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Articles

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INTERNATIONAL JOURNAL OF MANAGEMENT

(A Double Blind, Peer Reviewed Bi- Annual Journal)

Volume 8 **Number 2** **December 2022**

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TSM Business Review (TBR) *is the official bi-annual publication of Thiagarajar School of Management, Madurai, India. TBR is published since 2013 regularly during the months of June and December. It provides an open platform for reading and sharing articles, research papers and case studies that have a high impact on the management field. It has a special emphasis on management issues that are relevant to emerging economies and aims at providing a link between academic research and practical implications.*

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Editor-in-Chief

I am happy to note that TSM Business Review has finally regained life after a temporary gap of four years due to pandemic. This issue has eight papers covering different issues in management. The first paper by Manivannan analyses and discusses the turnaround time of patients at hospitals undergoing different medical procedures. The second paper by Gaur, Suri, and Gupta studies the impacts of digital marketing platforms in eco-tourism. Sachan, Chauhan, and Agarwal, in the third paper, identify the impediments faced by the smart cities in achieving sustainable development goals. Specifically, they identify 12 major impediments. Kaul and Agarwal, in the fourth paper, argue out-of-home (OOH) advertising as an alternative to digital advertising. They propose a rating system of the media based on fuzzy technique. In the fifth paper, Agarwal and Kaul have identified the challenges in implementing the (human-to-human) H2H marketing strategy by grouping the factors into cause/effect clusters. Kumar, Suman, and Rajak, in the sixth paper, have analyzed the factors that influence the sustainable development of electric vehicles. In the seventh paper, Agarwal and Malhotra discuss in detail about the challenges that dominate the implementation of Society 5.0. Specifically, they identify 18 challenges that are likely to be faced during implementation. The final paper by Dwivedi, Verma, Kumar, and Prasad helps to identify the factors that are critical in evaluating the effectiveness of the mutual funds from the customers' point of view.

I sincerely hope that the readers will benefit from these papers and continue to support TSM Business Review!!!!!!!!

Associate Editor

It is my pleasure to announce the forthcoming publication of our journal's latest volume, which features a compilation of the most cutting-edge research and developments in our field. As the associate editor of this publication, I am excited to share this valuable resource with our community.

The authors have provided unique insights and findings through their research, which we believe will be of great interest to academics, researchers, professionals, and students alike.

The publication would not have been possible without the contributions of the authors, whose rigorous and innovative work has made this volume possible. We are grateful to them for their hard work and dedication.

We would also like to express our sincere appreciation to the reviewers who have provided invaluable feedback and critique on the submitted manuscripts. Your contributions have been instrumental in maintaining the high standards of our publication and ensuring the quality of the articles published.

Our journal's latest volume is a reflection of our commitment to promoting the advancement of knowledge and providing a platform for the dissemination of ground-breaking research. We believe it will make a valuable contribution to the field and encourage further research in this area.

We hope that the publication will be of interest and use to you and that it will inspire new and exciting research in the years to come. We look forward to your support and continued engagement with our community.

CONTENTS

Articles….

Analysis and Improvement of Patients Turn Around Time (TAT) in an Investigation Procedures

K. Manivannan

Abstract

This study is done to know the turnaround time and waiting time of the investigation procedures in the hospitals including the order time, technician call time, reporting time to the radiology department and actual start time of the procedure for each patient to study the turnaround time and the actual time taken at each step from order time to the executed time. This study includes the different departments such as Ultrasonography (USG), Computed Tomography (CT), Echocardiogram (ECHO), X-ray (X-RAY), Magnetic Resonance Imaging (MRI). The turnaround time (TAT) and waiting time for this study was estimated from the hour of the examination ordered to the hour it has been finished. This study has recognized time whereas, the TAT for MRI examination has surpassed the specified time acutely while TAT for USG and ECHO is surpassed mildly. The need of the study is to decrease the TAT because delivering reports late results in delayed diagnoses, longer wait times, and lower patient satisfaction. Increased patient satisfaction, improved care quality, happier staff members, and eventually higher hospital revenue will result from the TAT being reduced.

Keywords*: Turn Around Time (TAT), Reduced Report Turn Around Time (RTAT), Analysis, Hospitals*

Introduction

Diagnostic radiology- assists the healthcare providers to see structures inside your body. By utilizing the diagnostic pictures, the radiologist or different doctors can regularly analyze the reason for indications, Screen how well the body is reacting to a treatment patient is getting for his/her condition, Monitor for various ailments, for example, bosom malignant growth, colon malignancy, or coronary illness. The commonly used diagnostic radiology method includes- X-Ray, CAT (computerized axial tomography), MRI (Magnetic resonance imaging), USG (Ultrasound), ECHO, Fluoroscopy, PET (Positron emission tomography). Diagnostic radiological procedures are carried out in specific areas known as the Radiological department. It is one of the important departments of any hospitals. The diagnostic radiology department is an integral part of the hospital. It is necessary to create methods that will benefit the patients and improve the efficiency of investigations in the hospital.

TAT is a measure of punctuality and is frequently cited as a determinant of laboratory efficiency. Humans, by nature impatient, expect everything, including clinical laboratory reports, to be completed quickly. As a result, they prefer hospitals that provide prompt service and do not make them wait for long periods of time for test results and proper diagnosis, treatment, and management of their problems. These facts demonstrate the importance of TAT from both a medical and a commercial standpoint.(Bhatt, Shrestha, & Risal, 2019)

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Historically, laboratory TAT has been determined by the timely completion of three phases of testing: pre analytical, analytical, and post analytical. (Smellie, Johnston, & Galloway, 1994) assessed TAT based on the timeliness of these individual phases using manual records, but no previous reports of the use of a laboratory information system (LIS) to record and analyze TAT have been published. As a result, we created a new LIS that automatically records TAT data and analyses the time required for the three phases that comprise the total laboratory TAT for each test. The four pillars of efficient laboratory services are accuracy, precision, timeliness, and authenticity. Clinical biochemists may overlook timeliness as an important attribute in order to focus on improving the analytical complexities of sample processing. However, clinicians frequently use timeliness, expressed as turnaround time (TAT), as a benchmark for laboratory performance. Clinicians rely on fast TATs to diagnose and treat their patients as soon as possible, as well as to discharge patients from emergency departments or hospital in-patient services as soon as possible. As a result, shorter TATs play a role in reducing general government spending.(Nichols et al., 2007) Delayed TATs increase the likelihood of duplicate samples being sent to the laboratory. This increases the laboratory's workload even more. The evaluation and improvement of turnaround times is critical for laboratory quality management and patient satisfaction.(Goswami, Singh, Chawla, Gupta, & Mallika, 2010)

Getting the correct diagnosis is a vital part of medical services- it gives a clarification of a patient's medical condition and educates ensuing health care decisions. The investigation process is a compound, synergistic activity that includes clinical reasoning and data get together to decide a patient's medical problem.(Stachler et al., 2012) As indicated by the improving diagnosis in healthcare, analytic error-wrong or delayed analyses persevere all through all settings of care and keep on harming an unsatisfactory number of patients. The diagnostic department is a fundamental part of the hospital. It is important to make strategies that will profit the patients and improve the productivity of examinations in the department.

When analyzing process times, it is critical to understand the various definitions for time intervals. One of the most common measures of laboratory or pathological services is turnaround time (TAT), which has been widely used since 1980 to objectively quantify the time required to perform laboratory tests. TAT was first defined in 1971 as the time interval between electrocardiogram printing and placement of the printout in the patient chart. TAT is an important performance indicator in the laboratory workflow, and it is even regarded as a "necessary condition for trust between patient and physician."(Khan & JCDR, 2014)Limiting the waiting time and TAT is one of the approaches the objective of achieve the desired goal. This study is likewise utilized for the correlation of specified TAT given by the area of expertise. The overall TAT and was estimated from the hour of the examination ordered to the hour it has been finished. The overall radiological examinations evaluated for this study were X-ray, USG, CT and MRI, ECHO.

The TAT is characterized as the amount of the time that proceeds between an imaging assessment ordered and executed. Minimizing TAT and waiting time is one of the ways to achieve the goal. The Radiology report TAT is one measure that is frequently used as marker of Radiologist efficiency. Interestingly, the radiologist regularly sees TAT as the time from when an examination is finished and free for understanding until final signature. There are a few turnaround times that are frequently checked in radiology departments as a feature of quality improvement and confirmation programs. The time from the moment the study is ordered by the clinician to the moment the imaging examination is performed and becomes available to the radiologist to interpret is defined for the purposes of this manuscript as the system turnaround time (TAT).

TAT is one of the parameters to measure performance of any hospital and is often give importance on accuracy and precision of the test as their goals for quality service. In many cases, clinicians tilt towards faster TAT of the tests which may help them with investigating, treating and discharging the patients rapidly. Moreover, a slow TAT can lead to increase in the dissatisfaction and irritation to the IPD patients. This might also increase the cost burden of healthcare. The total TAT for the investigation procedure includes the entire interval from ordering the test to the time it has been done.

The aim of this study is to determine the TAT of the diagnostic procedures of the IPD patients to evaluate the time that elapses between an imaging examination ordered and executed to the total TAT and to see the depicted by which all out TAT can be reduced. The Clinical Biochemistry Laboratory Section at Singapore General Hospital executed a laboratory automation system, and the mean TAT for both stat and routine samples was significantly reduced. TAT reduction was expected as a result of implementing laboratory automation to improve patient safety and clinician satisfaction.(Angeletti et al., 2015)

Purpose and Objectives of the Study

The purpose of this study is to determine the turnaround time–TAT and the cause of delay of the investigation procedure.

Objective

- To analyze the time taken of the procedure from the order time to the time it has been done.
- To the study the waiting time of the diagnostic procedures.
- To give recommendations based on study findings.

Review of Literature

TAT is among the most observable indicators of a laboratory service and is utilized by many clinicians to assess the caliber of the laboratory. Users immediately voice their problems when

TAT is delayed, but not when TAT is sufficient. Unacceptable TAT is a significant source of complaints about bad service to the laboratory, and it takes a lot of the laboratory staff's time and effort to resolve concerns and improve service. Despite improvements in computerization, transportation, and analytical equipment, many laboratories have had trouble increasing their TATs. (Hawkins, 2007) In decreasing Variability in turnaround time for radiographic studies, they were able to successfully decrease both the average TAT for radiographs as well as the variability, as manifested by a decrease in the mean TAT for from 23.9 to 14.6 minutes, an increase in the percent time of radiographs with a TAT of 35min. or less than 82.2% to 92.9% and a lessening in the standard deviation for the TAT from 22.8 to 12.7. The improvements in radiology TAT have had a direct effect on the overall patient flow. This was achieved essentially by methods for expanded transparency, individual training, and feedback in a setting where work process and electronic frameworks had just been upgraded to improve TAT. (Towbin et al., 2013)

TAT is a crucial benchmark for the quality of investigation services. The period from the time of ordering to the time of result reporting is referred to as the "whole laboratory testing cycle." However, the definition of TAT may change depending on the cycle's various starting points, including test ordering, phlebotomy, and laboratory receipt. It can also be divided into different process phases, such as pre-analytical (order to preparation), analytical, and post-analytical, or according to the priorities of the requests (STAT, urgent, and routine). Monitoring the entire TAT from phlebotomy to reporting (PR-TAT), which the laboratory assumes responsibility for, is regarded as one of the most crucial quality measures of investigation performance. (Lou et al., 2017) The study explains how lean management principles and techniques can be used to drastically shorten radiology turnaround times for emergency departments. As a result of similar initiatives being completed that support the spread of a lean culture, employee communication, involvement, and process awareness are favored in addition to helping to comply with regulations and improve patient care quality. (Verbano, Crema, & Management, 2019) Earlier study they had clarified that the investigation included 7378 radiology studies from 100 workday shifts, from which 1537 RVU flow 30 & 792 RVU flow 60 information focuses were produced. RVU flow 60 ($p = 0.0026$) and RVU flow 30 (< 0.0001) were altogether connected with radiology report TAT. One going to radiologist had genuinely critical lower TAT 30 and TAT 60, though another had lower TAT 30 however not TAT 60. The presence of an occupant was altogether connected with diminished TAT 30 ($p = 0.0005$) and TAT 60 ($p= 0.0028$) what's more, presence of a resident is fundamentally connected with radiology report TAT. RVU flow ought to be viewed as while assessing radiologist and overall system performance concerning report TAT.(Rathnayake, Nautsch, Goodman, Forman, & Gunabushanam, 2017). In another study they concluded that the Inpatient Access to MRI exams can be enhanced by allocating a scheduled examination time to the patients- An overall improvement in TAT of 45.2% have been noticed and secondly MRI technologists to complete screening forms with inpatients – An increased improvement in

TAT of overall 55% noticed. (Drose, Pritchard, Honce, Snuttjer, & Borgstede, 2019) By examining the importance patients have on receiving and understanding radiology data, it is possible to discover practice gaps in this study that is focused on developing patient portals. (Mervak, Davenport, Flynt, Kazerooni, & Weadock, 2016) It is crucial that clinical laboratories gather data on mistake incidence rates across the whole testing cycle, including the pre-, intra-, and post analytical phases, in light of the growing emphasis paid to patient safety and the need to lower laboratory TAT. (Carraro & Plebani, 2007)

Information gathered from the RIS to improve the sequencing of the workflow, arranged by radiology division and patient sort. Fortnightly, the fitting information record is moved to every division for investigation, through the office's PC organization. A one venture measure follows, utilizing work area Macintosh PCs and a custom program written in MS excel. Separated information are immediately changed over into a custom fitted division rundown, and a report is naturally created. (Crabbe, Frank, & Nye, 1994) The maximum TAT for MRI investigation has exceeded the stipulated time by 77 min. The maximum TAT for USG investigation has exceeded the stipulated time by 5min. The mean TAT for all the modalities is within the stipulated time given by the department. The increased TAT and waiting time in MRI may be due to longer scan times. The mild increase in USG TAT may be due to increased patient preparation period such as waiting for full bladder. CT has lower TAT which may be due to shorter scan times. In this study proved that the department stipulated time is applicable for CXR, DXR and CT non- contrast patients. If contrast, special procedures and emergency cases were included then the TAT and WT for the procedures might exceed the stipulated time. Additional steps can be implemented to further reduce TAT and WT by employing sets up for report composing with experience in clinical terms. Framing a concentrated reporting room for all modalities and incorporate progressed tele-reporting system to decrease the report preparation time extensively and to reduce the patient waiting time and to know the causes of longer turnaround times in carrying out the procedures and the major causes of linger TAT identified were power black outs, burnouts of staffs while working alone.(Odhiambo, Joash, & Kanamu, 2015) Sub specialized radiological reporting reduces radiology report turnaround time, did a study on radiology report turnaround time (RTAT) between modality-based/decentralized and sub specialized radiological/ centralized reporting at multi-centre radiology enterprise as they were able to change the reporting system from decentralized/ modality-based to centralized/sub specialized radiology was associated with a significant decreased RTAT. In specifically, the RTAT for MRI reports and regular radiographs was altogether decreased. An articulated RTAT decline was seen at minor hospitals. (Zabel, Leschka, Wildermuth, Hodler, & Dietrich, 2020)

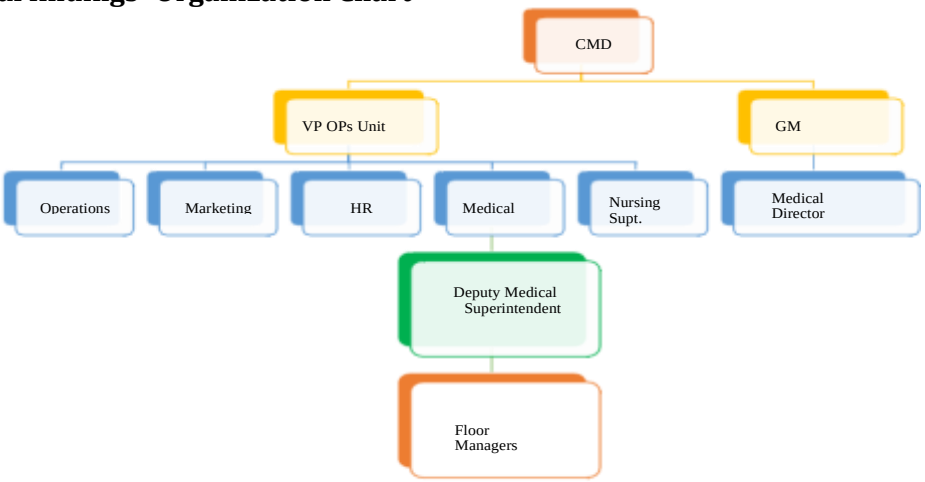
Research Methodology

It is a descriptive, analytical & observational study. Primary data was collected through interacting with HODs, executives, Doctors, Nursing staff and other valuable employees of the

hospital and the secondary data collected through registered records, website of the hospital, literature available about the hospital like magazines, brochures, written documents.

