTICAL ASSOCIATION - FROM EDITOR'S DESK

SANKHYA VIGNAN is a peer reviewed refereed Bi-Annually journal that published empirical, conceptual and review papers of exceptional quality that contribute to Statistics Theory and enriched Applications of Statistical Techniques in various fields. The objective ofthe Journal is to disseminate knowledge, which ensures good practice of professional management and its focal point is on research and reflections relevant to academicians and practitioners in the field of Applied Statistics.

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(1) To maintain PEER REVIEW REGISTER giving full details about authors, Refrees, decisions and internal rankings, before printing the Issue.

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   a) send the paper to two reviews, if the results were negative by one reviewer and positive by the other one; then the editor may send the paper for third reviewer or he take immediately the final decision by accepting/rejecting the paper. The Editor In Chielf will ask the selected reviewers to present the results within 7 working days, if they were unable to complete the review within the agreed period then the editor have the right to resend the papers for new reviewers using the same procedure. If the Editor In Chief was not able to find suitable reviewers for certain papers then he has the right to accept/reject the paper.
   b) send the paper to a selected editorial board member(s) or reviewer.
   c) the Editor In Chief himself evaluates the paper.

(3) The authors of the papers/articles accepted for publication need to submit a duly signed copyright form within maximum one week of their receiving intimation of acceptance of their paper/article.

(4) To give each published issue for evaluation by two external Refrees other than editors, obtain evaluation reports and journal evaluation score out of 10 points.

(5) To declare average Journal Evaluation Scaore on the basis of the scores given by these two Refrees for each published issue.

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Each submitted manuscript is evaluated on the following basis :

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- The soundness of its theoryu and methodology.
- The coherence of its analysis.
- The ability to communicate to readers (grammar and style)
- All research paper are reviewed by at least two suitable qualified experts.
- All publication decisions are made by the journals' Editor on the basis of the review provided.
- Normal turn-around time for evaluation of manuscripts is 21 days from the date of recipient.

GUIDELINES FOR AUTHORS

1. The first page of the article should contain full name of authors with designation and correspondence address, contact numbers and email ID's (Both Institution & residential)
2. The research must be original in nature and is neither published nor under consideration for publication anywhere else.
3. The review process may take 2-3 days and the status would be known within 24 hours of submissions of the article. It is mandatory to mention a valid email and mobile number. We acknowledge the receipt of your article and subscription fee be email.
4. The abstract s hould not be more than 200-2502 words and it should adequately describe the work and highlight its signifcance. Avoid the use of abbreviation and reference in the abstract. The abstract should be folowed by relevant keywords.
5. The main paper (Manuscripts) should not exceed more than 3,000 to 4,000 words (inclduing graphs & charts.)
6. Article should be typed in 12 point - Times New Roman Font English with a one and half space and single column with 1 Margin on a Standard A4 size paper. The page numbers should be at the center of every page. All headings & sub headings must be in bold letters.
7. Table should be numbered consecutively, the title of the table should be placed above the table. The source should be indicated at the bottom.
8. All the tables, charts, graphs, diagrams should be in black and not in colors.
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A) We will accept soft copies of article through online submissions at the Email ID: (1) svgsa2045@gmail.com, (ii) drjayesh.purohit@gmail.com, (iii) bbjani2012@gmail.com

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RESEARCH ARTICLE

A REVIEW OF STANDARD ANALYTICAL MODELS IN SUPPLY CHAIN INTEGRATION

Dinesh S. Dave[(1)], Varinder Sharma[(2)] and Ajay Aggarwal[(3)]

ABSTRACT

It is a known fact that supply chain management is the most critical function of an organization in today's global competitive environment. Supply chain management continues to gain high visibility, particularly due to current environmental issues of pandemic. The supply chain integration is a business strategy that brings several supply chain-links into closer working relationships with each other, which enhances an organization's competitiveness by reducing cost and improving order fulfilment. This study presents basic quantitative and analytical models applicable in supply chain management specifically when organizations continue to integrate internal as well as external business functions. The analytical and quantitative approaches include demand planning models, materials management models, logistics models such as transportation and transshipment models, the facility layout model and the line-balancing approaches. The quantitative models in certain combinations can be applied toward the supply chain integration.

KEY WORDS : Integrated Supply Chain, Logistic, DEA, Fuzzy Logic

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(rcd. Jan.'21 / rvd. Feb.'21)

1. INTRODUCTION

It is widely known that supply chain management (SCM) is viewed as the most imperative function for organizations that are participating in the global chain of a supplier. As a result, supply chain management continues to gain high visibility, particularly due to current environmental issues of pandemic. SCM embraces the coordination of all activities from acquiring raw materials until the delivery of the final product to customers, is obviously the most important function in an organization in the global competitive environment. The major goal of a supply chain is to improve the performance of participating organizations and enhance customer satisfaction by efficiently delivering products and/or services (Sahin and Robinson, 2002). Recently, Wisner (2017) describes SCM as a network of organizations in the production of goods, services, and associated functions for the consumers.

Organizations around the world have been involved in integrating internal functions to realize the benefit of supply chain with a major objective of efficient fulfilment of customer orders. Additionally, companies have been expanding integration by incorporating functions of their supply chain members. The supply chain integration is a large-scale business strategy that brings as many links of the chain as possible into a closer working relationship with each other. The major benefits of an integrated supply chain process include concentrated professional expertise, cost efficiencies, improvements in response time and production time, reduced redundant costs, and elimination of waste, which benefits every link or member of the supply chain. In essence, supply chain integration is a process of fulfilment of customer orders by the supply chain members behaving as one system. The general view of integrated supply chain is presented in Figure 1.

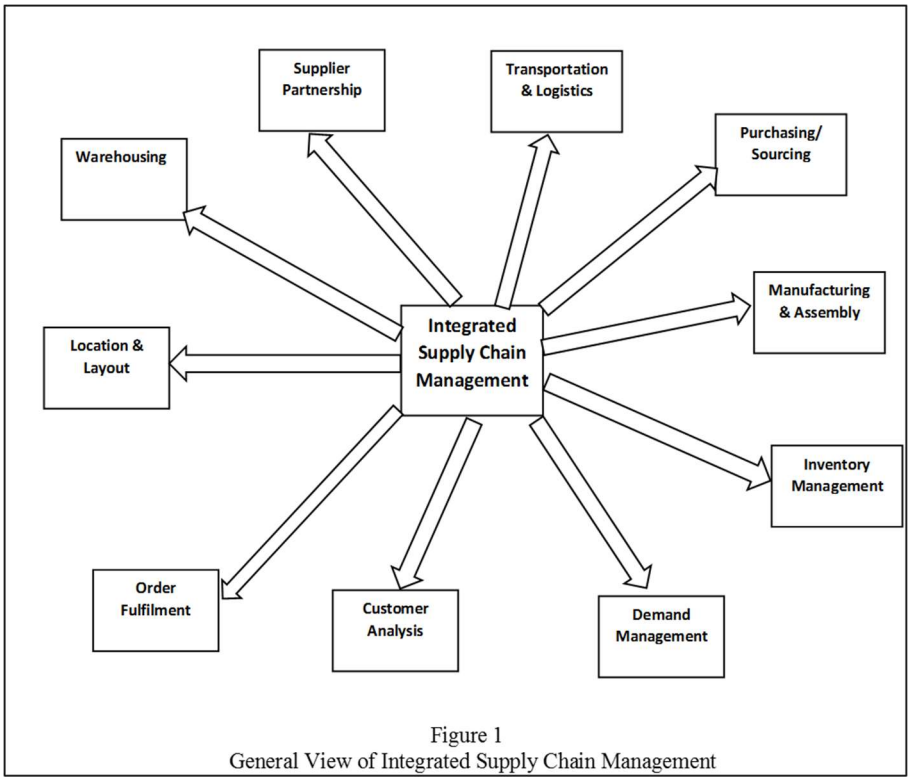

Figure 1
General View of Integrated Supply Chain Management

Many researchers view SCM by itself as an integration of business processes such as demand planning, sourcing, manufacturing and assembly, distribution and logistics, management of resources and customer-focused process management (Lummus and Vokurka, 1999; Mentzer et al., 2001; New, 1997; Zolait, A., et al., 2010). Well-integrated supply chains also create value for the shareholders by reducing costs and expanding market share (Lee, 2000). Regardless of the perspective, a comprehensive SCM integration remains to be achieved by implementing appropriate technologies along with quantitative and analytical models. The study presents the supply chain demand planning models, inventory management models, logistics models such as transportation and transshipment models, the facility layout model and the line-balancing approaches. The combinations of standard quantitative models can be applied to integrate firm's internal and external business functions to enhance the

supply chain integration environment. Information technology and enterprise resource systems coupled with analytical models can enhance organization's supply chain integration which results in enhanced fulfilment efficiency and customer satisfaction.

2. BASIC QUANTITATIVE MODELS IN AN INTEGRATED SUPPLY CHAIN

Various standard analytical and quantitative models can be effectively applied to enhance the performance of the supply chain in an integrated supply chain environment.

Models for Demand Planning:

Various forecasting models are used for demand planning in an integrated supply chain management. Figure 2 depicts those models. Demand planning is performed through causal and time series models. Whereas the time series models are used to incoprorate effects due to trend, seasonality, and cycles in demand planning, the causal models are deployed to predict the customer demand based upon the related variables such as price, quality, etc. The primry purpose is to minimize the differences between the demand forecast and the actual supply needed to satisfy customer demand.

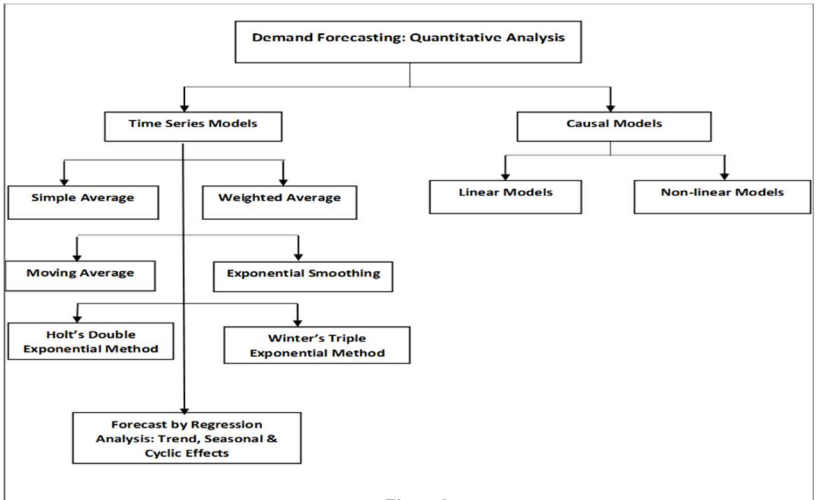

Figure 2
Demand Planning Models

Inventory Management:

Supply Chain Managers around the world recognize that an appropriate inventory management is critical for the success of an organization. Improper management of inventory can not only cause a disruption in supply chain but can also be extremely costly. Organizations may carry either raw material inventory, work-in-process inventory, or the inventory of finished goods or all these types of inventory; the primary objective of inventory management is to keep a balance between the investment in inventory and customer service. Inventory for retailers can facilitate in providing the potential customers with product variety and avoid stockouts during customer demand fluctuations. For the manufacturing companies, inventory can protect their organizations excessive work-in-process inventory of unfinished products. Finally, inventory can also hedge firms against price rise. Inventory management is a critical problem since excess inventory as well as insufficient inventory incur significant costs to organizations. Thus, to maintain an optimal level of inventory requires an appropriate application of the inventory model.

The basic inventory model is known as the economic order quantity model (EOQ) model where both the inventory holding cost and ordering cost, or setup cost are balanced. In some situations, the supplier offers quantity discount if the organization orders quantity larger than the optimal economic order quantity. Additionally, in many situations, the decision maker analyzes cost of shortage and the cost of coverage. In this type of single-period inventory model, an appropriate probability distribution of the demand is applied to recommend the suitable inventory level. Furthermore, the supply chain managers are faced with the decision regarding the safety stock to balance the service cycle level during the lead-time (time between the placement and receipt of ordered goods. The decision becomes more complex when the lead-time is variable, and the supply chain managers apply stochastic processes in making inventory decisions. Some of the inventory management models are presented below.

EOQ Model: $Economic\ Order\ Quantity\ (EOQ) = \sqrt{\frac{2D}{H}}$

Total Inventory Cost = (DS/Q) + (QH/2)

Total Annual Cost = (DS/Q) + (QH/2) + PD

D = Annual demand; Q = Order quantity;

S = Ordering cost or setup cost; and H = Inventory holding cost

P = Purchase price; all other terms are defined above.

To analyze the quantity discount situation, the supply chain manager minimizes the total annual cost which includes the inventory carrying, ordering, and the materials costs as presented next.

Reorder Point and Safety stock

ROP = (dL) + $Z\sigma_{dLT}$ and Safety Stock = (dL) + $Z\sigma_{dLT}$

d = Daily demand; L = Lead-time in days; Z = Standard normal variable

σ_{dLT} = Standard deviation of demand per day

We suggest that the demand forecasting and the inventory management models should be worked jointly as one is the input of the latter. This would help in developing a better control over the inventory levels and hence a step toward increasing integration of the SCM.

Transportation, Logistics, and Warehousing:

The primary objective of the transportation models is to minimize the total logistics cost. The unit transportation costs are assumed to be constant, however, the sensitivity analysis can be performed to determine the range for an optimal solution. Figure 3 shows a basic transportation model.

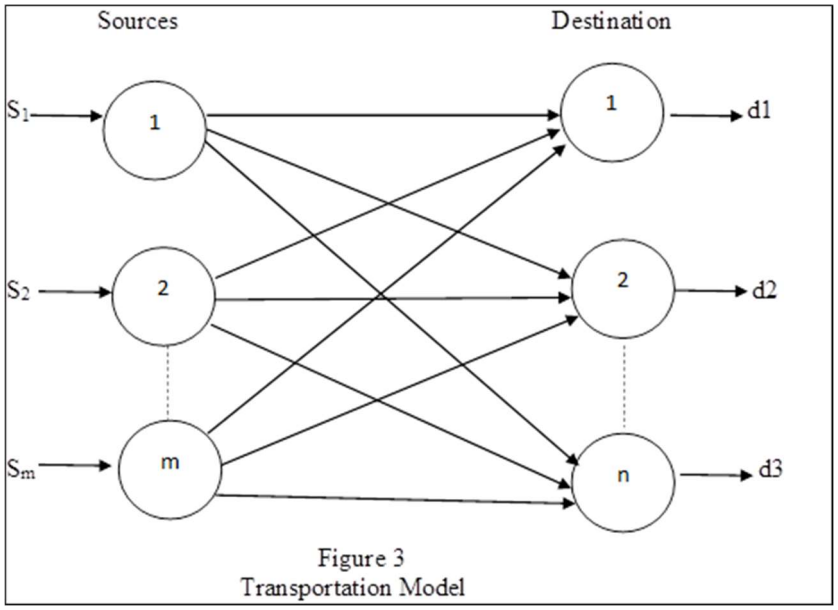

Figure 3
Transportation Model

The transportation model becomes a transshipment model when the material is shipped from plants or sources to warehouses and then to the destinations; warehouses are considered as intermediary nodes. Figure 4 show a basic transshipment model.

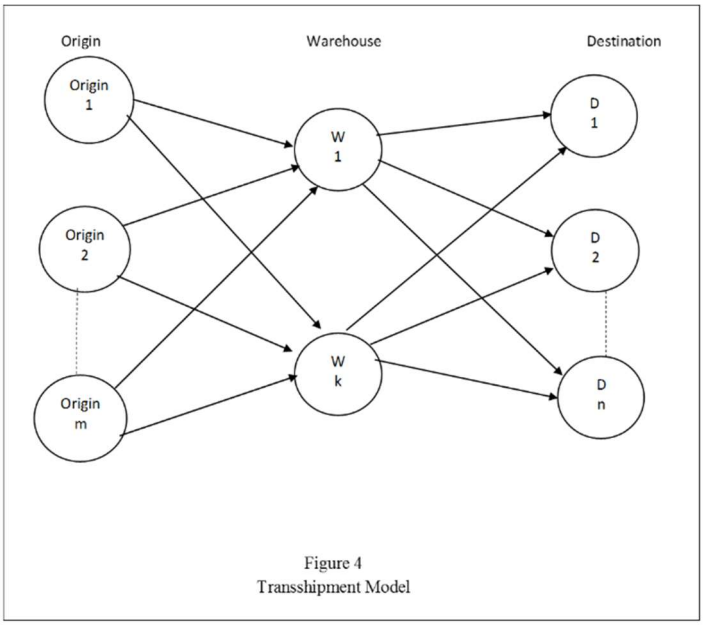

Figure 4
Transshipment Model

The linear programming format of transportation problem can be written as:

$$z = \sum_{i=1}^{m} \sum_{j=1}^{n} x_{ij} c_{ij}$$

Subject to the constraint

$$\sum_{j=1}^{n} x_{ij} = a_i, i = 1,2,...m$$

$$\sum_{i=1}^{m} x_{ij} = b_j, j = 1,2,...n.$$

And Xij ≥ 0, for all i and j

Location Analysis:

Organizations apply the location analysis techniques to evaluate location decisions because location impacts variable costs, fixed costs, overall risk and profit. Reasons of location decisions include expansion of current facility, adding another facility while operating the current one, or closing the current facility and moving to another location. In a domestic supply chain as well as in a global supply chain, the location related decision can be made using the Factor Rating method, Centre of Gravity method, and Break-even analysis or crossover charts; the Factor Rating method and Centre of Gravity method use the weighted average approach. Likewise, location analysis can be used to minimize the transportation costs. Warehousing decisions can be analysed along with the location analysis and the transhipment models. Furthermore, if these decisions are taken together in conjunction with the demand and inventory management modelling, they can further supplement the supply chain integration.

Factor Rating Method:

Factor rating method uses weighted average of the factor scores and the assigned weights as presented in the following formula. The qualitative factors are assigned weights according to their importance when comparing several locations.

$$Average\ Rating\ Score = \frac{\sum XiWi}{\sum Wi}$$

Where, Wi = Factor weight; n = Number of factors; Xi = Factor score

Center of Gravity Method:

The center of gravity method is a quantitative method used to determine the location of a distribution center or a facility that minimizes the logistics costs. This method considers the location of markets, amount of material transported to the markets, and the transportation costs in determining the best location for a distribution facility. The shipping locations are placed on the coordinated map and the weighted averages of both X and Y coordinates are computed using shipping volume as the weights using the following formulas:

$$C_x = \frac{\sum d_{ix} V_i}{\sum V_i} \qquad C_y = \frac{\sum d_{iy} V_i}{\sum V_i}$$

C_x = X coordinate of center of gravity

C_y = X coordinate of center of gravity

d_{ix} = X coordinate of the ith location

d_{iy} = Y coordinate of the ith location

V_i = volume of goods moved to or from ith location

Centre of Gravity Formula

Crossover Charts:

The crossover charts allow the comparison of different production processes for a specified range of production volume to determine which process is more economical than the others. For example, one process may have lower unit cost but may have a higher fixed cost as compared to the other process with higher unit cost but with a lower fixed cost. Integrating demand planning with crossover charts can further facilitate in selecting the most economic process. Figure 5 depicts a typical crossover chart.

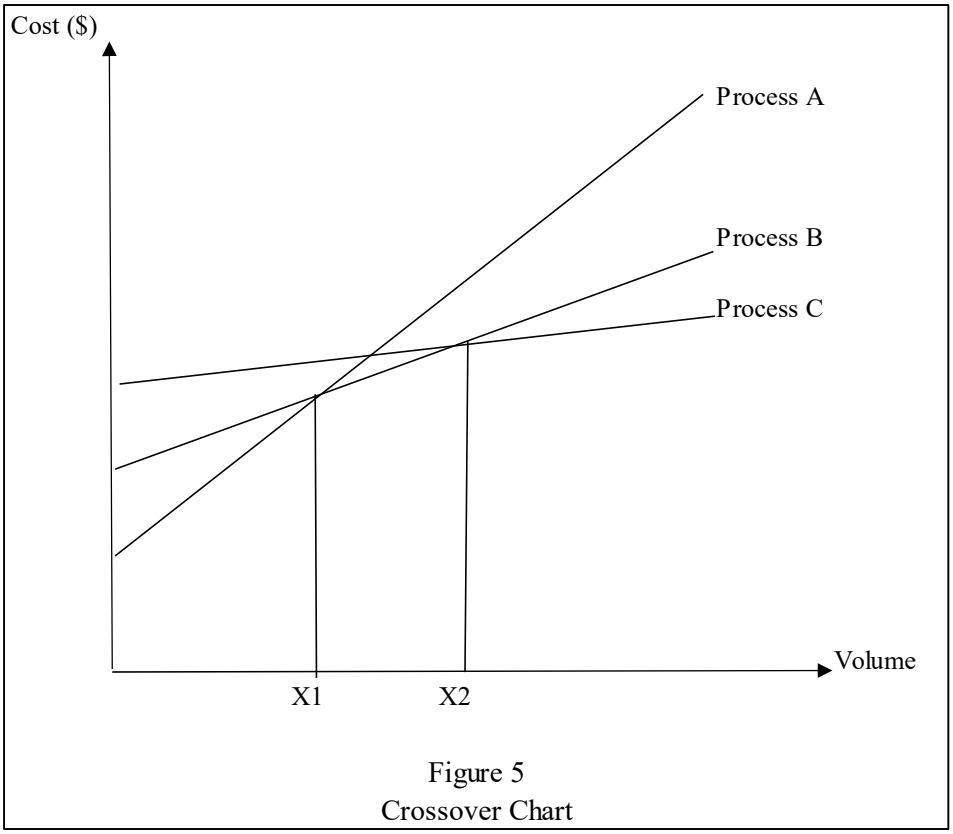

Figure 5
Crossover Chart

The chart compares three different processes. The process A has the lowest fixed cost followed by the processes B and C. The process A has the largest variable cost followed by the processes B and C. The crossover chart

compares the total costs for all three processes and yields the quantity range for which a process is the most economical. The Figure 5 indicates that the process A is the most economical for the quantity range of 0 to X1, the process B is the most economical for the quantity between X1 and X2, and the process C is the most economical for quantity greater than X2. The supply chain manager can select a process based upon the demand planning and forecasting.

Line Balancing:

In a product-oriented layout, fabricated parts are combined in a series of workstations. The main objective of the product-oriented layout is to minimize the variation or imbalance in the assembly line. In other words, the time to complete fabricated parts of tasks in one workstation should be approximately same as the time to complete tasks in other workstations. The advantages of the balanced line include reduced work-in-process inventories and higher throughput. The assembly line balancing is presented in Figure 6.

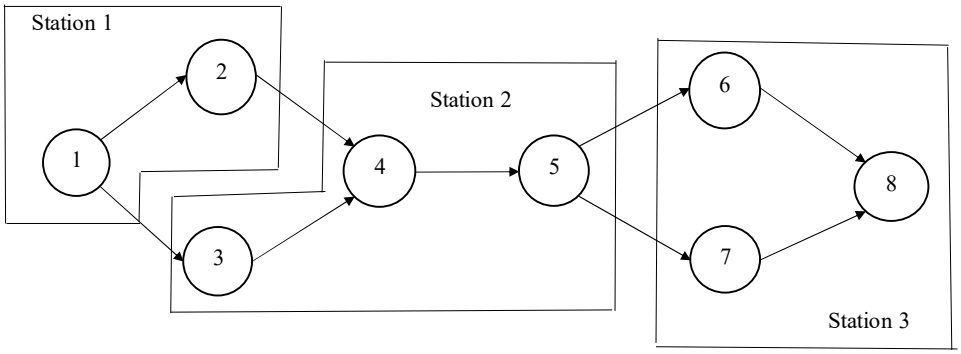

Figure 6
Line Balancing

The Figure 6 indicates that the tasks 1 and 2 will be performed workstation 1, the tasks 3, 4, and 5 will be placed in the workstation 2, and the

tasks 6, 7, and 8 will be performed int the workstation 3. The primary objective of line balancing is to create the cumulative task time of each workstation approximately equal. The balanced line will reduce the wait time as well as the idle time of the tasks. This would enhance the throughput time of the product, which enhances customer satisfaction since they receive the delivery on time.