The Sample size is 461 and proposed to use a non-probability convenience sampling technique was deployed to collect data for this study. Appropriate statistical techniques are used for analyzing the primary data. Valid conclusions are drawn from the analysis of data.

1. General findings- Organization Chart



Cath Lab

Catheterization laboratory is an examination room with diagnostic imaging equipment used to envision the arteries of the heart and the chambers of the heart and treat any stenosis or abnormality found.

Diagnostic procedures performed here are

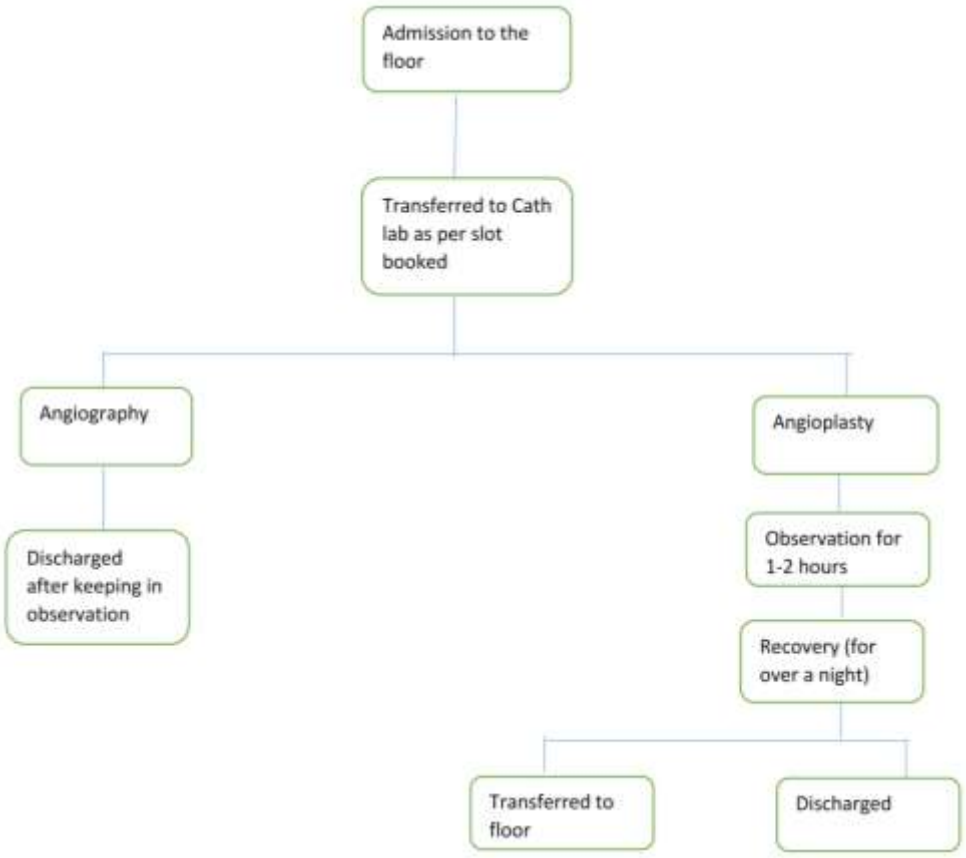
- Angiography
- Angioplasty
- Cath study
- Electrophysiology study (EPS)

Other procedures are

- Percutaneous Transluminal Coronary Angioplasty
- Radio Frequency Ablation
- Intra Cardiac Defibrillation
- Permanent Pacemaker Implantation and many more.

Slots are booked for everyday as per the Doctor's and patients' convenience. About 70% of the slots booked are treated every day.

Process Flow of Patients

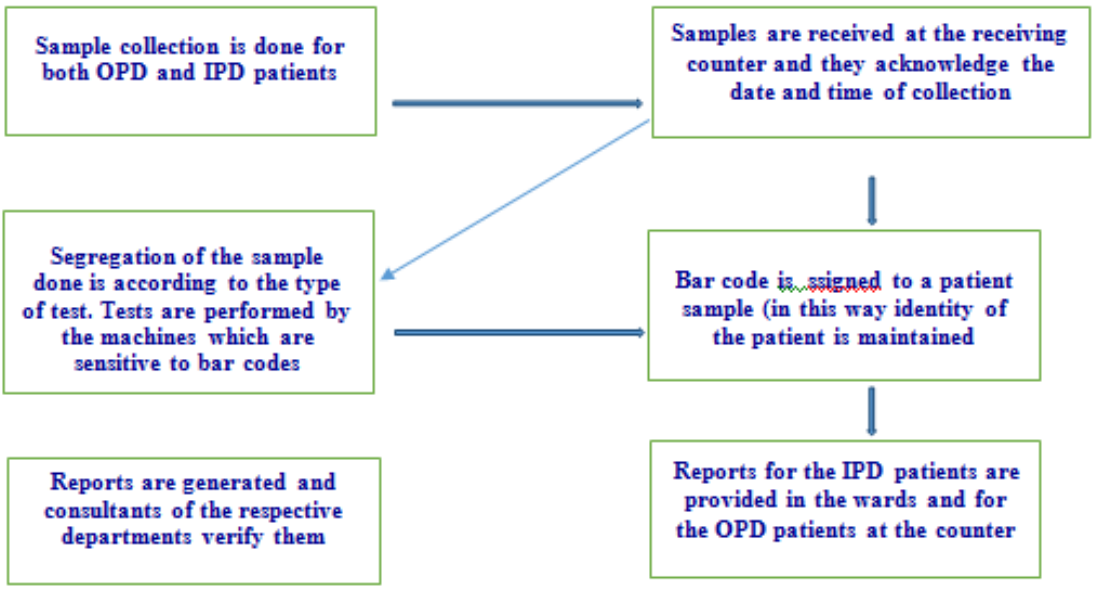


Laboratory Department

Laboratory comprises of the following services:

- Biochemistry
- Hematology
- Immunoassay
- Histopathology
- Clinical pathology
- Microbiology
- Serology
- Cytology

Process Flow of Lab. Department

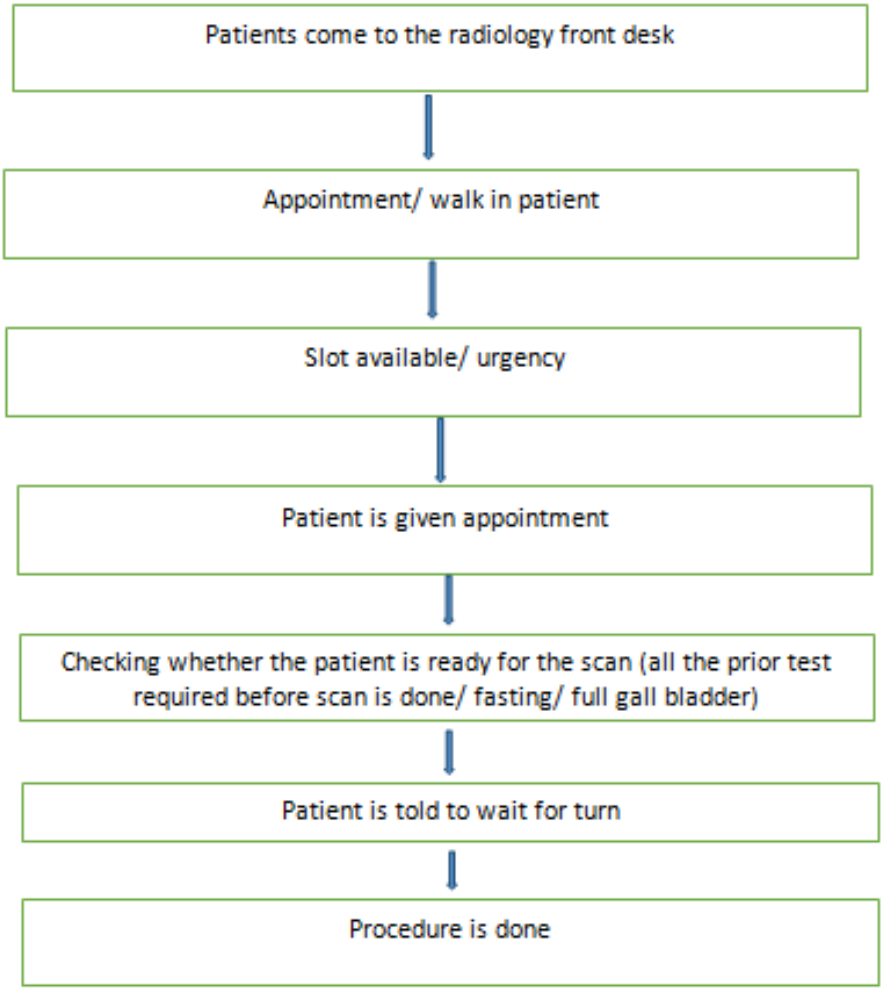


Radiology Department

Procedure done in the department:

- X-ray
- USG
- Mammography
- Dexa scan (Bone Densometery)
- Special imaging techniques- CT scan, MRI

Process flow in radiology department



Analysis and Findings

Analysis

A total data of 461 samples has been recorded and analyzed on the basis of different diagnostic modalities which includes- CT SCAN, MRI, ECHO, USG, X-ray and also if these modalities are being done within the TAT hours i.e. 4 hours or not.

Row Labels	Count of TAT
Delayed	22.78%
within TAT	77.22%
Grand Total	**100.00%**

Complete Analysis

Total Data Recorded

Row Labels	Count of Remarks
CT	18%
ECHO	7%
MRI	11%
USG	28%
X-RAY	36%
Grand Total	**100%**

Turn Around Time (TAT) of the Diagnostic Procedures

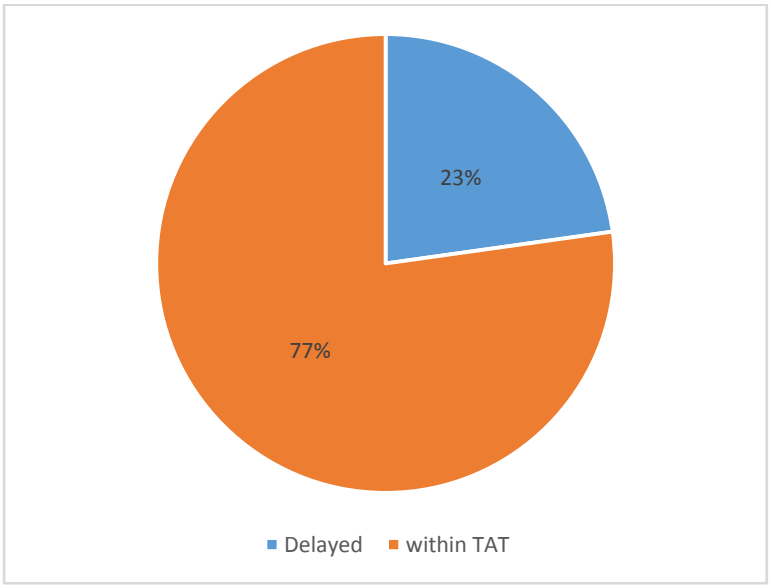
Count of Remarks	Column Labels		
Row Labels	**Delayed**	**within TAT**	**Grand Total**
CT	3%	15%	18%
ECHO	1%	6%	7%
MRI	3%	8%	11%
USG	7%	21%	28%
X-RAY	8%	29%	36%
Grand Total	**23%**	**77%**	**100%**

Reasons for Delays

Count of Remarks	Column Labels					
Row Labels	**CT**	**ECHO**	**MRI**	**USG**	**X-RAY**	**Grand Total**
Delayed on technician's end	1%	0.00%	0%	0%	0%	1%
GDA unavailability	2%	0.70%	3%	3%	5%	14%
Machine were busy	7%	5.00%	5%	8%	13%	37%
No delay	6%	0.70%	2%	7%	10%	26%
Patient related delays	2%	0.40%	1%	8%	5%	15%
RIS error	1%	0.20%	1%	1%	4%	7%
Grand Total	**17.79%**	**6.94%**	**11.06%**	**27.77%**	**36.44%**	**100%**

Findings

Graph 1- Complete Analysis



The above pie chart shows the complete analysis of the data recorded of the IPD patients undergoing some investigation procedures.

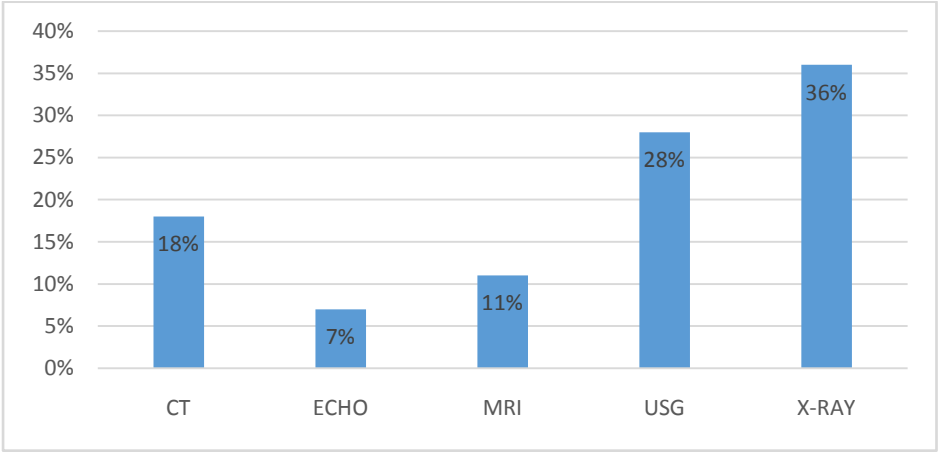
The complete TAT account of recorded cases i.e., 100%

Out of which 77% cases were within the TAT whereas, 23% were delayed.