Linear Programming:

Linear programming methods have been widely used in production planning, product-distribution problem, resource allocation problems, product mix problems, etc. The general format of linear programming problem is presented below.

Maximize (or Minimize)

$$c_1x_1 + c_2x_2 + \cdots c_nx_n$$

Subject to

$$a_{11}x_1 + a_{12}x_2 + \cdots a_{1n}x_n (\leq, =, \geq) b_1$$

$$a_{21}x_1 + a_{22}x_2 + \cdots a_{2n}x_n (\leq, =, \geq) b_2$$

$$a_{m1}x_1 + a_{m2}x_2 + \cdots a_{mn}x_n (\leq, =, \geq) b_m$$

$$x_1, x_2, \cdots, x_n \geq 0$$

General Linear Programming Model

The general form of linear programming model has an objective function and several constraints. The objective would be to either maximize the profit or revenue or to minize the cost or risk. Additionally, the model has several constraints and they could be either ≤ or ≥ or = type constraints. For example, the supply chain manager is interested in determining the amount of each of the 'n' products by maximizing the total profit. This production planning may have several restrictions or constraints. For example, the manager has restriction of the available capacity which may result in ≤ type constraint or the minimum demand requirement which may result in ≥ type constraint. The objective

would be determine the oprimal amount of the each product to produce to maximize total profit by satisfying all constraints or restrictions. The linear programming method is very useful in analyzing a variety of supply chain issues including production planning, resource allocation, sourcing, etc.

Data Envelopment Analysis:

Data Envelopment Analysis (DEA) is a non-parametric linear programming method that can be applied in a variety of supply chain management issues. For example, it can be used in supplier selection, product selection, and many other situations. DEA measures the efficiency of the decision making unit (DMU) by comparing with the best producer in the sample to derive compared efficiency (see Charnes et al., 1978; Charnes et al., 1994; Cooper et al., 2007). DEA generates subjective measures of operational efficiency through the number of similar entities compared with each other.

$$\max \quad \frac{\sum_{k=1}^{s} v_k y_{kp}}{\sum_{j=1}^{m} u_j x_{jp}}$$

$$s.t. \quad \frac{\sum_{k=1}^{s} v_k y_{ki}}{\sum_{j=1}^{m} u_j x_{ji}} \leq 1$$

$$v_k, u_j \geq 0$$

where,
$k = 1$ to s,
$j = 1$ to m,
$i = 1$ to n,
y_{ki} = amount of output k produced by DMU i,
x_{ji} = amount of input j produced by DMU i,
v_k = weight given to output k,
u_j = weight given to input j.

Data Envelopment Analysis Model

Fuzzy Logic:

In fuzzy logic the individuals make decisions based on imprecise and non-numerical information. This technique has been used in various fields including supply chain when decision makers are dealing with uncertainty issues in data sets. Felix at al (2008) applied the fuzzy logic based Analytic Hierarchy Process to efficiently analyze quantitative and qualitative decision factors involved in selection of global suppliers. The study provides an example of a manufacturing firm to recommend a global supplier for a critical component. Srinivas (2019) also uses fuzzy logic to study supply chain performances including fill rate, build-to-stock, and others under customer order uncertainty. The results show that the fill rate is sensitive to customer uncertain demand and supplier reliability Also, the study finds that the total cost for the unreliable raw material supplier increases with decrease in uncertainty.

3. CONCLUSIONS

Supply chain management is the most critical function of an organization which encompasses the coordination of all relevant activities from raw materials procurement to satisfying the final customers. In this endeavor, the supply chain management enables an oganization to realize a sustainable competitive advantage. In order to take full advantage of the supply chain, organizations need to collaborate with suppliers and customers as well as integrate different functions within the organization. This study described basic analytical and quantitative models applicable in the integrated supply chain management environment. Analytical models coupled with information technology and enterprise resource planning systems can potentially enhance a firm's competitiveness by integrating internal and external functions of the organizations. The external functions would include the internal functions of the supply chain member organization. Well-organized supply chain integration potentially results in efficient fulfilment and customer satisfaction.

Future research may include artifical intelligence, internet of things, and neural netwrok to improve internal and external supply chain integration.

4. ACKNOWLEDGEMENTS

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RESEARCH ARTICLE

EFFICIENCY ANALYSIS OF PUBLIC DISTRICT HOSPITALS IN TAMIL NADU USING DATA ENVELOPMENT ANALYSIS

P. Mariappan[(1)], Ms. A Jenifer Christianal[(2)], Dinesh S. Dave[(3)] & Ms. S. Bhagavathy[(4)]

ABSTRACT

The aim of this study is to identify the performance efficiency of public district hospitals in Tamil Nadu using the non-parametric approach of Data Envelopment Analysis (DEA). The study investigations the efficiency level of hospitals by considering various input and output measures. The finding of this study provides the efficient and inefficient public district hospitals in Tamil Nadu.

Keywords: Public District Hospitals, Efficiency Analysis

1. INTRODUCTION

Public health system in Tamil Nadu

Tamil Nadu health care sector consists of both private and public provider. Tertiary health care is offered by a few public hospitals located in state capital and other larger towns. At the same time the government health system has no referral system. Providers in tertiary care institutions can be approached by patients from any part of the state before being referred to by providers at the

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lower levels of care. Tamil Nadu is the fifth largest economy and the sixth most populous state in India with the third highest Human Development Index amongst 29 Indian states (HDR Govt. of Tamil Nadu 2003). In terms of health indicators including infant mortality rate and maternal mortality rate The health sector in Tamil Nadu is improving rapidly.

Status of Public Hospital

In the past several decades remarkable progress has been made in India for improving the health and well-being of its people. Life expectancy rose from 17 years to 61 years over the past 40 years. Infant mortality has fallen by more than two third to seventy-four deaths per thousand live births. Inspite these remarkable strides India is behind many less wealthy nations on indicators of health system performance (World bank 2005). Out of 191 WHO member countries, India was ranked 112 on an index of overall performance of health system. Whereas 108, 110 and 127 respectively on the basis of their responsiveness of health system, level and distribution (World Bank 2005). Because of bureaucratic processes and excessive hierarchical channels in the implementation of cost control measures public hospitals are less efficient.

2. INTRODUCTION TO DATA ENVELOPMENT ANALYSIS

Data Envelopment Analysis (DEA) is a methodology based upon an interesting application of linear programming. It was originally developed for performance measurement. It has been successfully employed for assessing the relative performance of a set of firms that use a variety of identical inputs to produce a variety of identical outputs. The principles of DEA date back to Farrell (1957). The recent series of discussions on this topic started with the article by Charnes et al (1978). A good introduction to DEA is available in Norman and Stoker (1991). Cooper et al. (2000) provide recent and comprehensive material on DEA. Data Envelopment Analysis (DEA) is a non-parametric method in operations research and economics for the estimation of production frontiers. It

is used to empirically measure productive efficiency of Decision-Making Units (or DMUs). Most of these DMUs are non-profit organizations, where the measurement of performance efficiency is difficult. The performance of DMUs is assessed in DEA using the concept of efficiency or productivity, which is the ratio of total outputs to total inputs. Efficiencies estimated using DEA are relative, that is, relative to the best performing DMU (or DMUs if there is more than one best-performing DMUs). The best performing DMU is assigned an efficiency score of unity or 100 per cent, and the performance of other DMUs varies, between 0 and 100 percent relative to this best performance.

3. REVIEW OF LITERATURE

Reviewing the past literatures, the present study investigates the efficiency of public district hospitals functioning in Tamil Nadu by considering the study period between 2011 – 2019. For this purpose, the data envelopment analysis was used with two input variables and three output variables. The efficiency scores were calculated for a sample of thirty-one public district hospitals functioning in Tamil Nadu. The result analysis shows the best performing hospital in Tamil Nadu.

4. RESEARCH METHODOLOGY

Data collection

For this study, the required data for the hospitals in Tamil Nadu have been taken from Ministry of health and family welfare for the financial years 2011-2018 [Annexure A].

Selection of Input and Output Variables

Reviewing the literature on the application of DEA, different studies have used different combination of inputs and outputs. For the current study, the researcher considered two input variables and three output variables in order to have an elaborate study. The variables under the study are listed below:

Input Variables	Output Variables
Number of staffs	Number of in and out patients
Number of beds	Number of major surgeries
	Number of minor surgeries

5. MATHEMATICAL MODEL

Fractional DEA Program

Let there be N DMUs whose efficiencies have to be compared. Let us take one of the DMUs. Say the DMU. And maximize its efficiency, according to the formula given above. Here the DMU is the reference DMU.

The mathematical problem is,

$$Max\ E_m = \frac{\sum_{j=1}^{J} v_{jm} y_{jm}}{\sum_{i=1}^{I} u_{im} x_{im}}$$

Subject to the Constraints

$$0 \le \frac{\sum_{j=1}^{J} v_{jm} y_{jn}}{\sum_{i=1}^{I} u_{im} x_{in}} \le 1;\ \text{n= 1,2,K,J}$$

$$v_{jm}, u_{im} \ge 0;\ \ i = 1,2,K,I;\ \ j = 1,2,K$$

Where,

E_m is the efficiency of the m^{th}DMU,

Y_{ij} is the j^{th} output of the m^{th} DMU,

V_{jm} is the weight of that output,

X_{im} is i^{th} the input of the m^{th} DMU,

U_{jm} is the weight of that input, and

Y_{jn} and X_{in} are output j^{th} and i^{th} input, respectively, of the nth DMU, n = 1,2,…,N.

Note that here n includes m.

CCR AND BCC MODEL

The original CCR model was pertinent only to that expertise which is categorized by constant returns to scale. The major advancement was extended by Charnes, and Cooper (BCC) model to facilitate expertise that reveals variable returns to scale. This study has used input-oriented DEA model, which emphasizes on the minimization of inputs and the maximization of outputs held at their current levels. Also, the BCC model with variable return to scale is considered.

General form of CCR Model

The general form Output Maximization DEA [CCR] model can be represented in the form of Fractional Programming Model as follows:

Here the general model is constructed to maximize the efficiency of the qth output variable:

v_{jq} - j^{th} output value of the q^{th} DMU

y_{jq} - j^{th} output variable of the q^{th} DMU

u_{iq} - i^{th} input value of the q^{th} DMU

x_{iq} - i^{th} input variable of the q^{th} DMU

E_q - Efficiency of the q^{th} DMU

$$\text{Max } E_q = \frac{\sum_{j=1}^{m} v_{jq} y_{jq}}{\sum_{i=1}^{s} u_{iq}\, x_{iq}}$$

Subject to the constraint

$$\frac{\sum_{j=1}^{m} v_{jq} y_{jq}}{\sum_{i=1}^{s} u_{iq}\, x_{iq}} \leq 1; \quad q = 1,2,\ldots,n$$

$$v_{jq}, y_{jq}, u_{iq}, x_{iq} \geq 0 \; for \; all \; i = 1,2,..s; j = 1,2,..m, q = 1,2,...n$$

Solving this fractional programming problem directly is so tedious; hence the fractional programming model is converted into regular linear programming model as described below:

$$Max \; E_q = \sum_{j=1}^{m} v_{jq} y_{jq}$$

Subject to the constraints

$$\sum_{i=1}^{s} u_{iq} x_{iq} = 1$$

$$\sum_{j=1}^{m} v_{jq} y_{jq} - \sum_{j=1}^{m} u_{iq} x_{iq} \leq 0; \quad q = 1,2,...n$$

$$v_{jq}, y_{jq}, u_{iq}, x_{iq} \geq 0 \; for \; all \; i = 1,2,..s; \; j = 1,2,..m, \;\; q = 1,2,...n$$

The general form of input minimization DEA [CCR] linear programming model can be represented as follows:

$$Min \; E_q = \sum_{i=1}^{s} u_{iq} x_{iq}$$

Subject to the constraints

$$\sum_{j=1}^{m} v_{iq} y_{iq} = 1;$$

$$\sum_{j=1}^{m} v_{jq} y_{jq} - \sum_{i=1}^{s} u_{iq} x_{iq} \leq 0; \quad q = 1,2, \ldots n$$

$$v_{jq}, y_{jq}, u_{iq}, x_{iq} \geq 0 \text{ for all } i = 1,2,..s; j = 1,2,..m, q = 1,2, \ldots n$$

General form of BCC Model

The DEA envelopment program for considering variables return to scale is as follows:

$$Min\ \theta_m$$

Subject to the Constraints

$$Y\lambda \ \geq \ Y_m; \ X\lambda \ \leq \ \theta X_m$$

$$\sum_{n=1}^{N} \lambda_n = \ 1$$

$$\lambda \geq \ 0 \ ; \theta_m \ free\ variable$$

6. EMPIRICAL RESULTS

Constant Return to Scale [CCR Model]

Table 1 communicates that the DEA efficiency score based on Technical Efficiency [Constant return to scale] under the CCR Model. It is observed that there is a varying trend in their mean of Technical Efficiency of hospitals in Tamil Nadu, the score lies in the interval [0.542, 0.932].