Average TAT for all the Modalities

Modalities	Average TAT (In No.)
CT	133
ECHO	157
MRI	165
USG	157
X-RAY	156

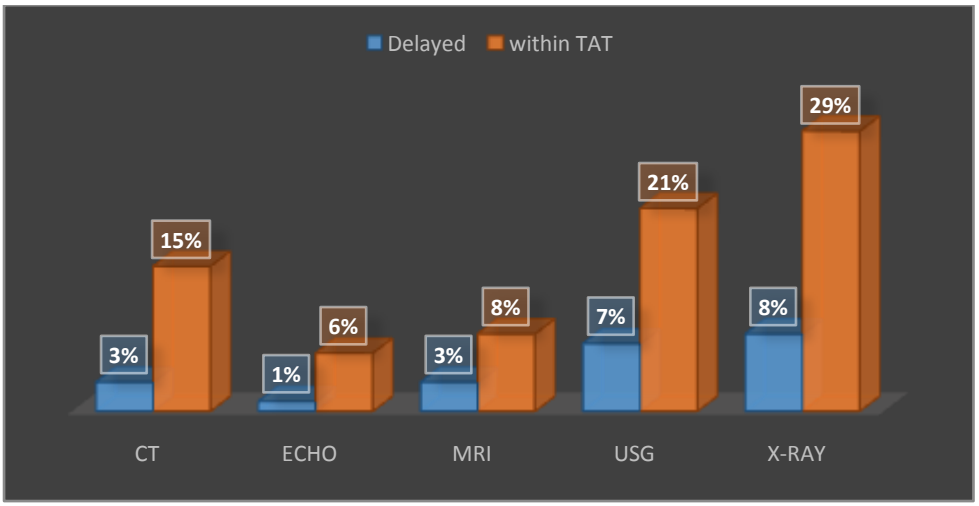
Graph 2- Total Data Recorded



This graph was recorded in order to calculate the average TAT of the patients undergoing subsequent investigation procedures and the data collected were as follows:

18% cases were recorded for CT scans, 7% were recorded for ECHO, 11% were recorded for MRI, 28% were recorded for USG, and 36% were recorded for X-ray.

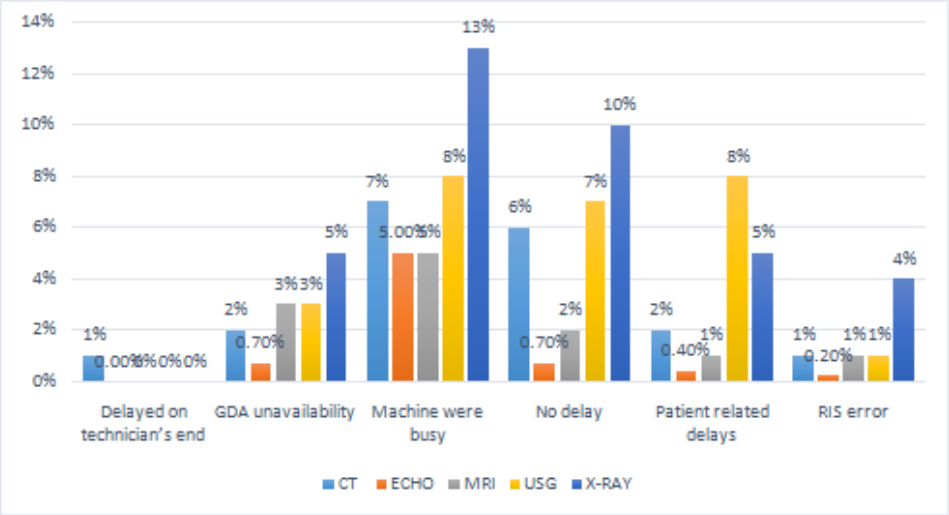
Graph 3- Turnaround Time (TAT) of the Diagnostic Procedures



This graph shows the time management between the procedure requested and when it was executed. Also, if it was within TAT hours i.e. 4 hours or not. So, on the basis of the analysis the following data was recorded i.e.

- For CT scans, out of 18% cases- 15% were within the TAT and 3 % cases were delayed.
- For ECHO, out of 7% cases- 6% were within the TAT and 1% cases were delayed.
- For MRI, out of 11% cases- 8% were within the TAT whereas, 3% cases were delayed.
- For USG, out of 28% cases- 21% were within the TAT and 7% cases were delayed.
- For X-RAY, out of 36% cases- 29% were within the TAT and 8% cases were delayed.

Graph 4 Reasons of Delays



The above graph depicts the various reasons for delay in the turnaround time of the different modalities.

For CT cases

- 1% were delayed from the technician's end,
- 2% were delayed due to GDA (HR) unavailability,
- 7% were delayed because machine was busy,
- 1% were delayed due to RIS error,
- 2% were delayed from the patients' end,
- 6% were within TAT

For ECHO cases

- 0.7% were delayed due to GDA unavailability,
- 5.0% were delayed because machine was busy,
- 0.4% were delayed from the patients' end,
- 0.2% were delayed due to RIS error,
- 0.7% were within TAT

For MRI cases

- 3% were delayed due to GDA unavailability,
- 5% were delayed because machine was busy,
- 1% were delayed due to RIS error,
- 1% were delayed from the patients' end,
- 2% were within TAT.

For USG cases

- 8% were delayed because machine was busy,
- 3% were delayed due to GDA unavailability,
- 8% were delayed from the patient's side,
- 1% were delayed because of RIS error,
- 7% were within TAT.

For X-ray cases

- 13% were delayed because machine was busy,
- 5% were delayed because of GDA unavailability,
- 5% were delayed from the patients end,
- 4% were delayed because of RIS error,
- 10% were within TAT.

Critical Observations

The important constrictions within the TAT of investigation modalities are recognized as follows:

- Delayed, as the technician mentioned that there was unavailability of the contrasting media, ultrasound gel and other armamentariums, occupancy of the machine and too much patient load.
- Delayed as already the investigation was going on for the previous patient or too many OPD patients and IPD patients was on hold.
- Delayed from the patient's side; as the patient refused for the odd hours, patient was supposed to be NPO, but had something, for USG patient's bladder was not full, patient was not fit for the procedure, some patients were uncooperative.
- Delayed due to technical error, due to bad network, behind the scheduled time, constraint display.
- Delayed due to lack of human resources.

Scope of the Study

The scope of the study for the researcher is that it is assisted with acquiring knowledge and experience and furthermore gave the chance to grasp and observe the reasons in the delay of the diagnostic modalities in the hospitals to increase the patient satisfaction.

Recommendations

- Technician being fully aware of the patients load and the need of machinery like, if there's no emergency case and the patient has to go for a routine investigation, a dedicated time slot should be given preferably, in the evening hours when the OPD is over.
- Proper information should be given to the nursing staff or the concerned person if the machine is busy, so that patient does not have to wait for a longer period of time.
- Sufficient supply of the armamentarium: a regular check for the contrasting media, ultrasound gel and so on should be made mandatory.
- Proper time management – In some cases, the doctor advised the procedure, but the nurse could not go on time, so it led to delay.
- Guiding the patient through the process, as if the patient has to be NPO or precautions and preventions if any to be taken before and after the procedure. In those cases, an organized check list should be made and kept by the patient's side, so that everyone will be aware if any precautions need to be taken.
- Adequate amount of the human resources in need: we should have a roughly idea that how many GDA's are required on a daily basis and if there's a lack of it then from where to compensate it.
- Lack of miscommunication between the staff or person accountable.
- Follow a proper protocol to prevent any RIS error: like software should be updated in time and if any procedure asked it should be well reflected with the time.
- Keep on monitoring TAT to ensure compliance and sustain enhancement/ improvements.

Conclusion

The aim of the study was to calculate the time that elapses between an examination 49 ordered and accomplished to the total TAT and to see the number of orders being reported outside the defined TAT. Concluding the report on the data collected from the hospitals, out of 461 records, 77.22% were within the TAT (i.e.,04 hours) whereas 22.78% cases were delayed.

To summarize the graphical analysis for all the modalities, it contemplates, the time management between the procedures requested and when it was executed. Also. If it was within TAT hours i.e. 4hours or not. It was identified that for CT cases 15% recorded data were within TAT, for ECHO 6% were within TAT, for MRI 8% were within TAT, for USG 21% were within TAT and lastly for X-ray 29% were within TAT, while on contrary a whole delay of 3% was seen in CT cases, 1% in ECHO, 3% in MRI, 7% in USG and 8% in X-ray. The reasons being from the technician's side, from the patients end, technical error and due to unavailability of human resource. And to enclose, the average turnaround time i.e., TAT of the recorded data of all the investigation procedures was 153 minutes.

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From Dreaming to Believing: Impact of Digital Media on Consumer Buying Behaviour with Special Reference to Marketing of Eco-Tourism

Richa Gaur, Pradeep Suri and Ashulekha Gupta

Abstract

We have all the fun and relax during the holidays. Currently, when pollution and threats to the environment are increasing due to normal tourism, it is recommended that we take part in such tourism which causes the least damage to the environment. Initially conceptualised as way for the conservation of environment and to save natural heritage from negative consequences of tourism activities, Eco-Tourism is currently considered as one of the fastest growing tourism segment. In this research paper, it is accepted that digital marketing platforms like social communication platform marketing, search engine marketing, search engine optimization, content marketing is etc are very useful tool to promote Eco-Tourism Increasing usage of social communication platform is generating a favourable openings for digital marketing and to draw the attention of their customers through digital platform. In this paper, we will scan the role of digital media in promoting Eco-Tourism. We will also find the factors of digital marketing that appeals customers the most.

Key Words**:** *Consumer Buying Behavior, Digital platforms, Eco-Tourism, Sustainability*

Introduction

The brick and mortar marketing system is no longer an adequate solution for any large company In order to remain competitive in today's market. Keeping up with the rapid pace of technological advancements and changing consumer preferences requires organizations to have an online presence. Both the consumer and the marketplace are changing. Marketing has taken on a new form, and it is inevitable that the traditional 4P's will lose their relevance in the future. As a result of McKinsey's survey of marketing executives around the world, it is becoming increasingly apparent that marketing is changing and a wide variety of marketing activities are being conducted online by companies, from awareness building to customer service and that digital tools play a significant role in their marketing strategy. As part of their marketing efforts, ecotourism service providers utilize a variety of digital media tools. The tourism industry is also getting immense benefit from it. Since services (tourism) are intangible in nature so digital marketing will provide tangibility to the tourism sites. Promotion of Eco-Tourism destinations are mainly done through digital marketing. At pre-experience stage when a tourist plan a tour different decisions are to be made and at this stage of buying process he collects information from different sources compare it and then make a decision. One of the most important source is Internet through which he gets all the information about a Eco-Tourism spot. Internet Site creates a physical evidence for that Eco-Tourism destination.

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Through that particular web site he gets all relevant information so without visiting that location he gets a feel of that place and develops a perception about that place. Through Internet while reading the webpage a few Eco-Tourism destination reader won't only gets the all the information concerning a specific destinations but also the thought behind Eco-Tourism if the webpage is carefully designed. Digital marketing is a technique with which awareness regarding concept of Eco-Tourism is generated by using digital technologies such as social communication platform (Facebook, Twitter, Instagram), e-mail, web pages, search engine optimization etc. One of the most important digital marketing channels nowadays is social communication platform marketing. Social communication platform marketing is a web tool that permits individuals to produce, interchange thoughts, data & images and share them in the group. As stated by Nielsen, internet user are generally more engaged with social communication platform platforms like Facebook, Twitter, LinkedIn than any other digital platform. Companies can promote their product and services events in these social communication platform platforms and explore untapped opportunities. Linked ln is a social communication platform for professional where they share their expertise and experience and write articles too. The objective of digital marketing is to reach prospective tourists through differences sources when they are online for different purposes like reading, searching, shopping, and socializing digital. The purpose of this paper is to examine the factors eco tourists consider crucial when making purchase decisions through digitally.

Research Objectives

The primary aim of the research paper is to identify different factors pertaining to digital marketing which are significant for eco tourists when they plan their tour through digitally. Are the users of digital media planning their trips based on the information provided by digital media about Eco-Tourism? Are the users satisfied with the information provided by the digital media regarding Eco-Tourism? What are the different factors of Eco-Tourism that are important for the customers? The presented research paper will give us information related to all these subjects.

Literature Review

The economy of Uttarakhand is based on Tourism; Hydropower project is another source of revenue for the government. Within the process of growth and development environmental degradation also happened. The study done by Kala &Bagri(2018) in his paper stated that since Eco-Tourism is beneficial for both local community and environment so it is very much necessary to involve local community in the planning and other processes. Hernández-López, et al. (2018) stated that while creating a product or service related to eco-tourism it is important to involve local people and in order to increase loyalty among customers value co creation plays an important role. According to Gupta, G. (2019) Business cannot avoid digital marketing in present scenario if they want to sustain their businesses.

People trusts comments that are posted online because they develop a sense of community when they are a member of a community (Utz, Kerkhof, & van den Bos, 2011). When ever a tourist plan his travel in order to search best option for tour destination he uses social communication plat form sites and locate information about that uncommon destination, Google and search for images and access feedback of other tourists regarding that particular destination and the service provider (Sicilia & Ruiz, 2010). In the field of Eco-Tourism Marketing Consumer association with social communication platform has become an thought-provoking concept for researchers (Constantinides, 2014). More attention is now given to social communication platform influencers by researchers and practitioners, because tourists are influenced by these social communication platform influencers. Social communication platforms are now a very effective tool to enhance the marketing performances(Ye, Law, Gu, & Chen, 2011).According to Dr. Manoj P. K. (2017) in his paper stated that economy of a particular country could be improved by tourism but excessive tourism is very harmful and in later stage it will be very negative for environment as well local population. So while making strategies focus should be on sustainable development. Aswin Sangpikul., (2010) stated that most of the Eco-Tourism service providers are doing insufficient marketing through internet and they are posting content in the right manner. Magnini, V. P., (2010) stated that small references mentioned in advertisements plays important role in generation awareness about Eco-Tourism and gender do not plays a role of moderator. MengShiunn, et al. (2011) discussed about the main factors of Taiwan tourism sector and those success factors were digital marketing and advertising. Whenever an eco-tourists plan for his or her vacations he also passes through all the steps of consumer buying process i.e. idea generation , information search to purchase decision and post purchase anxiety and digital marketing helps him or her in finding a right Eco-Tourism site according to his interests and paying capacity. The tourism as an industry count on to a great degree on internet communications. Through digital communication tour operator can reach their customers. Tourists also can search remote and unique locations where they can plan their holidays. Sivasankaran(2017) stated in the paper that Internet and digital technologies have changed the entire tourism market. Pitana and Pitanatri (2016) stated that due to advent of digital technologies now people buying pattern has been altered in tourism sector. Future of every industry lies on the fact that how smartly they switch from traditional marketing to digital marketing practices. Eco-Tourism sector is no exception. According to Kaur (2017) digital marketing is essential for success of in today's scenario. It has entirely changed the way; the tour service provider promote their products and services to their tourists. If we talk about Eco-Tourism in particular than digital marketing plays a very important. Trandafilović (2013) stated that digital marketing plays a very important role in managing bio waste generated through activities of Eco-Tourism. Avinash et al. [2016] stated that tourists is provided with huge information regarding different tour packages and payment options through digital marketing platforms. Ling-Chuan, et al.(2019) in their work stated that Digital booking or searching for

tourism information is different from traditional way of buying, in traditional way of buying a tourism product customer takes advise of his friends and relatives but in digital marketing every bit of information is available online. ZhengXiang, et al. (2016) stated in their paper that digital reviews are very useful both for other tourists as well as for service provider. They can improve their service quality as per expectations of tourists and fellow tourists can plan their tour according to the feedback provided to them on digital media. Vasiliki Baka (2016) observed that with the help of digital marketing customers can get the feedback of other customers and get a balanced view instead of asking few of his or her relative and come to a conclusion. Beverley A. et al, (2013) stated that trustworthiness of content is particularly important in case of digital marketing of Eco-Tourism. Castley, J. G., (2013) stated that pictures uploaded on websites play an important role in attracting customer to the particular Eco-Tourism destination. Sarkar S.K, et al. (2013) stated that socialisation on social communication platform plays a significant role in contributing awareness of Eco-Tourism on social communication platform. Hassangholipoor T. et al. (2014) stated that integrated marketing communication plays a very important role in generation awareness about the very concept of Eco-Tourism. Lu, W., et al. (2012) stated that attributes that are important for eco tourists while they choose an Eco-Tourism destinations are Eco lodges, food, and services and most important was value for money attribute. Tinelle Bustam et al. (2012) stated the importance of certification in promoting Eco-Tourism. Orasa Tetiwat, et al. (2017) developed a social communication platform model for promotion of eco- tourism and also developed a model explaining social communication platform marketing system stated that social communication platform has positive effect on Eco-Tourism destination popularity. Marios D. Sotiriadis (2017) stated that digital Media platforms have faltered the way tourists search find, read and disseminate information. Tetivat. O et al. (2018) in his paper stated that content of a web site plays a very important role and it should be organised according to activity, region and month. SudiptaKiran Sarkar, et al. (2015) stated that it is the duty of service provider to provide efficient and informative digital marketing services to develop trust, satisfaction among customers. Laura Hernández (2015) stated that the service provider should provide a safe and trustworthy platform on which tourist can exchange information with service providers and also offer them tailor-made solutions. Khwaja, M (2020) in his paper stated important factors for customers while they use digital marketing practices are Trust, Quality of Information and usefulness of information. Dastane, O. (2020) in the paper stated that digital marketing has a very constructive major influence on online buying intentions. AL-AZZAM, et al. (2021) in their paper stated that Digital world has tremendous growth opportunity, so firm should take benefits of them and adopt them as an key component of their marketing plans. Biswajit Roy &Sudin Bag(2021) in a study done in West Bengal stated that almost eighty percent customers prefers to purchase through digital platforms due to its ease of use, promotional strategies applied by companies etc. Husain, et al. in his paper stated that there is a significant relationship between mobile app usage and brand engagement, and