Variable Return to Scale [BCC Model]

Table 2 communicates that the DEA efficiency score based on Technical Efficiency [Variable Return to Scale] under the BCC Model.

Overall Mean Efficiency

Among all the thirty-one-district considered for this study, no district is more efficiency with the efficiency score of 1. The ranks of each districts are given in the Table 3.

7. CONCLUSION

In this study, the researcher taken thirty-one district hospitals in Tamil Nadu. Based on the CCR and BCC model results, there is no public district hospitals in Tamil Nadu attains the efficiency level. The analysis reveals that all the public district hospitals in Tamil Nadu should take necessary measure to improve their performance.

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10. APPENDIX

Table 1 Constant Return to Scale – Efficiency Table

Name of The District	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	Mean
Kancheepuram	0.834	1	0.788	0.855	0.156	0.522	1	0.95	0.763125
Vellore	0.797	1	1	0.919	0.676	0.59	0.754	0.114	0.73125
Tiruvannamalai	0.605	1	0.786	1	0.543	0.748	0.304	0.045	0.628875
Cuddalore	0.671	1	1	1	1	0.853	1	0.105	0.828625
Dharmapuri	1	0.853	1	0.636	1	1	0.495	0.039	0.752875
Salem	0.434	0.892	0.746	1	0.51	0.782	0.313	0.077	0.59425
Erode	0.647	0.726	0.618	0.582	0.135	0.771	0.839	0.032	0.54375
Coimbatore	0.388	0.702	0.817	0.422	0.743	0.773	0.41	0.029	0.5355
The nilgiris	0.198	0.33	0.458	0.552	0.569	0.495	0.734	0.388	0.4655
Trichy	0.962	0.926	0.669	0.543	0.88	0.727	0.287	0.034	0.6285
Pudukkottai	0.677	0.638	0.637	0.611	0.157	0.512	0.564	0.317	0.514125
Dindigul	0.79	1	0.744	0.675	0.15	0.729	1	0.581	0.708625
Madurai	1	0.946	0.975	0.394	1	1	0.204	0.033	0.694
Virudhunagar	0.735	0.65	0.641	0.414	0.156	0.938	0.677	1	0.651375
Sivaganga	1	0.844	0.565	0.573	0.317	0.483	1	0.161	0.617875
Ramanathapuram	0.434	0.599	1	0.452	0.52	0.196	0.593	0.135	0.491125
Tirunelveli	0.457	0.59	0.605	1	1	0.553	1	0.032	0.654625
Thoothukudi	0.977	0.801	0.775	0.875	0.519	0.74	0.402	0.051	0.6425
Kanyakumari	0.813	0.86	0.882	0.796	1	1	0.51	0.047	0.7385
Nagapattinam	0.582	0.836	0.855	0.415	0.124	0.42	1	0.401	0.579125
Thanjavur	0.524	0.803	0.6	0.613	1	0.562	0.012	0.167	0.535125
Villupuram	1	1	0.95	0.403	0.399	0.502	1	0.079	0.666625
Karur	0.461	0.8	0.809	1	1	0.566	1	0.153	0.723625
Perambalur	0.75	1	1	0.679	0.694	1	0.52	0.127	0.72125
Thiruvallur	0.693	0.724	0.856	0.711	0.356	0.708	1	1	0.756
Thiruvarur	1	0.839	0.615	0.903	1	0.53	0.636	0.131	0.70675
Theni	0.671	0.658	0.734	0.619	0.723	0.596	0.534	0.046	0.572625
Namakkal	0.705	0.677	0.714	0.883	0.234	1	0.706	0.149	0.6335
Krishnagiri	0.93	0.93	1	0.71	0.647	0.461	0.562	0.187	0.678375
Ariyalur	1	1	0.945	0.522	0.574	0.376	0.418	1	0.729375
Tirupur	0.544	0.747	0.767	0.64	0.336	0.805	1	0.247	0.63575

Table 2 Variable Return to Scale – Efficiency Table									
Name of The District	2011-2012	2012-2013	2013-2014	2014-2015	2015-2016	2016-2017	2017-2018	2018-2019	Mean
Kancheepuram	1	1	0.947	0.855	0.67	0.565	1	1	0.879625
Vellore	1	1	1	0.92	0.776	0.88	0.829	0.744	0.893625
Tiruvannamalai	0.644	1	1	1	0.802	0.755	0.304	0.062	0.695875
Cuddalore	1	1	1	1	1	0.926	1	0.106	0.879
Dharmapuri	1	1	1	0.772	1	1	0.713	0.088	0.821625
Salem	0.51	0.937	0.754	1	0.556	1	1	1	0.844625
Erode	0.825	0.744	0.632	0.611	0.472	1	1	0.389	0.709125
Coimbatore	0.533	0.737	0.839	0.477	0.784	1	1	0.302	0.709
The Nilgiris	0.302	0.602	0.895	0.633	0.673	0.857	0.988	1	0.74375
Trichy	1	0.964	0.83	0.977	1	1	0.317	0.067	0.769375
Pudukkottai	1	0.67	0.683	0.634	0.676	0.565	0.577	0.501	0.66325
Dindigul	0.92	1	0.752	0.702	0.666	0.847	1	1	0.860875
Madurai	1	0.991	0.991	0.844	1	1	0.209	0.061	0.762
Virudhunagar	1	0.654	0.666	0.505	0.498	1	1	1	0.790375
Sivaganga	1	1	0.776	0.628	0.521	0.489	1	1	0.80175
Ramanathapuram	0.447	0.631	1	0.521	0.803	0.216	0.645	0.201	0.558
Tirunelveli	0.466	0.598	0.615	1	1	1	1	1	0.834875
Thoothukudi	1	0.901	1	1	0.672	0.811	0.482	0.28	0.76825
Kanyakumari	0.891	0.907	1	1	1	1	0.713	0.463	0.87175
Nagapattinam	0.89	0.905	0.856	0.539	0.474	0.511	1	0.884	0.757375
Thanjavur	0.858	0.828	0.604	0.649	1	0.84	0.03	1	0.726125
Villupuram	1	1	0.959	0.639	0.504	0.609	1	1	0.838875
Karur	0.52	0.95	1	1	1	0.939	1	0.935	0.918
Perambalur	1	1	1	1	1	1	0.612	0.179	0.848875
Thiruvallur	0.707	0.728	0.864	0.927	0.607	0.771	1	1	0.8255
Thiruvarur	1	0.94	0.76	0.971	1	0.538	1	1	0.901125
Theni	0.675	0.698	0.747	0.665	0.777	0.598	0.64	0.058	0.60725
Namakkal	0.722	0.727	0.969	1	0.894	1	0.791	0.221	0.7905
Krishnagiri	0.976	0.996	1	0.753	1	0.618	1	1	0.917875
Ariyalur	1	1	0.971	1	0.859	0.923	0.464	1	0.902125
Tirupur	0.561	0.763	0.781	0.759	0.698	0.958	1	1	0.815

Table 3 Overall Mean Efficiency

Name of The District	CRS Mean	VRS Mean	Overall Mean
Kancheepuram	0.763125	0.879625	0.821375
Vellore	0.73125	0.893625	0.8124375
Tiruvannamalai	0.628875	0.695875	0.662375
Cuddalore	0.828625	0.879	0.8538125
Dharmapuri	0.752875	0.821625	0.78725
Salem	0.59425	0.844625	0.7194375
Erode	0.54375	0.709125	0.6264375
Coimbatore	0.5355	0.709	0.62225
The Nilgiris	0.4655	0.74375	0.604625
Trichy	0.6285	0.769375	0.6989375
Pudukkottai	0.514125	0.66325	0.5886875
Dindigul	0.708625	0.860875	0.78475
Madurai	0.694	0.762	0.728
Virudhunagar	0.651375	0.790375	0.720875
Sivaganga	0.617875	0.80175	0.7098125
Ramanathapuram	0.491125	0.558	0.5245625
Tirunelveli	0.654625	0.834875	0.74475
Thoothukudi	0.6425	0.76825	0.705375
Kanyakumari	0.7385	0.87175	0.805125
Nagapattinam	0.579125	0.757375	0.66825
Thanjavur	0.535125	0.726125	0.630625
Villupuram	0.666625	0.838875	0.75275
Karur	0.723625	0.918	0.8208125
Perambalur	0.72125	0.848875	0.7850625
Thiruvallur	0.756	0.8255	0.79075
Thiruvarur	0.70675	0.901125	0.8039375
Theni	0.572625	0.60725	0.5899375
Namakkal	0.6335	0.7905	0.712
Krishnagiri	0.678375	0.917875	0.798125
Ariyalur	0.729375	0.902125	0.81575
Tirupur	0.63575	0.815	0.725375

Annexure A: Data for the Financial Year 2011-2012

Hospital Name	Number of In & Out Patients	Number of Major Surgeries	Number of Minor Surgeries	Number of Staffs	Number of Beds
Kancheepuram	2393858	8083	37194	280	883
Vellore	3293455	9311	41622	429	972
Tiruvannamalai	2786119	7385	31456	517	947
Cuddalore	4207604	11289	38611	763	1256
Dharmapuri	5059954	720	12668	324	207
Salem	1757449	2930	30374	624	723
Erode	3273868	9168	16302	498	1203
Coimbatore	1360929	3265	12700	901	458
The nilgiris	1264871	3430	9441	1689	809
Trichy	8151547	3226	43979	558	599
Pudukkottai	5287544	9929	19955	587	1175
Dindigul	4269651	8350	23916	378	892
Madurai	4144176	3017	66365	1389	482
Virudhunagar	6324175	7979	23971	367	1070
Sivaganga	5192197	7061	13686	146	706
Ramanathapuram	2808173	6263	20516	683	1048
Tirunelveli	2235079	6687	25025	794	960
Thoothukudi	7168185	4497	24977	468	538
Kanyakumari	6138567	2239	6198	429	454
Nagapattinam	5289123	8943	38955	895	1177
Thanjavur	4280622	4918	56429	1094	1107
Villupuram	4198295	5472	46990	132	645
Karur	2155140	4647	16607	7643	532
Perambalur	1584970	3858	5897	675	238
Thiruvallur	2174587	6998	32772	845	614
Thiruvarur	3156149	5602	46487	121	552
Theni	5201504	3394	17200	478	586
Namakkal	6204131	4911	12594	578	721
Krishnagiri	4227631	6511	29667	378	577
Ariyalur	1666682	8596	16841	698	330
Tiruppur	3074979	5790	24001	379	900

RESEARCH ARTICLE

REGRESSION MODEL FOR SERVICE QUALITY OF CRM PRACTICES IN BANKS: AN APPLICATION OF EXPLORATORY FACTOR ANALYSIS

Kamlesh L. Patel[(1)] & Sanjay G. Raval[(2)]

ABSTRACT

The objective of this research article is to study the causal relationship among the Service Quality and Customer-Satisfaction in the banking industry of the Gujarat state. To assess the perception of customers about Service Quality of CRM practices of the banking sector of Gujarat state; the SERVPERF scale measure has been used to fulfil said objective. Results were indicating significance positive relationship among the constructs of Service Quality of CRM practices and Customer Satisfaction. Eventually these constructs of CRM practices were explained Customer-Satisfaction positively and significantly.