brand experience and DI both positively mediate this relationship and moderate it. As stated by MdWasiul Karim, et, Al. (2021) stated that an important predictor of impulse buying online is perceived enjoyment, which is positively influenced by website stimulus, marketing stimulus, and product variety and asked e-tailers to provide value-added products and services through online platforms in order to maximize their relationships with consumers. SemilaFernandis , et , Al (2021) in their paper stated that With the advent of technology, online shopping has become convenient for consumers in terms of accessing information and product recommendations, searching for and evaluating information, resulting in the purchase of the product. Maidiana, Karlls (2021) in their research work stated that quality assurance is the only variable with a significant positive relationship with information search and online shopping behaviour. Brands should provide detailed information on their websites and build products that meet customer expectations. Nayak, et ,AL. (2021) stated that online shopping perceptions of usefulness, perceived quality, and buying intention may be mediated by perceived benefits and perceived trust. Ivan Wen(2009) in his research work stated in the context of e-commerce, that customer satisfaction is "the level of satisfaction the customer has with his or her past buying experience with a given electronic exchange provider". Although customer satisfaction is an important consideration in tourism and hospitality e-commerce, there is no well-developed measurement for it and its mediational effect is unknown. Hysa, Et, al. (2021) stated that In Social Marketing(SM), There is a substantial difference between generations, such as the use of social media for checking opinions about tourist attractions, suggesting holidays based on positive comments, and resigning from holidays based on negative comments.

MohdSadiq & MohdAdil(2021) in their paper stated that Tourists' intentions to adopt technology depend on their perceptions of ease of use, usefulness, and quality of electronic information.

Research Gap

As a result of Utilizing mobile technologies, social media platforms, and eWOM for digital marketing, we have become increasingly accustomed to communication and marketing through mobile technologies, social media platforms, and electronic word of mouth (Ghani, et al., 218; Salloum, et al., 2018; Mohammed Habes et al., 2018). Due to increased global competition and the use of new technologies, recent years have seen a significant increase in the development of the marketing field. The above factors have changed the behavior of customers and the thinking of tourists in a way that cannot be compared with the old form of advertising and marketing. Using digital technology affords consumers the opportunity to enjoy a wealth of information, as well as a variety of tourism related services. As a result of the rapid development of technology and changing habits of young people, it is clear that today's consumers require people to communicate with them in a new way, particularly in the tourism sector, where the choices of destinations have changed significantly

(Penni, 2015). Finally, tourism behavior is influenced by eWOM through digital surveillance through social media and mobile applications.

The success of ecotourism will depend on its popularity, so a thorough analysis of the different approaches to ecotourism education presently prevailing in India is required. Ulfy, et, al. (2021) in their research work stated that It is necessary to utilize social media advertising in ecotourism in order to offer a rapid understanding of the industry. As of the present, there has not been sufficient research on the topic of digital marketing in the field of ecotourism, specifically in Uttarakhand. A study done by Saraswati A.K., &Ram P. (2017) and Amit, M. P. K. (2016) found that states in India such as Himachal Pradesh, Sikkim, Maharashtra, and Uttarakhand have been promoting ecotourism through digital marketing; however, not much progress has been made. For Uttarakhand to continuously benefit from its eco-tourism segment, more research is needed related to eco-tourism and about the factors which are important for ecotourists while using digital marketing tools.

Research Methodology

This research work is exploratory in nature and its objective is to find various factors that influence eco-tourists when they digital marketing while planning their holidays. The sampling technique is non probability cumulative sampling. Questionnaires were randomly distributed through Google forms, to 280 respondents for completion, of which all responded, and 25 questionnaires were not filled properly and that's why we rejected them. So the total numbers of valid responses were 255. The general rule of thumb for factor analysis is "Tabachnick's rule of thumb", that indicates that minimum 300 cases should be analysed. Hair et al recommended that sample size must be 100 or greater. In their study by Comrey and Lee, it was recommended that sample sizes should be as follows: 100 meant poor, 200 meant fair, 300 meant good, 500 meant very good, and 1000 meant superb. The demographic profile (age, occupation, Income Group) of youth is shown in table 1 mentioned below, data on factors related to digital marketing and how it is helping customers when they decide to plan a eco tour is also included. Questionnaire has included 5 point likert scale. Questionnaire consisting of 22 questions was prepared and data was collected hailing from Dehradun district of Uttarakhand in the month of August – November 2021. If a variable is found to have multiple significant loadings, this is referred to as cross-loading. As a result, labelling all the factors that share the same variable becomes problematic, and these factors are difficult to distinguish as distinct concepts and represent distinct concepts. It was not found that any cross-loading occurred in this research paper. In essence, factor loading refers to the correlation coefficient between the variable and the factor. Factor loading gives an indication of how much variance is explained by each variable on that particular factor. In this paper we have extracted all factors with a factor loading of 0.5 or higher. Item are finalised on the basis of prior literature.

Table 1 Demographic Profile of Samples

Category	Total Number	Percentage
Gender	255	
Male	146	57
Female	109	43
Age	255	
Under 20	19	7
21-30	43	17
31-40	74	29
41-50	88	35
Above 50	31	12
Occupation	255	
Service	126	49
Business	82	32
Service	98	39
House wife	19	7
Students	25	10
Retired	31	12
Annual Income	255	
Below 10Lakhs	19	7
10-15 Lakhs	40	16
15-20 Lakhs	86	34
More than 20 Lakhs	110	43

Results and Discussion

Factor analysis is used as a statistical method where in respondents asked 23 questions related to factors affecting them while they travel and plan to visit a Eco-Tourism destination of the state. The respondents were given questionnaire and requested to fill the questionnaire consists of 23 questions options were ranged from "Strongly Disagree" to "Strongly agree" (5 point likert scale)Table 2 mentioned below shows Cronbach's Coefficient (Alpha) values. Cronbach's Coefficient for the 23 variables is 0.914, suggests that the variables here have comparatively great uniformity. Value of Cronbach's alpha reliability coefficient usually ranges from 0-1. If the value of Cronbach's alpha reliability coefficient is close to 1 it is the sign of better reliability (Cronbach's 1951).

Table 2

Reliability Statistics	
Cronbach's Alpha	**N of Items**
.914	23

KMO and Bartlett's Test

Table 3

	Reliability Statistics	
Factor	**Cronbach's Alpha**	**N of Items**
Dependability	.990	6
Utility	.930	5
Flexibility	.891	4
Satisfaction	.737	5
Extra	.913	2

Table 4 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy	Approx. Chi-Square	df	Significance
.862	7222.268	253	.000

Bartlett's Test for sphericity is calculated to find out if the number of correlation among the variables was statistically significant or not. In order to determine whether our sample size is adequate for factor analysis, we use the Kaiser-Meyer-Olkin test. Ideally, we should aim for 0.7 or higher, but a value of less than 0.5 indicates a small sample size. Table 4 shows that the value of KMO Measure is 0.862, whereas lowest cut off rate is 0.50. This suggests that the we can do factor analysis on this data. Bartlett's Test of Spericity is showing the value of Chi-Square at 7222.268 with 253 degree of freedom, which was significant at 0.00 level of significance that also indicate the suitability of data for factor of analysis. Thus, all of these analyses is showing that data and number of samples are fit for factor analysis.

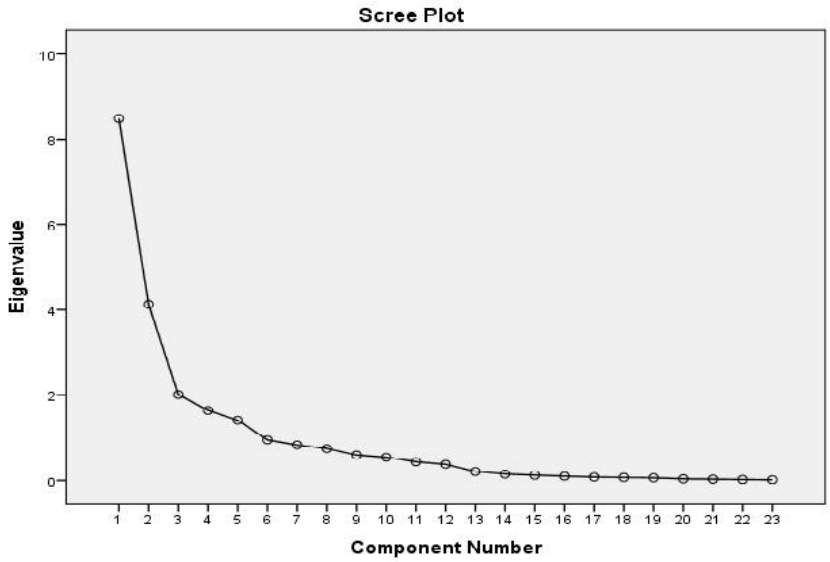
Table 5 The Extracted factors Together with their Eigen Values, Percentage of Variance and Cumulative

Factors/Items	Eigen value	Variance Percentage of Eigen value	Cumulative Variance Percentage
Reliability	8.487	36.901	36.901
Extensive and accurate information	4.126	17.937	54.839
Less expensive	2.007	8.726	63.565
Time and place utility	1.640	7.130	70.695
Hassle free speedy buying	1.408	6.122	76.817
Speedy delivery and prompt response	.949	4.126	80.943
Easy targeting	.830	3.608	84.551

Can Choose from different available alternatives	.743	3.229	87.781
Accessibility to customers	.592	2.574	90.355
Alters buying behaviour	.539	2.345	92.700
Increase rate of conversion	.432	1.877	94.577
Online customer support	.373	1.624	96.201
Improved quality of life	.206	.894	97.094
Information about unique destination	.146	.636	97.730
Competitive pricing	.119	.519	98.250
Immersive advertising	.096	.419	98.669
Detailed itinerary	.077	.336	99.004
Electronic Word of Mouth	.068	.297	99.302
Free tour package	.060	.263	99.564
Coupons and discounts	.036	.157	99.721
Share feedback	.030	.128	99.850
Best for luxury goods marketing	.020	.087	99.937
Can plan holiday according to own choice	.014	.063	100.000

Percent (%) of Variance measures the extent to which each factor can explain the variance in the dataset. A relatively large proportion of the variance is explained by the first few factors compared to the latter factors. The factor that accounts for a significant amount of variance is all that we are interested in extracting.

Figure



The Scree Plot (SP) in Figure 1 is used to categorize the ideal number of factors that can be taken out from the data and it is done by plotting the eigenvalue alongside number of factors in their order of extraction (Darlington, 1973). According to scree plot only 5 factors can be formed from given data. After factor analysis varimax rotation is done. Variable whose factor loading was more than .50 was included in the factors. Five factors were identified, which are Dependability, Utility, Flexibility, satisfaction and Extra.

Table 6 Important Factors and Variables relating to the Digital Marketing which People Consider when they Purchase an Eco-Tourism through Digital Modes in Dehradun District of Uttarakhand

Factors/ Item Name	Factor-related Marker	Factor Load
	1. Dependability	
IRC	Digital marketing develops trust hence increases the rate of conversion from lead to consumer for a product or service	.961
OCS	online customer support system is available through digital platforms	.961
IQL	Digital media has improved my quality of life to a great extent	.958
Rel	Digital marketing increases reliability of the product	.952
BR	Digital marketing helps in developing better relationship with customers.	.947
INFO	Digital marketing gives extensive and accurate information about the product	.933

	2. Utility	
ET	Digital marketing aids to buying thus stress linked to buying is reduced and that alters the buying behaviour	.933
WOM	Digital Marketing help me share feedback and recommend the social networking pages of tourism with my colleagues and Friends on social communication platform	.921
UDINFO	Digital marketing provides us information on unique destinations	.885
IA	Digital media immersive advertising appeals to visit a tourist destination	.879
CP	With digital media I can also read the users comments and experiences with a destination/tour package and plan accordingly	.640
	3. Flexibility	
TPU	Digital marketing provides us information on our convenient time and place	.829
BEST	I can make changes in my tours plan according to available slots	.781
Choice	Digital marketing provides me different choices on packages according to my time and paying capacity	.780
	4. **Extra**	
FTP	I have availed free tour package coupons before my actual purchase to get the real experience	.944
Feedback	I Share feedback and recommend the social networking pages of tourism with my colleagues and Friends on social communication platform?	.940
	5. Satisfaction	
HSB	Digital platforms helped me in choosing destination for myself after comparing different alternatives	.742
SDPR	I receive whatever I have expected from the booking done through digital platforms	.699
LE1	Digital marketing is less expensive in comparison to traditional marketing	.678
coupon1	With digital media I can also read the users comments and experiences with a destination/tour package and plan accordingly after full satisfaction	.566
ABB	Instant discounts and offers sometimes push me to impulse purchase	.507

A principal component analysis with varimax rotation was used to analyze twenty-two questions related to the benefits associated with digital marketing when tourists use it. Using the KMO sampling adequacy measure and the Bartlett's sphericity test, factor analysis was done and it was appropriate: The Kaiser-Meyer-Olkin sampling adequacy measure was .862, above the commonly recommended value of .6, and Bartlett's sphericity test indicated that the sample was significantly spherical ($\chi 2$ (253) = 7222.268, $p < .001$). By utilizing scree plots and eigen values greater than 1, the analysis revealed fiver factors that explain 76.87 percent of the variance. Factor 1 was labelled 'Dependability' because of the high loadings by the following items: Digital marketing develops trust hence increases the rate of conversion from lead to consumer for a product or service; online customer support system is available through digital platforms; Digital marketing provides us information on unique destinations; Digital marketing increases reliability of the product; Digital media immersive advertising appeals to visit a tourist destination; Digital marketing gives extensive and accurate information about the product; This first factor explained 36.90 per cent of the variance after rotation. Factor 2 was labelled ' Utility' because of high loading of following items: Digital marketing aids to buying thus stress linked to buying is reduced and that alters the buying behaviour; Digital Marketing help me share feedback and recommend the social networking pages of tourism with my colleagues and Friends on social communication platform; Digital marketing provides us information on unique destinations; Digital media immersive advertising appeals to visit a tourist destination; With digital media I can also read the users comments and experiences with a destination/tour package and plan accordingly. The second factor explained 54.839 percent of variance after rotation. Factor 3 was labelled as flexibility because of high loading of following items; Digital marketing provides us information on our convenient time and place; I can make changes in my tours plan according to available slots; Digital marketing provides me different choices on packages according to my time and paying capacity. The third factor explained 63.565 percent of variance after rotation. Factor 4 was labelled as 'Extra' because of high loading of following items; I have availed free tour package coupons before my actual purchase to get the real experience; I Share feedback and recommend the social networking pages of tourism with my colleagues and Friends on social communication platform. The fourth factor explained 70.695 percent of variance after rotation. Factor 5 was labelled as satisfaction because of high loading of following items; digital platforms helped me in choosing destination for myself after comparing different alternatives; I receive whatever I have expected from the booking done through digital platforms; Digital marketing is less expensive in comparison to traditional marketing ; With digital media I can also read the users comments and experiences with a destination/tour package and plan accordingly after full satisfaction; Instant discounts and offers sometimes push me to impulse purchase. The fifth factor explained 76.817 percent of variance after rotation.