Key words: Service Quality, Customer-Satisfaction, CRM, SERVPERF

1. INTRODUCTION:

Customer Relationship Management (CRM) practices is an important relationship management (RM) technique which enhances the bond between customers and an organization in systematic way. This technique is a heart of any service sector industry, especially in the field of banking sector its work successfully. The successful formula for business is to concentrate on needs,

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requirements and demands of the customers; CRM helps to read the changing mind of customer and their needs very sophisticated way. With the help of CRM, banks manage their services in such a way that customers are assured of the existence and success of their bank organization. Instead of making more profit from any transaction, banks increase their profits by maximizing profitability through total customer relationships during that period. Therefore, it is necessary for service organizations to increase the satisfaction of target customers with the quality of services they expect.

2. REVIEW OF LITERATURE:

To discover the research space, the researchers have conducted the following reviews to understand the problem.

2.1 Service Quality:

Service-Quality can be enhanced due to high-quality relationships with customers. Service Quality is defined as "the general appraisal of a specific service organisation that grades from comparing that firm's presentation with the customer's overall expectations of how firm in that industry should perform" (Parasuraman, Zeithaml, & Berry, 1988). In the word of Kotler and Armstrong "Customer satisfaction is the post-sales evaluation of products or services taking into account expectations. Research has repeatedly shown that quality of service affects customer satisfaction" (Kotler & Armstrong, 2011). According to Paul and others "Overall satisfaction of customers is influenced by Service-Quality of organisation. In the case of PSU banks, product knowledge, response to need, solving problems, quick service, speedy link to the proper person, and reducing waiting time were found to be the latent variables that were significantly associated with overall satisfaction" (Paul, Mittal, & Srivastav, 2016).

2.2 Customer-Satisfaction:

"Customer-Satisfaction is a vital factor to increasing revenue potential and increasing market segment of all manufacturers' organizations or service providers. Customer Satisfaction often tends to a positive word for purchase, product trustworthiness and word of mouth advertising and therefore ultimately improves financial performance. Banking is considered as customer oriented service industry, where the customer is at the centre" (Deboshree & Kamesh, 2019). "The banking sector has always been a customer oriented, service sector. Therefore, through the vast satisfaction of customers, in today's competitive age they must provide personalized services. Banks should implement and develop a "first customers" strategy and try to maintain a strong relationship with their customers" (Shikha, 2017). According to Parker & Mathews "Satisfaction is the customer's emotional response to evaluate his or her previous experience and the disparity among the product and the organization's expectations and the actual experienced performance realized after contact with the organization and after use of product or service" (Parker & Mathews, 2001).

3. OBJECTIVES OF STUDY:

As per review and experts suggestions, the authors approach the following objectives:

(1) To identify independent constructs (latent variables) of Service-Quality of CRM practices of public sector banks of Gujarat state.

(2) To study the relationship among Constructs of Service-Quality of CRM practices of public sector banks of Gujarat state.

(3) To test the impact of constructs of Service-Quality of CRM practices of public sector banks of Gujarat state on Customer-Satisfaction.

4. RESEARCH HYPOTHESES:

(1) H_{01}: There is no significant relationship among items (statements) of service quality of CRM practices of public sector banks of the Gujarat state.

(2) H_{02}: The constructs of service quality of CRM practices of public sector banks of the Gujarat state do not significantly impact on Customer-Satisfaction.

5. RESEARCH METHODOLOGY:

To execute the above objectives sample of 325 customers of banking sectors of Gujarat state ware selected at random and collect the data regarding perception of services of CRM using 5 point Likert structural questionnaires with 32 statements. Before survey; pilot study was conducted in which 50 respondents were selected and they were understood all statements of questionnaire items. Total 500 questionnaires were distributed to respondents out of which 350 questionnaires were collected; eventually 325 questionnaires were involved in the study.

6. EXPLORATORY FACTOR ANALYSIS:

EFA and PCA both are useful to reduce number of scale items from the data set information and to obtain independent constructs from the set of large number of scale items.

6.1 KMO and Bartlett's Test:

Table 1 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.939
Bartlett's Test of Sphericity	Approx. Chi-Square	4526.948
	df	378
	Sig.	.000

Table 1 revealed that value of KMO statistics was 0.939 which was greater than 0.7; it indicates that there were sufficient items in each construct to measure construct. Bartlett's test value was significant ($p < 0.05$); hence H_{01} is rejected, hence correlation matrix was significantly differing from identity matrix therefore Bartlett's test allowed us for factor analysis (Nancy, Karen, & George, 2014)

6.2 Total Variance Explain:

Table 2 shows how the total variance divided into 28 possible factors. Note that the first five factors have eigenvalue more than 1.0, which is common criterion for factors to be useful. When the factor eigenvalue less than 1.0; that factor explain less information than a single item would have explained such items are not shown in the table.

Table 2 Total Variance Explained

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	11.076	39.556	39.556	6.032	21.542	21.542
2	1.985	7.089	46.645	3.395	12.125	33.667
3	1.278	4.565	51.210	3.149	11.247	44.913
4	1.171	4.181	55.391	2.299	8.210	53.123
5	1.047	3.740	59.131	1.682	6.008	59.131

The first component explains 39.556% of the total variance, but this is less than 50%, we probably want to rotate more than one component, as shown on the right hand side of this Total Variance Explained table 2. After rotation, the first component accounted for 21.542% of the variance, the second component accounted for 12.125% of the variance, the third component explained 11.247%, the fourth and fifth components explained 8.210% and 6.008% respectively. Noted that communality of item09, item15, item24 and item25 are less than 0.5, hence these items are removed from data and remaining 28 items ware used for factor analysis.

6.3 Rotated Component matrix:

The factors are rotated to make it easier to interpret, so that as many different things as possible are explained or predicted by various underlying factors.

Table 3 Rotated Component Matrix[a]

	Component				
	1	2	3	4	5
Item30	.791				
Item28	.721				
Item22	.701				
Item29	.695				
Item26	.688				
Item31	.688				
Item21	.674				
Item32	.656				
Item23	.629				
Item20	.607				
Item27	.563				
Item14		.659			
Item19		.640			
Item12		.622			
Item17		.589			
Item13		.553			
Item16		.539			
Item11		.536			
Item06			.726		
Item02			.647		
Item04			.645		
Item08			.578		
Item10			.521		
Item01				.710	
Item03				.693	
Item07				.585	
Item05					.718
Item18					.711

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

Principal components analysis with varimax rotation was conducted to assess five factors of "Service Quality" of CRM practices in public sector banks of Gujarat. The results of EFA gave independent high loaded extracted factor components and corresponding factor scores were obtained by Anderson-Rubin method which produces scores that are uncorrelated and standardized (Tabachnica & Fidell, 2007). "The first underlying construct of the factor is 'Responsiveness' which consists of eleven items with an eigenvalue of 6.032. The second construct is made up of items that relate to 'Tangibility' which consists of seven items. The third construct includes items relating to the 'Assurance' which consists of five items with an eigenvalue of 3.149. The fourth Construct consists of 3 items that relate to 'Reliability' and the last construct consists 2 items which are related to Empathy" (Krishnamoorthy, Aishwaryadevi, & Bharathi, 2016).

6.4 Reliability and Validity of Constructs:

In order to collect the data authors were used a structural questionnaire as a measuring instrument to measure the perceptions of the customers, to check the reliability of questionnaire items Cronbach's alpha is a powerful test. The data of 325 customers of public sector banks of Gujarat consist of 28 items and Cronbach's alpha of each item was more than 0.94 and its overall value was 0.945. Also, Cronbach's alpha values for different constructs are shown in Table-4 which is more than 0.7 and the overall reliability of constructs is 0.847, hence the measuring instrument is reliable and valid.

Table 4 Reliability Statistics

Constructs	Cronbach's Alpha	No. of Items
Responsiveness	0.922	11
Tangibility	0.835	7
Assurance	0.810	5
Reliability	0.729	3
Empathy	0.708	2
Overall	0.847	6

7. **REGRESSION ANALYSIS:**

Reduced 28 items (observed variables) into five independent CRM Constructs (latent variables) by factor analysis technique and multiple regression analysis were conducted where Customer-Satisfaction was taken as the dependent variable and the five Constructs of Service Quality of CRM practices of public sector banks of Gujarat taken as independent variables.

7.1 Model Summary:

Table 5 Model Summary[a]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.608[a]	.370	.360	.66801	1.959

a. Predictors: (Constant), Empathy, Reliability, Assurance, Tangibility, Responsiveness

b. Dependent Variable: Customer-Satisfaction

Table 5 revealed that multiple correlation coefficients R was 0.608 and adjusted R square was 0.360, hence 36% of the variance in the Customer-Satisfaction can be manipulated by independent variables. Moreover, the value of Durbin-Watson is 1.959 which indicates there is no autocorrelation in the data.

Table 6 ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	83.444	5	16.689	37.399	.000[b]
	Residual	142.349	319	.446		
	Total	225.794	324			

a. Dependent Variable: ASAT

b. Predictors: (Constant), Empathy, Reliability, Assurance, Tangibility, Responsiveness

ANOVA (Table 6) shows that calculated value of $F_{(319,5)} = 37.999$ and p- value is less than 0.05; hence H_{02} is rejected. This indicates combination of predictors is significantly impact on Customer-Satisfaction.

7.2 Beta Coefficients:

Table 7 Coefficients[a]								
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	3.522	.037		95.037	.000		
	Responsiveness	.341	.037	.409	9.193	.000	1.000	1.000
	Tangibility	.264	.037	.316	7.111	.000	1.000	1.000
	Assurance	.193	.037	.231	5.206	.000	1.000	1.000
	Reliability	.139	.037	.167	3.747	.000	1.000	1.000
	Empathy	.122	.037	.146	3.283	.001	1.000	1.000

a. Dependent Variable: Customer-Satisfaction

Table 7 revealed that all p-values of CRM Constructs are less than 0.05; hence all Constructs of Service Quality was significantly contributed to explaining the Customer-Satisfaction. Among the five Constructs; the beta coefficient of Responsiveness has the highest value (0.341) while Empathy has the lowest beta coefficient (0.122), which means Responsiveness has more power than Empathy to predict Customer-Satisfaction. Also, all VIF values are exactly 1.0 therefore there is no multicollinearity among the constructs of CRM practices.

8. CONCLUSIONS AND RECOMMENDATIONS:

The current investigation concludes that CRM practice is the key to enhance customer satisfaction. This shows that bank management should pay more attention to the administrative quality given to the customers and train the bank staffs to deal with the issues and objections of the customers, which is mainly important for the satisfaction of the customers. CRM should be seen as a profit-enhancing factor rather than just a customer's record. In this competitive time of the banking industry, banks should give more importance to CRM practices to increase customer satisfaction. On the bases of the conclusion, the authors give the following recommendations

(1) Public division banks in Gujarat should comprehensive extraordinary preparing programs for all first-line authorities to manage clients by recognizing key CRM devices in the financial business.

(2) Bank management should improve procedures and methods of customer rigidity and direct problems that can improve customer satisfaction through CRM.

(3) Bank management should pay more attention to the responsive attitude of employees, service assurance, service reliability, physical environment, and technical services.

9. LIMITATION AND SCOPE OF THE STUDY:

Investigations were conducted for customers of public sector banks in the state of Gujarat; the limited geographical area of research affects this research. A number of measurement procedures have been used in the investigation, these statistical methods have their own limitations; all of these barriers affect research. The area of study in the present research is only the public sector banks of the State of Gujarat, thus the results can be verified by applying the same research in other parts of the country. Items (observe variables) were not included in this research like technical services; so new researchers can check these matters in their study.