Conclusion and Limitations

The given research paper establishes a fact that eco tourists are using digital marketing services to book their eco-tours. Factors including reliability, extensive and accurate information, less expensive time and place utility, speedy buying, speedy delivery, prompt response, improve quality of life, online customer support, competitive pricing, immersive advertising and flexibility were tested and grouped in to 5 main factors. This study has supported the outcomes of other researcher papers mentioned in the literature review (Avinash et al. 2016; Khwaja, M , 2020; Biswajit Roy et al, 2021, Dastane, O. 2020, Sudipta Kiran Sarkar et al 2015). This research paper establishes the fact that use of digital marketing is mandatory for the growth and success of Eco-Tourism. Eco-Tourism is not a new concept but still people are not aware of its true meaning. In fact Digital marketing is the best tool to promote Eco-Tourism in today's time. Through digital marketing service provider can offer their services to the Eco tourists. Its most important feature is its reach. Digital marketing gives their users time and place utility and that too from comfort of their home. An eco-tourist can find out different Eco-Tourism sites, select them on the basis of his or her requirement and purchase the services. One more important feature is this that since now a days maximum time a user spent with Mobile phone or laptops so it is both easy and comfortable for service provider and customers to meet each other on internet. Moreover Digital media techniques like AI, Virtual Intelligence make online advertisement so engaging that it increases excitement of the user to visit a particular destination. Through digital media a service provider has capability to reach its customer when he is relaxing at the comfort of his home too. Digital marketing provides total solution to its buyer. The expansion of information technology(IT) over the internet has altered the existing information related to eco-tourism It has changed the way people plan and make travel choices. Eco-Tourism products are intangible in nature like any other services and hence cannot be evaluated before consumption or travelling. Thus, online suggestions/commendations in form of feedback can be utilised as proof of service (evidence) before booking Eco-Tourism products and can alter the decision of traveller. Thus digital marketing help in establishing trust among tourists that they will be getting what they have expected in most of the cases. In case of any discrepancies they can also share their grievances on digital media in public domain. So digital marketing act as an authority to check that the promises made to tourists are fulfilled. If promises are not meant then tourists have luxary to share their grievances any time. Whenever a tourists look for a tourist product online he always go through the feedback part of the webpage. So if there are more negative feedback about a tourist destination naturally other tourists are not going to visit that place again. This facility is not available with traditional marketing platforms. The main aim of this research paper was to classify the factors that influence the eco tourists while they use digital marketing for their tour planning and booking. We have identified five factors i.e. Trust, Utility, Satisfaction, Flexibility and extra benefits. First factor "Dependability" consists of different sub factors like Reliability, Extensive and Accurate Information, Online

customer support and improved quality life. Digital marketing provides reliable information. Reliability and accuracy of information could be rechecked by the feedback provided by tourists. Since it is a two way platform where service provider can share the information regarding their services special features, offers and online customer support, the same way consumers can also share experience and feedback about the services. Through digital marketing Customer gets hassle free shopping experience that in returns improve his quality of life. Another important sub factor for Dependability improved quality of life. Other important factor of digital marketing is identified as "Utility". Digital marketing also provides immersive experience to the user in the form of innovative videos with use of innovative technology, Since digital marketing is less expensive and it provides time and place utility. " Flexibility" is the third factor identified in the research paper. All three factors along with "Extra"(the fourth factor) results in "satisfaction" the fifth factor , to the tourists in form of positive post purchase behaviour, and reduced anxiety and expected tour experience. Digital Marketers use extensive promotional strategies by offering free tour packages, coupons and discounts and facility to share feedback anytime from anywhere constitute our fourth factor extra benefits, The digital marketing is like a magical wand and its proper use can do wonders both for customers as well as service provider.

One of the main limitation of the paper is sample size is very less and study is limited Dehradun districts of Uttarakhand only.

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Tunnelling the Challenges of Smart Cities for Achieving Sustainable Development Goals

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Abstract

Developing economies in the world are looking for a concrete framework and administration for achieving sustainable economic development, improving the standard of living, and resilient city planning. The concept of a smart city fosters comprehensive urban planning to achieve the desired socio-economic goals of developing economies through the efficient use of Information and communication technology (ICT) and digital infrastructure. The study provides exploratory research on smart city development for policymakers and administrators to study the key challenges in implementing the smart city model. The paper uses a quantitative method to filter the most prominent challenges via the fuzzy-Delphi model to validate the challenges using expert opinions. The results indicate that there are 12 most prominent impediments to successfully setting up smart city framework in developing countries namely effective lack of security, lack in value & increase in the volume of big data, lack of secured and resilient internet & information technology infrastructure, usage of unreliable hardware sources, the threat of information confidentiality and bigger surface attack, lack of standardization and integration of data, problems like atmospheric pollution and insufficient energy resources, lack in management & administration by govt., absence of adequate regulatory norms .policies and direction. It is noteworthy that this paper highlights critical insights and direction to further researchers, policymakers, members of the urban development community to analyze and overcome the constraints identified in the findings for efficient implementation of the smart city model in Indian spectrum.

Keyword*: Smart city, ICT, developing countries, sustainable development, Fuzzy Delphi Method, Internet of Things.*

Introduction

The rapid increase in urbanization in recent years has accelerated the challenges of sustaining the population efficiently (Rao and Syamala, 2017) The rise in population requires proper city models for effective management (Kaur and Maheshwari, 2016) this has given to the rise of the smart cities. A smart city is a geographically defined region in which advanced technologies such as Information and communication technology (ICT), coordination, energy production, big data, Internet of Things (IoT), and others work together to benefit citizens in terms of living standards, inclusion and involvement, environmental quality, and intelligent development.

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Smart cities tend to confer the inclusion of ICT infrastructure in a wide range of vertices and situations to enhance or upgrade the pre-existing infrastructural model of all city functioning. ICTs have grown increasingly prevalent in urban areas, and they constitute an important foundation for smart city resilience and sustainability (Mora et al., 2019). Widespread access to ICT services using mobile technology provides easy access to information and this can help to bring in revolutionary changes in the mindset of people towards development, with information in public forums accessible to all for public scrutiny it makes cities functioning more transparent and democratizes with fewer chances of corruption and promote good governance (Bibri, 2018).

An estimation of 70% of the population of world would be living in urban localities by 2050, which will result in an unprecedented increase in the consumption of existing resources. One of the major objectives of introducing smart cities into the urban context is for improving the well-being and prosperity of citizens, many of the features of smart cities specifically curb in pollution, a better economy which leads to employment, higher per-capita income, increase in GDP, affordable and easily accessible utility services, access to social service, easy and reduce in commute time which ultimately promotes sustainable growth and indicates development. The substantial use of greenhouse gas emissions around the world from 1995-2015, has resulted in public outcry which demands societies curb their dependence on fossil fuel consumption to limit global warming.

As per the world, the bank reported in the year 2012 nearly 3 billion urban residents generated about 1.5 billion tons of waste and by the year 2025, when 60% of the population will be living in urban vicinity the number rises to 6 billion tons of waste (Shahidehpour and Ganji, 2018). The previous predominant approaches of waste management i.e., reuse, reduce, recycle, recovering, plays a very generic role and needed to be advanced to sustain the populace. The idea of smart waste management incorporates a series of independent and integrated actions which holistically reduce waste generation by employing ICT, IoT, sensor technologies- RFID and QR codes, engineered robotics, and automatic waste collection system. The per capita income of emerging economies, their GDP, other economic growth metrics, and the growth of SMEs play a key role in economic growth (Bello et al. 2018). Creating jobs, avoiding poverty and inclusive devolvement should be a major priority while drafting policies and strategies to implement a smart economy. With the exponential growth of the population migrating to urban localities cities become extremely competitive, and allure productive and adept employees and competitive business, to deal with such scenarios cities required adequate upgradation in their infrastructure, utility facilities, rules, regulations, and administrative policies, and advanced city management. The usage of advanced and intelligent technologies in the functioning of cities like IOT and Big data will improve the current architecture and change it into an automated and efficient model (Tanwar et al. 2018, Sharida et al. 2020). United nation center for human settlement was set up to promote social, economic, and physical development in cities to transform cities into smart cities, with a vision

of better quality of life for every individual, UNCHS works to define smart cities as where everyone needs whether social, economic or political is satisfied and aims to build inclusive, sustainable and resilient communities. The Sustainable Development Goals Report 2018 (Nations, 2018). The sustainable development goals (SDG) of the 1990s by the United Nations (UN) strives to achieve 17 SDG goals for the overall development of economies, the context of smart cities which serve as a bridge to achieve SDGs, a goal like making cities and human settlement inclusive and safe, promoting resilient cities, poverty reduction, economic development, affordable and clean energy, safe water and sanitation to all, health and wellbeing, quality education, zero hunger is linked to features of smart cities (Petrova-Antonova and Ilieva, 2018)

The rapid development of the urban population, as well as the resulting increase in resource use, will certainly present cities with various issues. The statistic emphasizes shows the significance of changing paradigms in the way cities operate to achieve long-term sustainability. It is critical to creating a workable conceptual framework to link SDGs with Smart cities for this research. On a global scale, achieving sustainability necessitates various types of efforts in urban localities. Reasoned arguments addressed all aspects of sustainability, including the environmental, social, and economic, and provided a balanced perspective about what a smart city should have been (Toli and Murtagh, 2020) Most environmental and social definitions concentrate on how smart cities combine technology with governance to improve quality of life and minimize urbanism's environmental effect. Many of the SDGs like 1, 2, 3,5,6,7,8,9, and specifically eleven falls under the model of smart cities.

Countries to fulfill the need to achieve SDGs will be expedited with the pervasion of smart cities, features of smart cities are considered complex systems which revolve around innovative technology and creativity aiming to the development of a sustainable environment and ecosystem hence, it corroborates the attainment of SDGs.

Literature Review

The concept of smart cities was introduced in the 1990s with the basic aim to utilize the economic and environmental resources of the cities optimally and provide a superior standard of living and promote economic growth using state of technology and infrastructure to empower people with advanced and automated services. Several smart city models have been introduced to set up the required smart city which assists the economies in growing.

A smart city employs a framework of information and communication technologies to develop, deploy, and promote development strategies to address urban issues and build a technologically enabled and sustainable infrastructure. The prevalence of ICT and other technologies and infrastructure development instigate rapid change management to the overall structure of communities. The urban planning and policymakers in setting up smart

cities specifically in developing countries faced myriad challenges to set up a smart city as planned."

Numerous studies have studied the impact of smart city constraints faced by communities and authorities. One of the biggest challenges is the assimilation of big data due to heavy reliance on technology for building a smart city (Mohammed et al., 2019).

Illegal data gathering by eavesdropping or message analysis, as well as integrity to manipulate information and change system settings, such as unauthorized access to sensitive information available to make the system closed and unavailable to authorized users. Another problem associated with big data is the financial information and fraudulent users and financial losses due to malicious data and processing and sharing, intellectual property, users, personal privacy, and commercial secrets which results in the high volume of big data being accumulated critical to security breaches (Ismagiloiva et al. 2019)

Authentication is a serious security risk for IoT devices since an unauthorized user can transmit, receive, and replay all forms of data (Chauhan et al. 2016). A high level of data overcrowding increases data redundancy and makes big data management one of the serious challenges for smart cities. (Wang et al., 2019)

The veracity of data-related issues arises because of several reasons such as data uncertainty leading to dirty data, non-unified data, and non-traceable data, Data is collected from various sources such as sensors mounted on intersections, bus probe data stating their location, line, and delay, and data on the traffic arriving from various cities (Hamid et al., 2019).

There are other value-related obstacles, such as the difficulties in extracting patterns from municipal data, the inability to provide quality service to users by using fast processing engines to analyze large data sets on a timely basis bottlenecks in sharing processed data across various applications inefficient handling of large amounts of data inability to provide quality service to users by using fast processing engines to analyze large data sets on the absence of legal provisions to enforce data regulations in the city and expensive data processing computational costs which tarnishes the value of data (Löfgren and Webster, 2020).

Building a smart city requires strong privacy and security but setting up digital framework policymakers face privacy difficulties including a lack of feasible anonymization techniques, data accessibility, and data transport across unreliable networks. Users' information can be revealed by analyzing incorrectly masked data. (Sookhak et al. 2018, Yadav et al. 2019, Xie, et al., 2019).

Smart cities collect and analyze data using IoT devices such as connected sensors, lighting, and meters. These data are then used by cities to improve infrastructure, public utilities, and services, among other things. Standardization is critical for bidirectional communication and information exchange between smart devices, surroundings, smart objects, and other systems on the Internet of Things (IoT). It guarantees that stakeholders and data are seamlessly integrated. If there is any inconsistency in maintaining standardization it could result in mismanagement. IoT adoption requires seamless internet connectivity and a lack of optimum network infrastructure or interrupting or insufficient internet access will result in higher operational costs and a longer payback period (Sharma et al., 2020).

The power of GPS-based monitoring data, combined with precise personal information on shopping patterns, location, and personal interests, and conveyed through IoT-based infrastructure, raises serious security and privacy concerns and increases trust issues for the government and public (Butt and Afzaal, 2019).

Insecure norms, incorrect direction, and insufficient executions in IoT adoption result in mismanagement and disparity in smart city results and operations. Cyber security and attributable to the absence of institutionalization of IoT gadgets, the sensors are inclined to hacking. The security lapses in data breaches are a concerning issue due heavy accumulation of personal and confidential data the smart city model acquired to create a repository and database for operational activities. Cyber assaults can affect smart cities in a variety of ways. Unprotected smart city infrastructure, such as parking garages, electric vehicle charging stations, and surveillance feeds, offer cyber attackers a vast volume of targeted personally identifiable information that may be used for fraudulent transactions and identity fraud (Alamer and Almaiah, 2021). Notorious people can trap the sensors and feed counterfeit information, causing signal disappointments, and framework shutdowns. Unreliable use of hardware components and bigger attack surface because of the integrated ICT infrastructure, every device connected to the system is vulnerable to hacking which increases the risk of supporting stakeholder-owned devices in public and private companies. (Swami and Bhargava, 2019).

Cultural destruction, diffusion, radical change, and disintegration are some factors that are influenced by the uprise of smart cities. The use of technology may improve indigenous concerns and popular culture, but a lack of attention to regional native cultures may result in the creation of new cultures (Behzadfar et al., 2017)

The success of a smart city relies on the relationship between the public and private sectors as much of the work to create and maintain a data-driven environment falls outside the local government's remit. Smart city introduces dynamic change management towards society and brings radical changes in the administration and operations of the populace. People may be hesitant to make the urban environment smart or may lose interest owing to factors such as

network security and hence, it imposes a challenge for governments to build cohesion in society (Dadhkhah and Shahbazi, 2015). The older population lacks the necessary experience and expertise to administer ICT, and the assistance of youngsters is sometimes insufficient and difficult to follow (Skouby et al., 2014).

The role of administrators and managers who are directly involved in the building of a smart city, action plan for infrastructural development, system management, and lack of management skills possess several challenges to building a perceived smart city. Integration of power, and dictatorship could cause inefficiency in the successful implementation of the smart cities model (Allahar, 2020).