10. ACKNOWLEDGEMENT:

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RESEARCH STUDY ARTICLE

MULTIFARIOUS ANALYSIS OF DIRECT-TO-HOME/CABLE TV SERVICES AND VIDEO STREAMING SERVICES IN MUMBAI

Raju K. Lohot[1] and Research Study Group[2]

ABSTRACT

This paper investigates the choice of broadcasting platforms and factors related to these broadcasting platforms namely, Direct-to-Home/Cable Television and Video Streaming Services in Mumbai using primary data of size 591. Reasons for preferring one broadcasting platform and not preferring the other are evaluated to understand the factors that are given importance while selecting a broadcasting platform. Also, dependencies between the preference of broadcasting platform and age, interest level to watch series/serials and educational qualification are tested. The comparison between average monthly recharge of Direct-to-Home/Cable Television and Video Streaming Services is done. Also, the average number of hours streamed per day using mobile data and Wi-Fi are compared. To further understand the change in preference of broadcasting platforms in near future, proportions of users changing from

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Direct-to-Home/Cable Television services to Video Streaming Services and Video Streaming Services to Direct-to-Home/Cable Television services in the near future are compared and also reasons behind it are listed. With the motive of creating an ideal Direct-to-Home/Cable Television and Video Streaming Services, various provisions are rated and their importance is quantified by deriving the coefficient of variation for each. It would give insights to the creators of broadcasting platforms to attract a greater audience.

KEYWORDS

Broadcasting, Cable television, DTH services, Video streaming services, Over-the-top services.

1. INTRODUCTION

India marked the onset of the television industry in 1976, after which its telecast was separated from All India Radio. With the Government's permission of reception and distribution of satellite television, various Direct-To-Home (DTH) and Cable TV service providers flared up in India. Cable Television and DTH services have always been in a tug of war, but the digitalization of media led to an upsurge of Video Streaming Services (VSS) as a new competitor in the field of broadcasting platforms. VSS gave an alternative option in the form of on-demand content against traditional television which is a live broadcasting platform. Eventually Hotstar, Amazon Prime, Netflix and numerous other video streaming applications flooded the Indian market providing a wide array of series, movies and documentaries at just one click away. Wayne, M. L. (2018) stated that “New media forms do not replace old ones. Rather, the interplay of old and new is an ongoing negotiation between established and emerging practices. However, what this means for the future of branded TV content and the future of television branding itself remains unclear”. “The fierce competition between the two dominant players in the market, the service innovation is high and prices are kept low. As a result, end-users are highly demanding” according to Baccarne et al. (2013). “Customers are keen to demand more services when the technology brings them more opportunities.

But it is also observed that the awareness about the services is not in a satisfactory level" concluded by Renjith (2016) based on a survey conducted. On the basis above comments, this research is conducted to study the factors playing role in the case of broadcasting platforms.

2. METHODOLOGY

The analysis of the paper is done with the assistance of primary data, which were collected from the individuals residing in Mumbai, through a questionnaire. The minimum age-restricted for the respondents was 15 years. The questionnaire was divided into two sections based on the selection of preferred broadcasting platform, namely: DTH/Cable TV services and VSS. Data were collected using the convenience sampling technique, also known as availability sampling. The total sample size was 618. Out of which, after data cleaning, 591 responses were retrieved. Among the 591 responses, 332 individuals preferred VSS, and 259 individuals preferred DTH/Cable TV services as the most preferred broadcasting platform.

3. FACTORS AFFECTING INTEREST LEVEL TO WATCH SERIES/SERIALS AND CHOICE OF BROADCASTING PLATFORMS

3.1. INTEREST LEVEL TO WATCH SERIES/SERIALS ACCORDING TO EDUCATIONAL QUALIFICATIONS

The users belonging to different categories of educational qualification like "HSC & equivalent", "Graduation and equivalent" and "Post-Graduation and Higher studies" rated their interest in watching series/serials on the scale of 0 to 5 (0 denoting the least interest and 5 denoting the highest interest).

To test:

H_0: Interest level to watch series/serials is independent of educational qualifications of users.

Versus

H_1: Interest level to watch series/serials is dependent on educational qualifications of users.

Test statistic and p-value:

Test	ChiSquare	Prob>ChiS
Likelihood Ratio	23.951	0.0077*

As the p-value is significantly negligible, H_0 is rejected. Therefore, the interest level to watch series/serials depends on the educational qualifications of the respondent. Also, suppose we treat ratings between 0-2 as less and 3-5 as high interest level to watch series/serials, then it is seen that as the educational qualification increases the interest level to watch TV series/serials decreases as depicted in Fig. 1.

3.2. AGE INTERVAL AND THE MOST PREFERRED BROADCASTING PLATFORM

Different age groups were considered and were classified into intervals with width 5 as shown in Fig. 2. Subscribers belonging to these age groups selected their most preferred broadcasting platform: DTH/Cable TV or VSS.

To test, H_0: Choice of broadcasting platform is independent of the age of subscribers.
Versus H_1: Choice of broadcasting platform is dependent on the age of subscribers.

Test statistic and p-value:

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	69.211	<.0001*

As the p-value for the test is significantly negligible therefore, H_0 is rejected. As the result of this test, it can be said that the choice of broadcasting platforms is dependent on the age of subscribers. Age has a significant impact on the preference of broadcasting platforms. As seen in Fig. 2, with an increase in age interval there is a subsequent decrease in interest in selecting VSS and

an increase in interest in selecting DTH/Cable TV services as the most preferred broadcasting platform. Age 30 years works as a changing point, that is, a subscriber having age lesser than 30 has higher chances to select VSS as the most preferred broadcasting platform, whereas, age greater than 30 years has higher chances to select DTH/Cable TV as the most preferred broadcasting platform.

4. DTH/CABLE TV SERVICES

This section discusses the reasons to choose the current service providers. Also, the analysis in this section gives an insight into the reasons for not preferring streaming over DTH/Cable TV.

4.1. REASONS FOR CHOOSING CURRENT SERVICE PROVIDER

Higher priority while selecting a DTH/Cable TV service provider is given to factors like better connectivity (20.1%), locally preferred (19.7%), affordable prices (16.8%), and provision to recharge online (15.0%). On the other hand, factors like complementary services (internet plans) (1.6%) and provisions for recording, play and pause (1.6%) and other reasons (0.9%), are given lesser priority. 'Advertisements/references' and 'ease of portability' do not play a major role in selecting a service provider. Factors like the availability of discounts and free channels do not attract subscribers significantly.

4.2. REASONS FOR NOT PREFERRING VSS OVER DTH/CABLE TV SERVICE

Lack of time to view (17.7%), expensiveness to subscribe (17.7%) and internet issues faced while streaming (16.4%) are some of the main reasons for the viewers to drift away from choosing VSS. Addictiveness (10.2%) to watch video streaming content also goes down the same path of steering viewers away from choosing VSS. 21.2% of the total is contributed by reasons like lack of technical knowledge (5.7%), inappropriate content (5.3%), free access of content on the internet (5.1%), and limited screens (5.1%). Reasons like lack of content of choice on a single app (4.5%), health issues like cervical problems

and eye irritation (4.3%), lack of regional content (4.0%), and removal of favourite content (1.9%) are also the least rated reasons for the same.

5. VIDEO STREAMING SERVICES

This section discusses the subscribers' reason to choose VSS and compare average hours of streaming w.r.t. mode of streaming. Also, the analysis in this section gives an insight into the reasons to not prefer DTH/Cable TV over VSS.

5.1. REASONS FOR CHOOSING VSS

The availability of better options for movies and series (12%) and quality content (11%) are the reasons that mostly attract the subscribers. VSS are flexible to one's time (10%), easily accessed on mobile phones (10%) and also accessed anytime anywhere (8%), therefore these reasons are also some of the prime reasons for subscribers to choose VSS. Suggestions based on the content watched, better clarity, watching content privately and multilingual options comprise 20%. Wide range of regional content (3%), complementary service to your SIM card (2%) and frequent relocation of your residence (1%) are the least rated reasons.

5.2. MODE OF STREAMING AND AVERAGE NUMBER OF HOURS STREAMED PER DAY

Two sample t-test is used to compare the average number of hours streamed per day using mobile data and Wi-Fi.

To test $H_0: \mu_1 = \mu_2$ Versus $H_1: \mu_1 < \mu_2$

Where μ_1 = Mean of average number of hours streamed per day using mobile data and μ_2 = Mean of average number of hours streamed per day using Wi-Fi

Summary statistics, the test statistic and p-value:

Difference = $\mu_1 - \mu_2$

Estimate for difference: -1.186

T-Test of difference = 0 (versus <): T-Value = -5.83 P-Value = 0.000

DF = 604

Since the p-value is strongly negligible, H_0 is rejected. Therefore, it is concluded that mean of average number of hours streamed per day using Wi-Fi is more than the mean of average number of hours streamed per day using mobile data. So for streaming, Wi-Fi is more preferred than mobile data.

5.3. REASONS FOR NOT PREFERRING DTH/CABLE TV SERVICE OVER VSS

No variety of movies/series (15%), advertisements (14%), no ease of access (14%), limited episodes at a time (13%) are some of the major reasons that make the subscribers not prefer DTH/Cable TV. Some other reasons include lack of time (8%), difficulty in channel selection and payment (7%), lack of privacy (6%), and lack of accessibility (5%). As DTH/cable TV services cannot be shared among the users, it is one of the reasons they do prefer VSS. It is seen that problems like relocation issues (3%), living alone (1%) and peer pressure (1%) are the least rated reasons why VSS users do not prefer DTH/Cable TV.

6. COMPARISON BETWEEN DTH/CABLE TV SERVICE AND VSS

The comparison between DTH/Cable TV and VSS is done on the grounds of average monthly recharge and change in choice of broadcasting platforms in near future. Also, emphasis on the reasons behind this change is done.

6.1. AVERAGE MONTHLY RECHARGE OF BROADCASTING PLATFORMS

Average monthly recharge amount per DTH/Cable TV connection and average monthly subscription amount for Video streaming apps used by subscribers are considered. Here, independent two sample t-test is applied to compare their means.

Let μ_1= Mean of average monthly recharge per DTH/Cable TV connection

And μ_2 = Mean of average monthly payment for subscription of streaming apps

To test $H_0: \mu_1 = \mu_2$ Versus $H_1: \mu_1 \neq \mu_2$

Summary statistics, the test statistic and p-value:
Difference = $\mu_1 - \mu_2$
Estimate for difference: 47.4
T-Test of difference = 0 (versus ≠): T-Value = 1.07 P-Value = 0.283
DF = 586

Since the p-value is large enough, H_0 is not rejected. Hence, there may be no significant difference between the mean of average monthly recharge per DTH/Cable TV connection and mean of average monthly payment for subscription of VSS.

6.2. CHANGE IN CHOICE OF BROADCASTING PLATFORMS IN NEAR FUTURE

This section compares the percentage of subscribers changing from one broadcasting platform to the other in the near future, that is, from DTH/Cable TV service to VSS and vice-versa. The subscribers were asked if they would change their broadcasting platforms in near future. Test for two proportions is applied here to check if the proportion of DTH/Cable TV service users changing to VSS is equal to the proportion of VSS users changing to DTH/ Cable TV services in near future.

Let p_1 =Sample proportion of DTH/Cable TV service users changing to VSS in near future and p_2 = Sample proportion of VSS users changing to DTH/ Cable TV services in near future.
P_1 and P_2 are corresponding population proportions of p_1 and p_2.

To test, $H_0: P_1 = P_2$ Versus $H_1: P_1 > P_2$

Summary statistics, the test statistic and p-value:
Difference = $p_1 - p_2$
Estimate for difference: 0.272492
Test for difference = 0 (versus > 0): Z = 7.77 P-Value = 0.000

As the p-value is strongly negligible, H_0 is rejected. Therefore, it can be concluded that the proportion of users changing their preference from DTH/Cable TV to VSS is greater than the proportion of users changing their preference from VSS to DTH/Cable TV in near future. Better options of movies and series (11%), quality content (10%), and flexibility of time (9%) are the top three reasons to switch to VSS in near future. Other factors like ease of access on mobile phone (9%), accessibility anytime anywhere (8%), and downloading facility (7%) also attract many subscribers towards VSS. Factors like privacy (5%), better pricing (5%), subtitles (5%), uninterrupted connection (5%) and availability of applications as complementary services (5%) contribute equally for taking up VSS. Factors like watching in other languages (4%), suggestions based on content watched (4%), sharing of subscription (4%), range of regional content (3%), and frequent relocation (2%) are some of the least rated reasons. Though the proportion of video streaming subscribers changing to DTH/Cable TV services is comparatively lesser than that of vice-versa, factors like better connectivity (15%), provision to recharge online (13%), affordable prices (12%), and availability of discounts (11%) can be seen as some of the important factors for users to switch to DTH/Cable TV services.

7. IDEAL BROADCASTING PLATFORMS

With the view of creating an ideal broadcasting platform, the subscribers rated (on a scale of 0-5) various factors as per their needs. The importance of each factor is calculated using these ratings with the help of Coefficient of Variation (CV). If a particular factor has the highest average rate, it does not guarantee its consistency because it may be important only for a particular class of subscribers. Hence, there is a need to keep a watch on Standard Error (SE) of ratings along with its Mean. So, collectively CV is a good measure that takes care of both (SE and Mean) while finding the importance of the factor. The factor having a low CV bears higher importance as compared to the others.

7.1. IDEAL DTH/CABLE TV SERVICE

From Fig. 3, it can be seen based on CV that factors like quick fixture of technical problems (50.03093573), affordable prices (50.9670573), better customer care services (52.34953619), quality of servicing/maintenance charges (53.33791744), and time to time reminder for recharge (54.79105506) are the top five important factors in the creation of an ideal DTH/Cable TV service provider. Voice Search (71.07272096), facility of recording, pausing and playing (74.88813897), and complementary services (78.96071778) are given the least importance among other factors.

7.2. IDEAL VIDEO STREAMING SERVICE

From Fig. 4, on the basis of CV, factors like HD quality (26.00737827), ease to quick access to your favourite content (26.47025469), wide range of genres (28.78265391), cheaper rates of subscription (30.6724218) and lesser technical problems (30.97318167) are the top five most important factors in the creation of an ideal VSS. Notifications about new content (47.04931283), time to time reminder for payments (47.12447698) and voice search (56.60186409) are given the least importance among the other factors.

8. CONCLUSIONS

1. Educational qualifications have significant impact on the interest level to watch series/serials. As the educational qualification ascends, the level of interest to watch series/serials descends.
2. Subscribers below the age of 30 are more probable of being a VSS user. On the contrary, subscribers of the age 30 and above are more probable of being a DTH/Cable TV user. Hence, age 30 acts as changing point of preference of broadcasting platforms.
3. Factors like better connectivity, local preference, affordable prices and provisions to recharge online are the prime reason to incline the subscribers to select their respective DTH/Cable TV service provider. Whereas, factors like complementary services and provision to record, play, pause do not attract many subscribers in the selection process.

4. Factors like lack of time to view, expensiveness to subscribe and internet issues faced while streaming are the key reasons to keep DTH/Cable TV users away from VSS.
5. Availability of better options for movies and series, quality content, flexibility of time, ease of access on mobile phones, and also accessible anytime anywhere are the principal reasons to draw individuals towards choosing VSS.
6. The main reasons for not preferring DTH/Cable TV services by VSS users are no variety of movies/series, advertisements, no ease of access and limited episodes at a time. Relocation issues, living alone and peer pressure are the least rated reasons why VSS users do not prefer DTH/Cable TV.
7. An approximately equal amount of monthly recharge is paid by the subscribers for both DTH/Cable TV service and VSS.
8. The chance of DTH/Cable TV subscribers switching to VSS in the near future is more as compared to vice-versa.
9. Factors like quick fixture of technical problems, affordable prices, better customer care services, quality of servicing/maintenance charges and time to time reminder for recharge are the top five important factors in the creation of an ideal DTH/Cable TV service provider. Factors like voice search, facility of recording, pausing & playing and complementary services are given the least importance among other factors.
10. Factors like HD quality, ease to quick access to your favourite content, wide range of genres, cheaper rates of subscription and lesser technical problems are the top five most important factors in the creation of an ideal VSS. Notifications about new content, time to time reminder for payments and voice search are given the least importance among the other factors.

9. APPENDIX

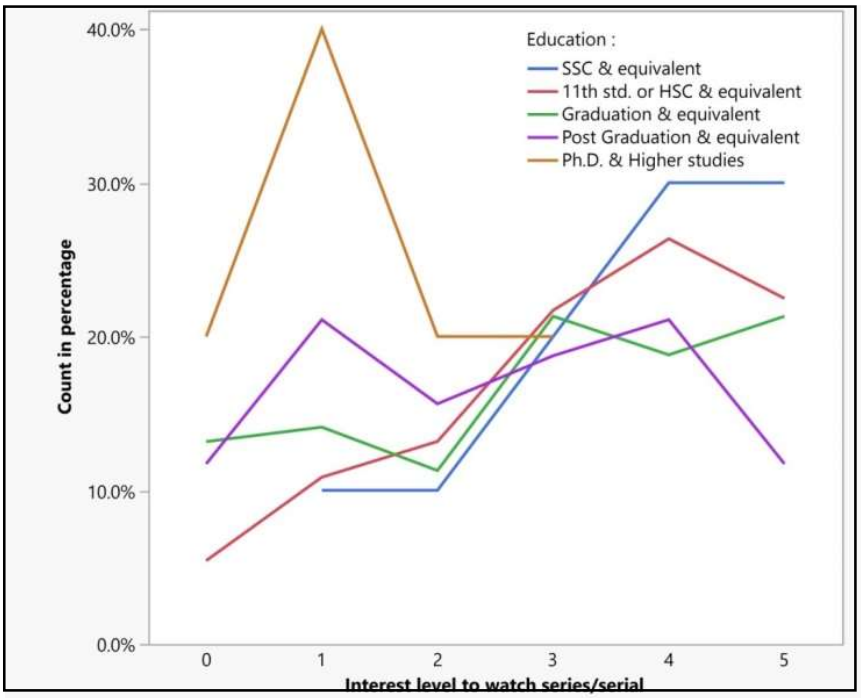

Fig. 1: Interest level to watch series/serial w.r.t. educational qualifications of the respondents.

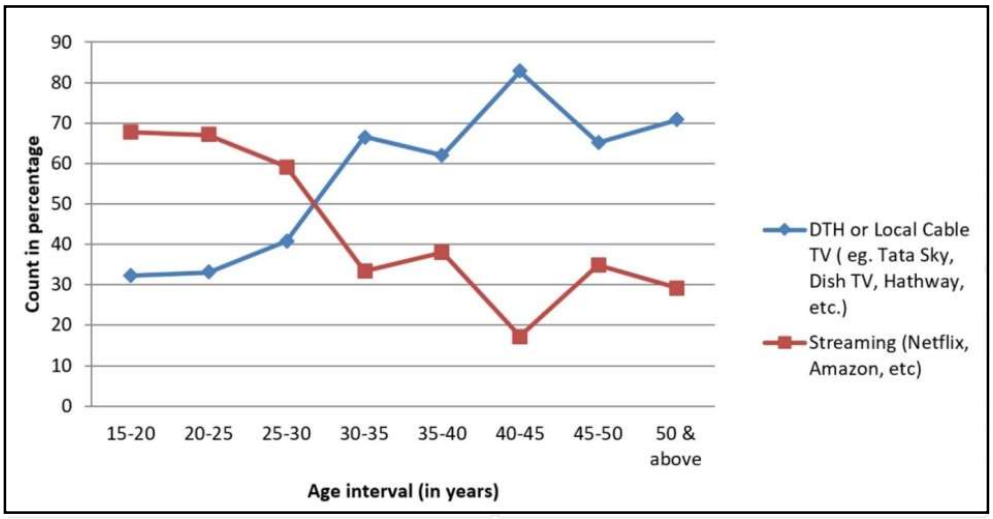

Fig. 2: Choice of broadcasting platforms in accordance with the respondents' age (in years).

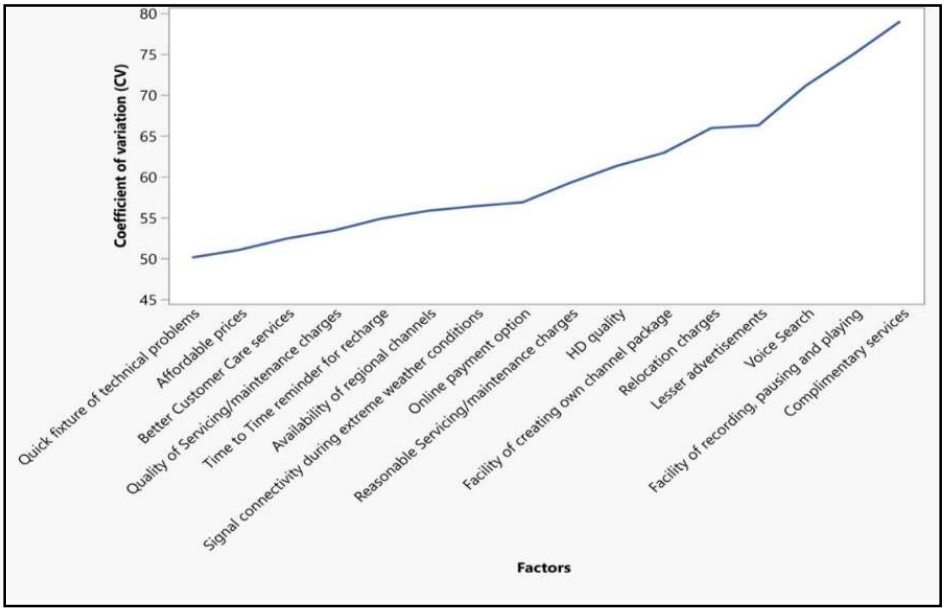

Fig. 3: Importance of factors in the creation of ideal DTH/Cable TV service using CV.

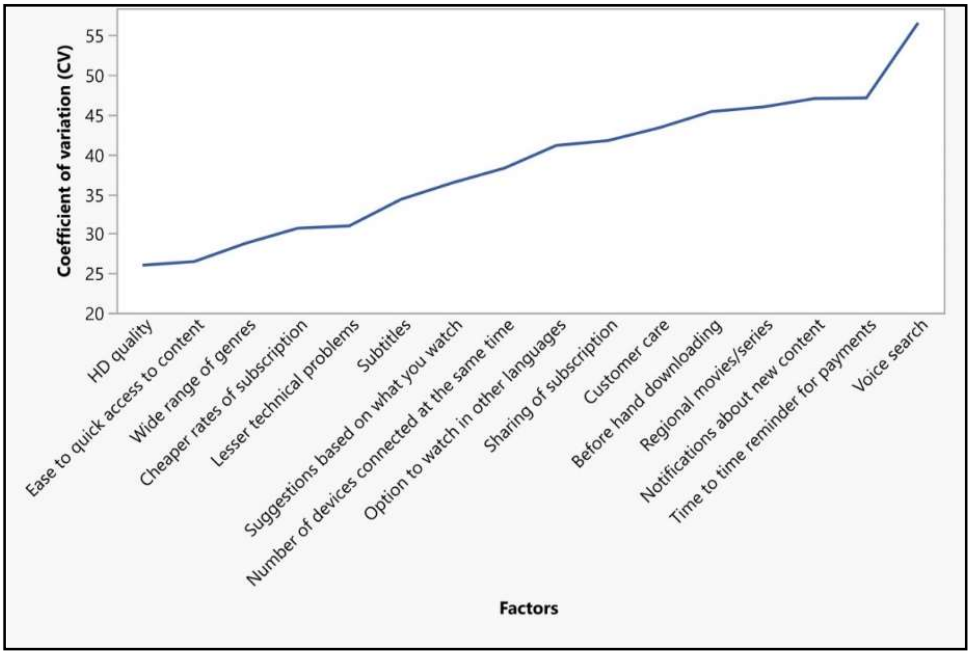

Fig. 4: Importance of factors in the creation of ideal Video streaming service using CV.