Apart from IOT and big data, constraints related to the environmental shift in setting up the smart city is an important concern, to overcome the challenges posed by geographical conditions, each city's management will require its planning (Saleem et al. 2020). Cities located near desert areas will face challenges of water scarcity and particulate matter pollution; as a result, such cities' management policies will need to focus specifically on efficient water-harvesting technology and particulate matter pollution control (Turgel et al., 2019).

Along with the development of world-class digital infrastructure, it is equally important to support the environment and have prudent smart city planning which leads to sustainable growth. (Toli and Murtahg, 2020). Cities will face several issues because of resource usage Developing nations attempt to incorporate the concept of smart cities into their present urban planning to achieve economic development and address the difficulty of rapid urban population expansion and increased resource consumption, which inevitably creates several challenges for cities. Integration of several high-tech technologies, effective models for establishing interoperability in city working models, and the incorporation of information and communication technology (ICT) all help to improve operational efficiency and, as a result, facilitate economic growth and sustainability (Yigitcanlar and Kamruzzaman, 2018).

Research Methodology

This study helps to identify the challenges in implementing smart city model. This section discusses the identification of challenges and addresses the proposed Fuzzy Delphi method (FDM). To increase the speed and quality of questionnaires, FDM was used to get a group conclusion by removing the fuzziness of expert assessments. As a result, the FDM combination offers the benefit of lowering the number of interviews and research time while also providing a more comprehensive depiction of experts' expertise. The FDM may be used to change expert views into accurate statistics to meet demand while also generating extra advantages in terms of decision-making time and cost.

According to expert p, attribute q has a significant value as stated by O = $(l_{pq}; m_{pq}; n_{pq})$, where p = 1,2,3,……..,y ; q = 1,2,3,……..,z ; then weight O_q of element q is $O_q = (l_q; m_{q;} n_{q)}$, where l_q

= min(l_{pq}), m_q = ($\prod_1^y m_{pq}$)$^{1/y}$, and n_q = max(n_q). Then, the fuzzy numbers and linguistic terms are converted into linguistic values.Convex combination G_q is generated by the following equations and are created by adding a β cut to reach the result.

$$x_q = n_q - \beta(n_q - m_q),\ w_q = l_q - \beta(m_q - m_{lq}),\ q = 1,2,3,\ldots,z \quad (1)$$

Generally, β is denoted by 0.5. It ranges between 0 to 1 according to negative or positive expert opinions.

The exact value of G_q can be generated using the following equation:

$$G_q = \int(x_q, w_q) = \gamma\left[x_q + (1-\gamma)w_q\right] \quad (2)$$

In most cases, 0.5 is used to signify **α in** frequent scenario. Depending on whether the experts are positive or negative perceivers, this rating might range from 0 to 1. The exact value could be calculated by using the following table 1.

Table 1 Linguistic judgements

Linguistic Terms (Importance)	Code	Corresponding fuzzy values
Extremely Important	EI	(0.75,1.0,1.0)
Important	I	(0.5,0.75,1.0)
Moderately Important	MI	(0.25,0.5,0.75)
Least Important	LI	(0,0,0.25)
Not Important	NI	(0,0,0.25)

Proposed Analytical Procedure

The goal of this study is to assess experts' opinions of the primary challenges in setting up smart cities by using the Fuzzy Delphi Method (FDM). In two stages, the method has been implemented. The theoretical assessment of proposed hurdles to set-up smart city which is gathered in the first step from literature and previous research papers. Experts' knowledge and reliability are assessed through a survey data which is gathered from experts and professionals working in urban city development or directly involve with setting up smart city.

The second phase of FDM is then used in the study's second phase to screen out unimportant characteristics and rank them according to their significance. The following is the evaluation procedure:

1. The most likely characteristics of SSWM barriers have been gathered from the literature. Following that, the experts evaluate the recommended attributes in a through a survey data.
2. With the help of Equation (1) and (2), phase 1 FDM is used to strengthen the important characteristics (2). The questionnaire is designed to allow experts to conduct a second evaluation based on the proposed barriers.

3. To improve measurement consistency and accuracy, third Round 2 FDM assessment is carried out. The questionnaire is recreated based on the results of phase 1 to obtain the experts' opinion on the best-performing evaluation. To develop the final set of challenges, the FDM technique is repeated, and the most critical barriers are reviewed to provide precise implications for improving most vital challenges in setting up smart city.

Results

The proposed presents 27 challenges taken from literature by 6 broad barriers big data, Improper IOT adoption in Smart cities framework, Privacy, Environment, Cyber security, Urban mobility and administrative and management. The results of FDM are shown below, in table 1 initial list of challenges collected from pre-existing research is listed further in table 2 initial 27 challenges and weights and threshold y = 0.3550 is given following which is later analysed and calculated to get the accepted challenges by FDM. In table 3 the final 12 accepted challenges and their ranks is screen out from initial 27 challenges.

Table 1 Initial Challenges for smart city settlement

Challenges	S.No	Sub challenges
Big Data	**C1**	Lack of Security
	C2	Increase in Volume of data
	C3	Increase in Variety of data
	C4	Lack in Veracity of data
	C5	Lack in Value
Privacy	**C6**	Lack of Privacy and security
	C7	Lack of TRUST
	C8	Increase in operational Cost
Improper IOT Adoption in Smart Cities Framework	**C9**	Lack of Standardization
	C10	Lack of Internet connectivity
	C11	Lack of IT Infrastructure
	C12	Lack of regulatory norms, policies and directions
	C13	Land and Geography
Enviornment	**C14**	Change in Climate
	C15	Problem with atmospheric Pollution
	C16	Lack in Water Resources
	C17	Lack in Energy Resources
Cyber Security	**C18**	Problem of unreliable Hardware usage
	C19	Bigger Attack surface
	C20	Threat of Information Confidentiality and security
	C21	Problem of Application hazard
Administrative and	**C22**	Lack in public cooperation / Participation

Management	**C23**	Challenges of Disability of the Elderly
	C24	Lack in Management
	C25	Lack in Information Security
	C26	Urban Mobility
	C27	Problems on Diverse demographics and cultural

Table 2 Initial Barriers and FDM application

Challenges	u(y)	l(y)	Db	Accept/ Reject
Lack of Security	0.9024	-0.0274	0.4443	Accept
Increase in volume of Data	0.8384	0.0366	0.4284	Accept
Increase in Variety of data	0.8180	-0.3180	0.3295	Reject
Lack in Veracity of data	0.7922	-0.2922	0.3230	Reject
Lack in Value (quality of data that is accumulated)	0.9114	-0.0364	0.4466	Accept
Lack of TRUST	0.7896	-0.2896	0.3224	Reject
Lack of Privacy and security	0.8865	-0.3865	0.3466	Reject
Increase In Operational Cost	0.8082	-0.3082	0.3270	Reject
Lack of Standardization	0.8180	0.0570	0.4232	Accept
Lack of Internet connectivity	0.8951	-0.3951	0.3488	Reject
Lack in IT infrastructure	0.8697	0.0053	0.4362	Accept
Lack of regulatory norms, policies, and directions	0.9024	-0.0274	0.4443	Accept
Land and Geography	0.5000	0.0000	0.2500	Reject
Change in Climate	0.5000	0.0000	0.2500	Reject
Problem with atmospheric Pollution	0.8765	-0.0015	0.4379	Accept
Lack in Water Resources	0.5000	0.0000	0.2500	Reject
Lack in Energy Resources	0.8617	0.0133	0.4342	Accept
Threat of Information Confidentiality and security	0.9114	-0.0364	0.4466	Accept
Problem of unreliable Hardware usage	0.8505	0.0245	0.4314	Accept
Bigger Attack surface	0.8900	-0.0150	0.4412	Accept
Problem of Application hazard - expands the danger of supporting stakeholder own gadgets in a professional workplace.	0.8122	-0.3122	0.3281	Reject
Problems on Diverse demographics and cultural	0.5000	0.0000	0.2500	Reject

Lack in Public cooperation / Participation	0.5000	0.0000	0.2500	Reject
Challenges of Disability of the Elderly	0.5000	0.0000	0.2500	Reject
Lack in Management by govt.	0.9024	-0.0274	0.4443	Accept
Lack in Information Security	0.8865	-0.3865	0.3466	Reject
Urban Mobility: Need of up-gradation of existing transport services `	0.5000	0.0000	0.2500	Reject
Threshold			0.358	

Table 3 Accepted challenges rank wise

S.No	Rank	Challenges	u(y)	l(y)	Db	Accept/ Reject
C5	1	Lack in Value (quality of data that is accumulated)	0.911	-0.036	0.447	Accept
C18	2	Threat of Information Confidentiality and security	0.911	-0.036	0.447	Accept
C1	3	Lack of Security	0.902	-0.027	0.444	Accept
C12	4	Lack of regulatory norms, policies, and directions	0.902	-0.027	0.444	Accept
C25	5	Lack in Management by govt.	0.902	-0.027	0.444	Accept
C20	6	Bigger Attack surface	0.890	-0.015	0.441	Accept
C15	7	Problem with atmospheric Pollution	0.877	-0.002	0.438	Accept
C11	8	Lack in IT infrastructure	0.870	0.005	0.436	Accept
C17	9	Lack in Energy Resources	0.862	0.013	0.434	Accept
C19	10	Problem of unreliable Hardware usage	0.851	0.024	0.431	Accept
C2	11	Increase in volume of Data	0.838	0.037	0.428	Accept
C9	12	Lack of Standardization	0.818	0.057	0.423	Accept

The set of selected challenges from FDM are ranked from highest to lowest the Db value of upper challenge is 0.446588331 is [C5] Lack in value of data (quality that is accumulated) and lowest marked challenge gives Db of 0.423239371 is [C9] Lack in standardization of data as shown in table 3.

The results shows the 12 challenges for setting up smart city efficiently are [C5] lack in value is the most prominent challenge in setting up smart city, following with [C18] threat of information confidentiality and security, [C12] lack in regulatory norms, polices and

directions, [C25] lack in management by government, [C1] lack in security, [20] bigger attack surface, [C15] problem with atmospheric pollution, [C11] lack in IT infrastructure, [C17] lack in energy resources, [C19] Problem of unreliable hardware usage, [C2] increase in volume of data, [C9] lack in standardization.

Implication

The challenges are observed because of poor management of big data, to enable the numerous components of smart cities to cooperate and interact with the network architecture, smart city designers use current technologies such as mobile cloud computing, electronic items, networks, sensors, and machine learning technologies. The processing and management of data is one of the most difficult tasks in the creation of smart cities [C2] lack in management of data. This refers to data that is already stored in city databases, as well as data that is linked to new technologies and sensors in the smart city, all of which have an influence on security and privacy (Shahidehpour and Ganji, 2018).

Smart city uses data and information about several segments of the society to conclude issues and form relevant and compatible decision based on the data stored in smart city database (big data), moreover a large volume of data is useless unless it is turned into something useful. Value denotes the extraction of intelligence from data to acquire a competitive gain for successful performance, lack in value [C5] create a bottleneck in data exchange between diverse applications and will result in inefficient and less feasible decision making by decision makers and policy formulators.

The security of data [(C1) lack in security] many of the challenges in smart cities include data processing and sharing security, intellectual property, users, personal privacy, trade secrets, and financial information and additional major difficulties with smart cities include fraudulent users and financial losses is a result of harmful data and breaches by malicious unauthorized people which results in significant losses of urban planners and is considered as an important element of setting up smart city. (Cheng et al., 2015). Threats like data breach, cyber related factors and unauthorised access can result in undesired consequences and disrupt the design and framework of smart city. Furthermore, due to high-tech appliances, IoT, Big data and other technological machines and information service management usage it becomes easy for hackers to attack [20] bigger attack surface.

Smart cities uses various kinds of sensing models, communication gears and IoT gadgets and technology, software and equipment for storing ,collecting, processing, retrieving, managing data, SC uses cloud based technology and other APIs to facilitates to exchange of data and resources for several operations of SC, the usage of these tech oriented hardware appliances make it possible for malicious attackers to attack such hardware and technologies and further capture the data and information, counterfeit the crucial data, corrupt the hesitative data. [C19] Problem of unreliable hardware usage.

Smart cities face barriers in terms of security and privacy since they must gather a large quantity of data, store it in databases, and perform batch and real-time analytics. Various concerns, such as weak security and encryption, the use of fragile inheritance frameworks and insufficient support, course affects, and human error, all contribute to frameworks' impotence. Users' sensitive information, such as their healthcare financial and bank credentials, are easily accessible to attackers. They can also carry out other forms of cybersecurity assaults with the goal of destroying: Confidentiality to extract information and monitor system operations, such as unlawful data gathering via eavesdropping or traffic analysis; Integrity to modify information and change system settings, such as unauthorised access to sensitive information [C18] threat of information confidentiality and security.

[C11] Lack in IT infrastructure: The IT infrastructure must be designed in accordance with the needs of smart cities. Only with the correct architecture can updated technologies be implemented. A smart infrastructure is a cyber-physical system that allows for the integrated management of all its components via the use of various technology tools that help assemble and analyse data to satisfy efficiency, sustainability, productivity, and safety goals.

[C12] lack in regulatory norms, polices and directions, The Internet of Things (IoT) framework is used by smart cities to deploy in a variety of components and functions. When there are no regulatory norms and rules in place, insecure standards, and inaccurate action direction result. Promote IoT implementation, a strong legal framework is required.

It becomes difficult for IoT companies and hardware sensors to agree on common interoperability protocols and standards for sharing and securing data. While there are no globally accepted standards, another challenge is that there are so many IoT standards being created that a single standard will be difficult to win popular support [C9] lack in standardization. With the availability of many touch points for hacking, different standards, networking patterns, and levels of maturity raise security threats.

Smart Cities lead to significant changes in society and the existing framework and city model and modify it into an automated and technology-enabled environment. Myriad changes in ecological and environment composition of the city carried out to build a resilient smart city. The level of cities' energy usage must be balanced with its surrounds and the environment. It is necessary to plan of time by gathering information through ICT, communication, and diverse platforms, and to coordinate with state electrical boards, the Ministry of Power, and the Ministry of New and Renewable Energy. [C17] lack in energy resources, planning out the usage of energy and impact on energy consumption should be carefully studied and managed. The environmental impact on city while developing SC could be delirious and led to mismanagement if not properly implemented(Yigitcanlar et al., 2019). Lack of policy and foresight in transportation, industry, energy consumption, and waste creation are frequently

the source of air pollution. Polluted air is known to harm big populations all over the city. Better rules and mechanisms for combating air pollution are required in smart cities. Continuous monitoring, identification of causes, and resolution of air pollution are required for the development of sustainable smart cities. [C15] problem with atmospheric pollution.

Administrative and government policies and management who implements the plan of SC plays an important role for building robust SC, Strategic and proper plan implementation and technology adoption is imperative which require strong regulatory and admirative policies. [C25] lack in management by government importance of public and government participation, at all levels, cooperation's, and integration of central, state and town governments and transparent, democratic, and responsible government efforts require to adopt desired SC.

Risk assessment and feasibility testing is required for planning any smart city model, the challenges which could be most prominent in different geographies should be duly segmented and defined for effective management of project. The selected challenges are identified in the study are analysed and researched via fuzzy- delphi method, while forming the smart city model (blueprint) the barriers identified in the study should be considered and further researched to layout the SC model hassle free and with minimal problems in Indian spectrum. Furthermore, research can be done to analyse each factor which is important and most prominent to find out the solution and remedy to overcome the challenge.

Conclusion

The Smart City idea works in a complicated urban context that includes a variety of infrastructure, human psychology, technology, social and political systems, and the market/economies. Smart city is illustrated as a prosperous society that uses smart city technology by bringing out several integrated intelligent technologies to manage a collection of smart city infrastructures that support sociotechnical and socioeconomic initiatives and ethnic diversity. Smart cities support the use of ICT and subsequent systematic technologies where it uses data as the means of making applicable and informed decisions to solve overall socio-economic, managerial, environmental, administrative problems, institutional, infrastructural issues.The paper uses quantitative method to filter most prominent challenges via fuzzy-Delphi model to validate the challenges using expert opinions. The results indicate that there are 10 most prominent impediments for successfully setting up smart city framework in developing countries namely effective management of big data, Internet of Things adoption for smart city structure, secured and resilient internet &information technology infrastructure, privacy and cyber security lapses, lack of standardization and integration of data, cost, environment degradation and poor government administration & management.

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Spicing up Advertising Campaign: Is Out-of-Home Media the Answer?

Arshia Kaul and Vernika Agarwal

Abstract

The two types of media used for advertising are either accessible to end consumers inside their homes or those to which they are exposed outside their homes. The Out-of-Home (OOH) media are the newer media that are being used for advertising. OOH, advertising can be a fantastic alternative to the world of digital advertising on the internet. Advertisers choose OOH advertising because of the potential impact it can have on customers. The research in the field of OOH advertisement still lacks understanding regarding the contextual relationship between the criteria for selection and the alternatives of OOH media available. The question that still needs deliberation for a firm that wants to advertise for their product is, which is the best media for advertising among various OOH platforms We propose a rating of OOH media utilising a Fuzzy-Technique for Order Preference to Similarity to Ideal Solution in this study. The data is validated for a durable technology product in the northern Indian market.

Keywords: *OOH, F-Topsis, Product promotion, Media selection, Advertising*

Introduction

A firm which is wanting to advertise must look for those options which are most effective as well as cost-efficient. The strategy for advertising must be developed tactfully (Tzu, 2006). Multiple media are available for advertising, which could be considered. These media can be classified under many heads, one such classification is based on the location of advertising relative to the home in which the end customers reside. The advertising inside the home and that which is Out-of-Home (OOH) media. The OOH media isused to reach the audience at large and is not confined to certain homes. These media not only refer to outdoor spaces but advertising cannot impact when the customer is at home. Earlier they were considered to be advertising which is in open spaces but now it refers to any kind of advertising which is not inside the home (Gambetti, 2010). This concept dates back in history and can be traced in India to ancient rock-art paintings and inscriptions in Egypt and Greece (Veloutsou & O'Donnell, 2005). These were used as means of communication. The way the OOH is being used has changed and is one of the most widely used media in recent times (Iveson, 2012). OOH advertising's main goal is to raise brand awareness, reinforce, reassure, or drive someone to a product or service(Cho et al. 2022). It's a shotgun marketing strategy in which a company focuses less on conversion rates and more on brand awareness and engagement. In the earlier times, the OOH was not so often used for advertising but over the years it has been extensively used by advertisers. Globally the expenditure on OOH advertising is expected to be 38.06 billion US dollars by the year 2020 which would be up from 25.54 billion US dollars (Statista, 2018). In India as well there has been a trend seen of increase in the expenditure on

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OOH media. There was an increase of 6 percent in the use of OOH in India in 2017 and the expenditure is INR 3085 crore (Nair-Ghaswalla, 2018). This type of media is being used extensively as it cannot be skipped by the customers. They do not have a choice of moving away from an OOH media. The newer field of OOH is a win-win situation for the various media houses to enhance synergy with the digital platforms (Roux and Van der Waldt 2016). OOH advertising has changed dramatically in recent years as a result of changing technology and increased customer awareness. It is gaining traction every day as more businesses invest in this sector (Wilson et al. 2015). The paper by Taylor (2015), suggests that the growth of digital OOH will be a boon for the community to have a real-time communications infrastructure.

There are a variety of types of OOH. Broadly there are four categories of OOH media (Roux, 2013):

(i) Outdoor Advertising Media

These comprise two formats: (i) outdoor advertising on constructions/buildings and (ii) free-standing outdoor advertising signs or billboards. In the case of advertising on constriction buildings, the advertising on the current structures or construction sites is used for advertising on bridges (SAMOAC 2010, 15). Other advertisements are placed on highways and major arterial roads. These are aimed at the larger audience and those who spend a lot of time traveling on the road (Bhargava, Donthu, and Caron 1994).

(ii) Transit Advertising Media

These are used by advertisers for targeting those who use the public transport services like buses, taxis, trains, and airplanes. They include both the moving transit media and the stationary advertising. The moving transit media is on buses, taxis, etc. Static/ stationary advertising is the placement of advertisements in the common areas in train stations or airport terminals and the like. They are generally used for targeting the adults who are working in metropolitan cities (Moriarty et al., 2012).

(iii) Street- and Retail Furniture Advertising

This is advertising which does not have a large reach to the commuters of the vehicular traffic. There are other formats of advertisements that are placed on different fixtures in the streets such as street poles or benches on the street. These are aimed essentially at pedestrians, commuters, or shoppers (Roux et al. 2013).

(iv) Alternative OOH Advertising

This is not the traditional way of advertising but the new media. These are the digital screens in stadiums, interactive displays in shopping malls, and the advertising displayed on different objects. These objects could be tee markers in golf, clothing, promotional street advertising by graffiti, and so on (Roux et al. 2013).

It can be observed that there has been discussion on the concept of OOH media by many researchers. They have discussed the essential components of OOH advertising in detail. There

has been much discussion on what media are available for advertising, but to the best of our knowledge, there has been very negligible research on the idea of trying to understand which of these OOH media are best suited for an advertising firm about their product. Moreover, there has been limited research on how to arrive at these decisions through mathematical notions. Here in our research, we have considered the decision of advertising through OOH media as a multi-criteria decision-making problem. The idea essentially is that many OOH media are available to the advertiser. The question to be answered is what is the best suited OOH media for the product. There is not one but many criteria based on which the advertising media must be chosen for advertising the product. Here we have used the Fuzzy-Technique for Order Preference by Similarity to Ideal Solution (F-TOPSIS). This approach is a Multi-Criteria Decision Making approach under the fuzzy conditions of real-life decision-making.

The rest of the paper is divided as follows: section 2 discusses the problem definition. Research methodology is given in section 3. Section 4 and section 5 discusses the case study and implications. The conclusion is given in section 6.

Problem Definition

The problem at hand to be solved is for a Bank (name not disclosed due toreasons of confidentiality) which wants to extensively advertise through OOH media. Any firm which wants to advertise would want to understand in which media it must advertise to get the maximum returns on investment (in terms of conversion of viewers to customers)in the minimum possible budget. In the same case, the Bank under consideration wants to understand the top OOH media which would be best suited for it. In this case, the overall presence of the Bank in the media is considered and not specifically any one product of the bank.

The objective of the problem could be considered to be comprised of sub-objectives:

- What are the alternatives of OOH media which are available in front of the firm?
- What are the criteria based on which the alternatives are evaluated to be best suited for advertising?
- What is the scale for evaluation?
- What is the importance of the individual criteria?

To address these sub-problems in the compact form we utilize the MCDM methodology F-TOPSIS. This methodology is explained in detail in the section that follows.

Research Methodology

To inculcate the views of the stakeholder's, having ambiguous and vague judgements, fuzzy set theory is the best alternative. In comparison to the other multi-criteria decision-making approaches such as analytical hierarchy process (AHP), TOPSIS is a preferred choice since it involves less number of computational matrixes. This will bypass the tedious pair wise comparison and aid in the calculation of priority vectors with fewer calculations. The current study uses fuzzy TOPSIS to prioritize the OOH media alternatives. The fuzzy TOPSIS

methodology is explained in the steps below with more detailed steps provided in the appendix:

Step 1: Identification of the decision matrix

Step 2: Determination of consolidated fuzzy weights of criteria.

Step 3: Fuzzy scores of the pair wise comparisons.

Step 4: Determination of Fuzzy positive and Fuzzy negative ideal solution

Step 5: Evaluation of the separation distances: The separation distance of the alternatives is calculated using the FPIS and FNIS.

Step 6: Determination of the closeness coefficient and ranking of agile strategies

Case Study Implementation

As stated earlier we are considering the case of an advertising campaign for a Bank. We add further that the bank wishes to initially advertise extensively in a metro city. The step-wise procedure is followed to conclude by choosing OOH advertising options from the alternatives available basis the criteria for the same. The decisions at every step are taken in discussion with a group of 10 decision-makers. This is a committee of top management (5) and special officers (5) from the Bank. This committee was constituted internally tomake decisions about the decisions to marketing for the Bank, in this particular case advertising.

Initially, the criteria for selection for choosing OOH media are considered. The details of the criteria are described in Table 1. After deciding the criteria for the choice of OOH media, the weights of importance of each criterion are decided by the committee members. The scale used for deciding the weights of the criteria is as defined by Chen (2000). Table 1 also defines the corresponding weights of the criteria.

Table 1 Criteria for Selection for OOH Media

Criteria No.	Criteria	Definition of Criteria	Fuzzy Weights of Criteria
C1	**Good reach to urban population**	Describes how well the media is have an impact on the end customers in the metro cities and higher higher-tier	(0.78,0.94,1)
C2	**Good reach to regional population**	Describes how well the media can impact the end customers in the rural areas and lower-tier cities	(0.38,0.58,0.78)
C3	**Good reach to an employed class**	Describes how well the media can have an impact on the end customers belonging to the working class	(0.7,0.9,1)
C4	**Good reach to an unemployed class**	Describes how well the media can have an impact on the end customers belonging to the	(0.14,0.34,0.54)

		unemployed class	
C5	**Good for targeting groups inside the venue**	Describes how well the media can have an impact on the end customers inside a particular venue	(0.62,0.82,0.96)
C6	**Good for targeting groups outside the venue**	Describes how well the media can have an impact on the end customers outside a particular venue	(0.7,0.9,1)
C7	**Fewer cost implications of the media**	Describes how well the media can have an impact on the end customers within the limited budget	(0.46,0.66,0.86)
C8	**No risk implications**	Describes how well the media can have an impact on the end customers with minimum risk	(0.66,0.86,0.98)
C9	**Consumer centric**	Describes how well the media can have an impact as per choice the of the end customer	(0.62,0.82,0.96)
C10	**Good consumer receptiveness**	Describes how well the end customer absorbs the communication by the particular media	(0.66,0.86,0.98)
C11	**Good creativity for engagement of the audience**	Describes how creative the media is while having an impact on the end customer	(0.34,0.54,0.74)
C12	**Not irritating the customers by over advertising/intrusiveness of the media**	Describes how well the media can have an impact while not having a negative impact from over advertising	(0.58,0.78,0.92)

Source for the criteria: Roux, 2013

In the next step, the initial fuzzy decision matrix is evaluated. Table 2 describes the fuzzy decision matrix which is computed with the decision-makers in the committee using the scale for performance for the alternatives concerning criteria as defined by Chen (2000). The alternatives for the problem include: "Outdoor advertising on construction or buildings"(OHM1), "Free standing outdoor advertising media" (OHM2), "Moving transit advertising media"(OHM3), "Static transit advertising media"(OHM4), "Street furniture advertising media"(OHM5), "Retail furniture advertising media"(OHM6), "Digital OOH advertising media advertising" (OHM7)and "Ambient OOH communication channels" (OHM8).

Table 2 Fuzzy Decision Matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
OH MI	(5.4,7.4,9.2)	(2.6,4.6,6.6)	(3.8,5.8,7.6)	(2.6,4.6,6.6)	(2.2, 4.2,6)	(1,3,5)	(1.8,3.8,5.8)	(1.4,3.4,5.4)	(7,9, 10)	(5.4,7.4,9.2)	(3,5,7)	(3.4,5.4,7.4)
OH M2	(5.8,7.8,9.4)	(2.2,4.2,6.2)	(4.6,6.6,8.2)	(2.2,4.2,6.2)	(1,3,5)	(3.4,5.4,7)	(2.6,4.6,6.6)	(2.6,4.6,6.6)	(5.4,7.4,8.8)	(4.2,6.2,8.2)	(2.2,4.2,6.2)	(2.2,4.2,6.2)
OH M3	(8.6,9.8,10)	(4.6,6.6,8.6)	(8.6,9.8,10)	(3,5,7)	(8.6,9.8,10)	(8.6,9.8,10)	(3,5,7)	(3.4,5.4,7.4)	(7,9,10)	(5.4,7.4,9.2)	(7,9,10)	(6.6,8.6,9.8)
OH M4	(6.6,8.6,9.8)	(3,5,7)	(6.2,8.2,9.4)	(3,5,7)	(5.8,7.8,9)	(5.8,7.8,9)	(2.6,4.6,6.6)	(4.2,6.2,8.2)	(7,9,10)	(6.6,8.6,9.8)	(6.2,8.2,9.4)	(4.6,6.6,8.6)
OH M5	(5.8,7.8,9.4)	(2.6,4.6,6.6)	(4.6,6.6,8.2)	(2.6,4.6,6.6)	(3.4,5.4,7)	(2.2,4.2,6)	(2.2,4.2,6.2)	(2.2,4.2,6.2)	(7,9,10)	(5.8,7.8,9.4)	(3.8,5.8,7.6)	(3.8,5.8,7.8)
OH M6	(7,9,10)	(1,3,5)	(7,9,10)	(1,3,5)	(7,9, 10)	(1,3,5)	(5,7,9)	(3,5,7)	(7,9,10)	(7,9,10)	(3,5,7)	(5,7,9)
OH M7	(7.8,9.4,10)	(1.8,3.8,5.8)	(7.8,9.4,10)	(1.8,3.8,5.8)	(5.4,7.4,8.8)	(4.2,6.2,7.8)	(3.4,5.4,7.4)	(3.8,5.8,7.8)	(7.8,9.4,10)	(7.8,9.4,10)	(6.2,8.2,9.4)	(3.4,5.4,7.4)
OH M8	(8.6,9.8,10)	(1.4,3.4,5.4)	(8.6,9.8,10)	(1.4,3.4,5.4)	(3.8,5.8,7.6)	(3.8,5.8,7.6)	(3,5,7)	(3.4,5.4,7.4)	(8.6,9.8,10)	(8.6,9.8,10)	(7,9,10)	(1.8,3.8,5.8)

To ensure that all our values are on the same level, the process of normalization is applied. Table 3 gives the normalized fuzzy decision matrix.