10. ACKNOWLEDGEMENTS

The authors are grateful to the referees and editor for reviewing and suggesting corrections for the paper. Special thanks to Dr. Vaijayanti U. Dixit for guidance, suggestions and valuable comments till completion of work and also to Mrs. Daksha P. Sawant for her valuable suggestions for the improvement of questionnaire.

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RESEARCH NOTE

DERIVATION FOR COST FUNCTION PERTAINING TO CD PRODUCTION FUNCTION UNDER NON NEUTRAL TECHNICAL PROGRESS.

M. K. Dave [(1)] and S. G. Raval [(2)]

ABSTRACT

Concepts of Production function models are extremely useful and important for applicability in micro as well as their macro system models in econometric theories. Emphasis given to these theories lead to empirical studies by means of their applications in different fields.

In this paper an approach for deriving cost function is considered for non-neutral technical progress pertaining to Cobb-Douglass production function model.

KEYWORDS

MPL, MPK, MRTS, TECHNICAL PROGRESS.

1. INTRODUCTION

In empirical econometric studies the concept of production function models is very useful for its applicability. Some studies made in this direction

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use the Cobb-Douglass production model under certain input factors of production. There can be a number of input factors of production, but basically we can place them only under two input factors namely capital and labour. Using them, CD production function model is expressed as

$Q = AK^{\alpha}L^{\beta}$ ……. (1)

Where A is technology parameter and $\propto and\ \beta$ are the respective partial elasticity measures.

If we write

$\frac{Q}{L} = q$ = Per capita output

and $\frac{K}{L} = k$ = Per capita capital invested

(Capital output ratio) then per capita form of above production function model takes the form under constant returns to scale is expressed as

$q = Ak^{\alpha}$ ……. (2) ($\propto + \beta = 1$)

For the general form given in (1),

$$\frac{\text{Marginal Product of Capital}}{\text{Avarage product of Capital}} = \propto$$

$$\frac{\text{Marginal Product of Labour}}{\text{Avarage product of labour}} = \beta$$

So that $\frac{(MP)_K}{(AP)_K} + \frac{(MP)_L}{(AP)_L} = \propto + \beta$

and under CRTS, this adds to unity as given by Euler's theorem.

In the above form of CD model given in (1) has neutral technical progress.

In general due to change in technology and innovations, it may be worthwhile to consider non-neutral technical progress. This leads to consider equation (1) as

$$Q = A(t)K^{\alpha}L^{\beta} \quad \text{.....(3)}$$

Where $A(t)$ represents non-neutral technical progress.

A general form for $A(t)$ can be expressed by $A(t) = A_0 e^{\delta t}$ .....(4)

Where δ is technology parameter

so that

$$Q = A_0 e^{\delta t} \cdot K^{\alpha} \cdot L^{\beta} \quad \text{.....(5)}$$

Which is CD production function model under non-neutral technical progress. This has four parameters

A_0, δ, α and β

For given data under usual assumptions loglinear form of the above model can be fitted by estimating α, β and δ which may become useful for predictions.

2. DERIVATION OF COST FUNCTION

Let us consider the general form of production function model under non-neutral technical progress as given in equation (5) above.

We may write the associated cost function in the form

$$C_0 = C_1 K + C_2 L \text{ .....(6)}$$

where C_1 and C_2 are the unit costs associated with the two input factors of production K and L respectively.

Here C_0 is the given total cost function with these two inputs.

Our basic aim is to derive total cost function with an objective of maximizing total output.

Thus to maximize $Q = A_0 e^{\delta t} \cdot K^{\alpha} \cdot L^{\beta}$

under the condition

$C_0 = C_1 K + C_2 L$ .....(7)

This is constrained optimization problem which can be solved using Langrange's multiplier λ

Thus maximize $Z = Q + \lambda(C_0 - C_1 K - C_2 L)$

$$\Rightarrow Z = A_0 e^{\delta t} \cdot K^{\alpha} \cdot L^{\beta} + \lambda(C_0 - C_1 K - C_2 L)$$

we have $\frac{\partial Z}{\partial \lambda} = 0 \Rightarrow C_0 = C_1 K + C_2 K$

$$\frac{\partial Z}{\partial K} = 0 \Rightarrow \lambda C_1 = \frac{Q\alpha}{K}$$

$$\frac{\partial Z}{\partial K} = 0 \Rightarrow \lambda C_2 = \frac{Q\beta}{L}$$

so that $\frac{C_1}{C_2} = \left(\frac{\alpha}{\beta}\right)\left(\frac{L}{K}\right)$

Hence $L = \left(\frac{C_1}{C_2}\right)\left(\frac{\beta}{\alpha}\right) K$ .....(8)

If we insert L in Q then

$$Q = A_0 e^{\delta t} \cdot K^{\alpha} \cdot \left[\left(\frac{C_1}{C_2}\right)\left(\frac{\beta}{\alpha}\right) K\right]^{\beta}$$

$$= A_0 e^{\delta t} \cdot K^{\alpha+\beta} \left[\left(\frac{C_1}{C_2}\right)\left(\frac{\beta}{\alpha}\right)\right]^{\beta}$$

Let us put $\alpha + \beta = \nu$ and write

$\left[\left(\frac{C_1}{C_2}\right)\left(\frac{\beta}{\alpha}\right)\right]^{\beta} = h$ then

$Q = A_0 e^{\delta t} \cdot K^{\nu} \cdot h$ .....(9)

Hence $K = \left[\frac{Q}{A_0 e^{\delta t} h}\right]^{\frac{1}{\nu}}$

Now we write total cost function

$$C_0 = C_1K + C_2L$$

$$= \frac{C_1(\alpha+\beta)}{\alpha} \cdot K$$

$$C_0 = \frac{C_1(\alpha+\beta)}{\alpha}\left[\frac{Q}{A_0 e^{\delta t_h}}\right]^{\frac{1}{\nu}} \quad \text{.....(10)}$$

Which is the cost function derived corresponding to maximized output for non-neutral CD production function.

In particular under CRTS($\alpha + \beta = 1$), we have the following form of cost function

$$C_0 = \left(\frac{C_1}{\alpha}\right)\left[\frac{Q}{A_0 e^{\delta t_h}}\right] \quad \text{.....(11)}$$

3. EXTENSION

We may consider generalised production function model using several input factors of production. Based upon it, by a similar approach cost function can be derived for such a case.

4. ACKNOWLEDGEMENTS

We thank the referees for reviewing this article which has helped us to revise it based upon the comments.

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BIOGRAPHY

KRISTINE SMITH*

H. D. Budhbhatti **

Kirstine Smith (April 12, 1878 – November 11, 1939) was a Danish statistician. She is credited with the creation of the field of optimal design of experiments.

Background

Smith grew up in the town of Nykøbing Mors, Denmark. In 1903, she graduated from the University of Copenhagen with a degree in mathematics and physics. After, she worked as secretary to astronomer and statistician Thorvald Thiele and later with the International Council for the Exploration of the Sea for which she authored several volumes on fish populations.

In 1916, Smith was admitted for doctoral training at the University of London where Karl Pearson had founded the first university statistics department. She was a student of Pearson who described her as "brilliant" in a letter to Ronald Fisher. At London, she produced an influential paper in the journal Biometrika on minimum chi-squared estimation of the correlation coefficient. Disagreements

*Adapted from Wikipedia(the free encyclopedia) and other related resources.
(We express our sincere thanks and gratitude for this assistance)

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(Thanks to the referee for reviewing this article)

about aspects of her work led to increased friction between Pearson and Fisher.
In her dissertation, which was published in 1918, she invented optimal design where she computed G-optimal designs for polynomial regression of order up to 6. After finishing her doctorate she moved to Copenhagen, where she worked as a researcher for the Commission for Ocean Research 1918 to 1924 and with with Johannes Schmidt at the Carlsberg Laboratory from 1920 to 1921. She eventually left research after obtaining her teaching credentials to become a high school teacher.

Selected statistical papers

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M. B. Thaker*

- The year passed was CORONA BLESSED YEAR. It taught us many things which we never knew neither expected. Its greatest impact has been with the education, where new experiments have been introduced but may be with disparity.
- There is a very interesting study made in this direction for 'offline' and 'online' education. The survey is, extremely good which is made by Prof. R. K. Varotaria (U. N. Mehta Arts College, Morabi) in the magazine 'Abhidrashti' (No. 156, February 2021) in our regional language.)
- Our journal SANKHYA VIGNAN was regularly published even during lockdown period and three prestigious issues were published for June, October and December 2020. This time we celebrated **World Statistics Day** on **October 20, 2020**.
- As envisaged earlier, year 2021 becomes the beginning year for this volume no. 17 of our journal SANKHYA VIGNAN as we make it Digital and EB will bring out 4 issues in this year 2021 (March, June, September and December)
- Our honourable **Professor P. Mariappan** was given a very special honour by awarding him **All Time Academic Achievement Award** specially in the field of **O.R. and its application areas**. Particularly in **Data Envelopment Analsyis**. The award was given by **Bishop Heber College at Trichi.** Professor Mariappan has been working as professor and Head of PG Dept. of Acturial science. He is a very learned professor, excellent teacher and a very decent gentleman, who is loving a docile also. His degrees are B.Sc., M.Sc., MBA, M.Phil, PGDOR, PGDECO, Ph.D.(Math) and Ph.D. (MGT). He has written 48 books, and 131 international research articles. He is chief editor in more than 5 international journals and received many best paper awards in conferences abroad. He has contact with more than 300 international professionals. He also received 19 very big awards. We are very fortunate to have such a dignitary on our EB. our best wishes for his long life and still brighter future.

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Ashwin J. Patel*

- **M,. M. Bhatt (Mumbai)**
  I always feel happy to receive SV Journal issues. SV team is progressing well. I do hope that the team will pick-up new ventures in the days to come. My best wishes.
- **Pratheeshkumar (Kerala)**
  We had a brief talk with team members on audio visual programme. I could know about the new developments for SV during this discussion. My blessing and best wishes for a brilliant future.
- **D. S. Dave (USA)**
  SV is now marching ahead for its 17th years with Digital issues and expanding the work by bringing out 4 issues in a year. I request to highlight application areas during further work. Indeed very good team work. Please keep it up.
- **D. K. Ghosh (Rajkot)**
  As envisaged earlier, now we have 4 issues of SV in a year. It is really good. EB may fixup different areas for different issues so that more recent articles with applications can be considered. Nice and praiseworthy team work.
- **P. P. Prajapati (Ahmedabad)**
  Few articles on econometric applications are found to be useful. More emphasis should be for application areas as this is and applied journal. Some articles for management areas are also found to be useful. Please keep it up.
- **M. B. Thaker (Ahmedabad)**
  Let more and more articles / papers to come. That will booste up competitive approach. Due importance can be given to management / application areas as it is the need of the day.
- **P. Mariappan (Trichi)**
  I feed happy with nice team work for SV. Now the work is expanding with digital layout. My blessing and best wishes to SV team.

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KIRSTINE SMITH*

Kirstine Smith (April 12, 1878 - November 17, 1939) was a **Danish Statistician.**

She was born at the town Nykobing Mars, **Denmark**. She graduated from the **University of Copenhagen** with degree in Mathematics and Physics. She had worked with the international council for the exploration of the sea and she had prepared several volumes of research in this field.

In 1916, Smith joined for doctoral training at University of London where **Karl Pearson** had founded the first University Statistics department. She was in very close contact with **Karl Pearson** and **Ronald Fisher**. She had produced an influential paper in **Biometrika**. Her famous work is for **minimum Chi-Sauared estimation of the correlation co-efficient.**

Her dissertation was published in 1978 and she had worked in **optimal design**s with **G-optimal designs for polynomial regression of order upto 6.**

She had worked as a researcher for the **Commission for Ocean Research** from 1918 to 1924. She had influenced contemporary researchers like **Gumpertz L, Guttop P., Lindgren G.** etc.

***Brief biographicasl sketch is given inside the journal.**

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