Table 3 Normalized fuzzy decision matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
OH MI	(0.54, 0.74, 0.92)	(0.30, 0.53, 0.76)	(0.38, 0.58, 0.76)	(0.37, 0.65, 0.94)	(0.22, 0.42, 0.6)	(0.1, 0.3, 0.5)	(0.2, 0.42, 0.64)	(0.17, 0.41, 0.65)	(0.7, 0.9, 1)	(0.54, 0.74, 0.92)	(0.3, 0.5, 0.7)	(0.34, 0.55, 0.75)
OH M2	(0.58, 0.78, 0.94)	(0.25, 0.48, 0.72)	(0.46, 0.66, 0.82)	(0.31, 0.6, 0.88)	(0.1, 0.3, 0.5)	(0.34, 0.54, 0.7)	(0.28, 0.51, 0.73)	(0.31, 0.56, 0.80)	(0.54, 0.74, 0.88)	(0.42, 0.62, 0.82)	(0.22, 0.42, 0.62)	(0.22, 0.42, 0.63)
OH M3	(0.86, 0.98,1)	(0.53, 0.76,1)	(0.86, 0.98,1)	(0.42, 0.71,1)	(0.86, 0.98,1)	(0.86, 0.98,1)	(0.33, 0.55, 0.77)	(0.41, 0.65, 0.90)	(0.7, 0.9,1)	(0.54, 0.74, 0.92)	(0.7, 0.9,1)	(0.67, 0.87,1)
OH M4	(0.66, 0.86, 0.98)	(0.34, 0.58, 0.81)	(0.62, 0.82, 0.94)	(0.42, 0.71, 1)	(0.58, 0.78, 0.9)	(0.58, 0.78, 0.9)	(0.28, 0.51, 0.73)	(0.51, 0.75, 1)	(0.7, 0.9, 1)	(0.66, 0.86, 0.98)	(0.62, 0.82, 0.94)	(0.46, 0.67, 0.87)
OH M5	(0.58, 0.78, 0.94)	(0.30, 0.53, 0.76)	(0.46, 0.66, 0.82)	(0.371, 0.65, 0.94)	(0.34, 0.54, 0.7)	(0.22, 0.42, 0.6)	(0.24, 0.46, 0.68)	(0.26, 0.51, 0.75)	(0.7, 0.9, 1)	(0.58, 0.78, 0.94)	(0.38, 0.58, 0.76)	(0.38, 0.59, 0.79)
OH M6	(0.7, 0.9,1)	(0.11, 0.3, 0.58)	(0.7, 0.9, 1)	(0.14, 0.42, 0.71)	(0.7, 0.9, 1)	(0.1, 0.3, 0.5)	(0.55, 0.77, 1)	(0.36, 0.60, 0.85)	(0.7, 0.9, 1)	(0.7, 0.9, 1)	(0.3, 0.5, 0.7)	(0.51, 0.71, 0.91)
OH M7	(0.78, 0.94,1)	(0.20, 0.44, 0.67)	(0.78, 0.94,1)	(0.25, 0.54, 0.82)	(0.54, 0.74, 0.88)	(0.42, 0.62, 0.78)	(0.37, 0.6, 0.82)	(0.46, 0.70, 0.95)	(0.78, 0.94, 1)	(0.78, 0.94, 1)	(0.62, 0.82, 0.94)	(0.34, 0.55, 0.75)
OH M8	(0.86, 0.98, 1)	(0.16, 0.39, 0.62)	(0.86, 0.98, 1)	(0.2, 0.48, 0.77)	(0.38, 0.58, 0.76)	(0.38, 0.58, 0.76)	(0.33, 0.55, 0.77)	(0.41, 0.65, 0.90)	(0.86, 0.98, 1)	(0.86, 0.98, 1)	(0.7, 0.9, 1)	(0.18, 0.38, 0.59)

Based on the importance of the criteria some weights are given to the criteria. The weights are utilized to determine the weighted fuzzy decision matrix.

Finally, the distance between the alternatives from the positive and the negative ideal solution is found. The idea is to find out alternatives that are closest to the positive ideal and furthest from the negative ideal solution. The Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS) is A*= (1,1,1) and A^-=(0,0,0) respectively. The distance of each alternative from the Fuzzy Positive Ideal Solution and Fuzzy Negative Ideal Solution and Closeness coefficient for all the alternatives is given in Table 5.

Table 5 Closeness Coefficient and rank for alternatives

Alternatives	d_i^+	d_i^-	CC_i	Rank
Outdoor advertising on construction or buildings (OHM1)	7.25922393	5.739173633	0.442	1
Freestanding outdoor advertising media (OHM2)	7.255949976	5.713913095	0.441	2
Moving transit advertising media (OHM3)	5.162990387	7.942168454	0.606	3
Static transit advertising media (OHM4)	5.809626449	7.32710281	0.558	4
Street furniture advertising media (OHM5)	6.816062108	6.197315118	0.476	5
Retail furniture advertising media (OHM6)	6.263608834	6.859870336	0.523	6
Digital OOH advertising media advertising (OHM7)	5.879855801	7.174423569	0.55	7
Ambient OOH communication channels (OHM8)	6.038775046	6.938968092	0.535	8

From the ranking, it can be observed that the best suited OOH media for advertising for the bank under consideration is the "Moving transit advertising media" followed by "Static transit advertising media". Transit advertising targets the millions of people who use or come across public transport facilities every day. It offers unparalleled ad exposure to drive greater frequency and impact for your marketing campaigns. Buses and trains are the most common transit channels in the majority of places, providing the audience with repeated exposure to the ads. The ads can be localized and hyper-target a particular demographic or market segment. More importantly, transit ads demand attention. Combining traditional media with

Implications

Practical Implications

The reason that advertisers love OOH advertising is due to the potential impact that it can have on consumers. They take notice of these large OOH ads.OOH campaigns can't be ignored, compared to TV, radio, or mobile, which can often be turned off, or the consumer can move to another channel. This means that advertisers can launch highly visual, impactful campaigns that attract the attention of consumers and allow brands to get their message to cut through. It can be observed that the best suited OOH media for advertising for the bank under consideration is the "Moving transit advertising media" followed by "Static transit advertising media". While the majority of OOH inventory is physical, more digital screens are now a crucial

part of OOH campaigns. Digital screens are providing better optimization, and this means that advertisers can create more personalized messaging. ON top of this, it's possible to use different kinds of triggers to trigger a more dynamic form of OOH advertising. This innovation is no longer in its infancy, and advertisers have shown precisely how effective digital OOH can be. As well as this, they have demonstrated the scalability of Digital OOH. Better and more accurate data is assisting in these innovations. Advertisers can now offer dynamic media based on the demographic and behavior of mobile devices in real-time. Real-time advertising is critical, but in reality, it is part of a growing trend in which the industry is becoming a more reactive solution. The large amount of data that marketers now have at their disposal is fueling this. This versatility is driving OOH personalization and leading to fantastic results for advertisers that are using Digital OOH to achieve their goals.

Theoretical Implications

Advertisers are in control of their OOH medium and creative. Map-based online OOH buying platforms that provide street-view imagery mean advertisers can effectively scout outdoor inventory to avoid running campaigns in undesirable and unsuitable locations. The literature must focus on moving transit advertising media, the planning of slots and generating revenue for the same. By engaging consumers in their day-to-day lives, OOH has a legitimizing effect that, even if an ad doesn't resonate with every viewer, builds brand trustworthiness.

Conclusion

This research considers the evaluation of the different OOH media which are available for advertising to a firm. The question that is in front of the firm advertising is what is the best suited OOH media for them. This becomes a multi-criteria decision-making scenario. There are multiple OOH media alternatives available for advertising and the firm needs to choose the best suited one for them. The case implemented in case of a Bank advertising through OOH media. The methodology presented here helps them make a choice of the best suited OOH media for them. The methodology could further be used in general by any firm as per situation. In conclusion the "Moving transit advertising media" followed by "Static transit advertising media" are ranked best and second best as per the closeness coefficient. The given research can be extended by additionally developing mathematical models for the placement of advertisements in different top ranked OOH media over different time periods with the objectives for maximising the reach to the end customers under the budget considerations. The consideration of segmentation in the market could be another aspect for future model extensions.

Appendix

We assume that there are K decision makers $D=\{D_1, D_2, \ldots, D_k\}$, criteria be n, given as $I=\{I_1, I_2, \ldots, I_m\}$ and alternatives be n given as $S=\{S_1, S_2, \ldots, S_n\}$. The opinion of the decision makers is taken at an equal level, without giving preference to any one decision maker. The weights of the criteria are denoted by decision makers $\widetilde{w}_{jk}= \{e_j, f_j, g_n\}$, where $e_j=\min(e_{jk})$, $f_{j=}\frac{1}{K}\sum_{k=1}^{K} f_{jk}$ and $g_j=\max(g_{jk})$.

Similarly, we calculate the rating of the priority of the alternatives concerning each criteria for each decision maker $\tilde{X}_{ij}$= {p_{ij}, q_{ij}, r_{ij}}, where p_{ij}=min(p_{ijk}), $q_{ij}=\frac{1}{K}\sum_{k=1}^{K} q_{ijk}$ and r_{ij}=max(r_{ijk}). Therefore, the fuzzy decision matrix is given as:

$$\widetilde{D} = \begin{array}{c} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{array} \begin{array}{c} \begin{array}{ccc} C_1 & C_2 & C_n \end{array} \\ \begin{vmatrix} \tilde{x}_{11} & \tilde{x}_{12} & \tilde{x}_{1n} \\ \tilde{x}_{21} & \tilde{x}_{22} & \tilde{x}_{2n} \\ \vdots & \vdots & \vdots \\ \tilde{x}_{m1} & \tilde{x}_{m2} & \tilde{x}_{mn} \end{vmatrix} \end{array} \quad \text{where } i=1,2,\ldots,m\ ;j=1,2,\ldots,n$$

As suggested by Majumdar et al. (2021), the linear transformation scale for comparison of the criteria can be helpful and less complex to use. Hence, we use the following formula for normalization in lieu of the complex normalization used in TOPSIS:

$\tilde{A} = \left[\tilde{a}_{ij}\right]_{mxn}$ *i=1,2,…,m ;j=1,2,…,n*

Where

$\tilde{a}_{ij} = \left(\frac{p_{ij}}{r_j^*}, \frac{q_{ij}}{r_j^*}, \frac{r_{ij}}{r_j^*}\right)$ and $r_j^* = max\ r_{ij}\ \ (J \in benefit\ criteria)$

$\tilde{a}_{ij} = \left(\frac{p_j^-}{r_{ij}}, \frac{p_j^-}{q_{ij}}, \frac{p_j^-}{p_{ij}}\right)$ and $p_j^- = min\ p_{ij}\ \ (J \in cost\ criteria)$

Construct the weighted normalized decision matrix $\tilde{V}$ by multiplying criteria weights $\widetilde{W}_j$ with $\tilde{R}_{ij}$ as shown below:

$\tilde{V} = \left[\tilde{v}_{ij}\right]_{mxn}$ *i=1,2,…,m ;j=1,2,…,n*

Where $\tilde{v}_{ij} = \tilde{a}_{ij}(.)\widetilde{w}_j$

Determine fuzzy positive ideal solution (FPIS or B^*) and fuzzy negative ideal solution (FNIS or B^-) as follows:

$B^* = (\tilde{v}_1^*, \tilde{v}_2^*, \ldots, \tilde{v}_n^*)$

Where $\tilde{v}_j^* = \max(v_{ij})$ *i=1,2,…,m ;j=1,2,…,n* for benefit criteria

Where $\tilde{v}_j^- = \min(v_{ij})$ *i=1,2,…,m ;j=1,2,…,n* for cost criteria

Calculate the separation measures for each alternative. The separation measures from FPIS and FNIS alternatives are calculated as follows:

$d_i^+ = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_{ij}^+\right)$, *i=1,2,…,m*

$d_i^- = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_{ij}^-\right)$, *i=1,2,…,m*

Where $d(\tilde{m}, \tilde{n})$ is the distance between two fuzzy numbers, calculated as:

$$d(\tilde{m}, \tilde{n}) = \sqrt{\frac{1}{3}[(m_1 - n_1)^2 + (m_2 - n_2)^2 + (m_3 - n_3)^2]}$$

Calculating the relative closeness to the ideal solution for each alternative, the relative closeness of j^{th} alternative with respect to PIS is calculated as follows:

$C_i = \frac{d_i^-}{d_i^- + d_i^+}$, $i=1,2,\ldots,m$

The index value C_i lies between 0 and 1. Rank the preference order of alternatives according to their relative closeness to the ideal solution.

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H2H Marketing: Together Can We be Relevant?

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Abstract

In this research we are highlighting an integrated MCDM methodology for identification and evaluation of challenges for H2H marketing strategy. The H2H marketing strategy would focus on looking after the benefits of the customer, in addition to incorporate the marketing objectives of the firm. The two step-methodology of Grey-Delphi and Grey-DEMATEL has been used in order to initially identify the challenges of implementing the H2H marketing strategy and subsequently dividing the factors into cause/effect clusters. The grouping of factors into cause/effect clusters would help in developing the H2H marketing strategy for the firms.

Keywords: *Sustainable, Service-Dominant Logic,H2H, Design thinking, Digitalization.*

Introduction

Marketing as a strategy has been criticized by many in the literature. In an article in Psychology Today in 2017 given by Marty Nemko titled stated that "Marketers use many psychological plays to make you buy what you shouldn't" ("Marketing is evil"). It was stated that there were many strategies through which customers buy many over-priced products. This is a very common thought process that people believe in across board as marketers continue to use their aggressive policies. Many believe that relevance of marketing and marketers is being lost. Digitalization in the markets is also adding to the negative belief about marketing, as not all marketing is able to communicate well to the consumers. In such a situation, marketing as a field staying relevant in the current state is questionable.

In order to ensure that their strategies are considered meaningful in the market there are many value propositions which needs to be made (Ganesan and Gopalsamy 2022). The current trend would want marketing to develop their strategy in order to correctly understand the attitudes and behaviour of the customers. They should interact with the customers directly in order to understand what they want. It has to be a combined effort by employees, customers, marketers together to understand the complex need of the customers in the market. The challenge lies in the fact that the production-oriented companies would have to look at providing for the customer-oriented market. Moreover, it is essential to go an extra mile to not only consider the customer-oriented approach but the human-centered approach so that marketers and their companies can play major roles in solving the human problems of the customers.

The H2H model is the one which was earlier called the "Bangalore Model" is the integrated model which incorporates the attributes of Design Thinking (DT), Digitalization(D) and,

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Service-Dominant Logic (S-DL). These three components get a marketing model in place for marketing. Design Thinking concentrates on the human centricity and works with the insights of what the customer wants. The Service-Dominant Logic which gives details of collaborative ecosystem. Digitalization highlights the new option available to the customer and the marketers for transactions and communication possibilities. The question that arises is that, to ensure that the marketing strategies which need to be developed can they actually be developed keeping in mind organizational objectives and also ensuring concerns for the humans and in general the society (Kartajaya et al. 2021). Theoretically the model may seem to be achievable and appropriate answer to the criticisms of the critiques (PURCAREA 2021).

Thus, in this research the aim is to determine the challenges to actually implementing the H2H policy under the uncertainties of the customer in the market. Initially, the list of factors impacting the system would be determined based on discussion with the decision makers in the field and subsequently it is important the categorization of these factors into the cause-and-effect clusters. The categorization would help to understand which are the factors which would increase or decrease in order to be have an overall impact of efficient sustainable marketing strategy, one in line with the organizational objectives and one which also looks after the customer needs and human aspect.

The paper is divided into the following sections: Section 2 discusses the current new literature in H2H. Section 3 gives details of integrated Grey-Delphi, Grey-DEMATEL Approach and Section 4 gives the data analysis and the results. Section 5 concludes the paper and highlights the limitations which act as an area for future research.

Literature Review

The new linkages between service-dominant logic and design thinking have been considered by Edman (2009). They state that there is a similarity in the principles of the two, and further digitalization, helps thinking in multiple directions for new strategies (Draganov et al. 2018). These three strategies may come from very different backgrounds, yet they can be combined together for value creation as stated by the researchers. There are some companies which are well-established companies which have implemented some of these combined strategies such as IBM, Apple to name a few. The idea of combining strategies is to keep ensuring the continuous improvements. Whether it is Satya Nadella who says “we refer to ourselves as the do more company” or whether Google considers the “Don’t be evil” thought, there is always an emotional quotient. It must not ever be forgotten that although we are becoming more and more technologically savvy and automating many of the systems, whenever there will be a problem that will arise there will always be a necessity of human intervention (Koporcic and Törnroos 2019). Companies would apply the Human-to-Human marketing inwards and outwards so that it becomes not an event for the company but a structure which has inherent human-to-human interaction (Kotler et al., 2021). The research question that arises from the literature is that how many of these companies and how many of these companies in the

future will be able to develop such marketing strategies which are sustainable? Are the theoretical models sustainable? Therefore, in this research we try to address this question and assess what are the causes of challenges which we are not being able to implement for the establishment of the sustainable strategies.

Methodology

The research objectives of this paper are:

- To identify the challenges affecting the humanitarian marketing strategy
- To evaluate the weights of attributes using MCDM approach

In this context, the focus of the present work is to identify the challenges from literature and decision makers and to understand the contextual relationship between them. For the selection of attributes affecting the humanitarian marketing strategy we have used grey-Delphi method combines grey system theory and the Delphi Method to determine assessment indicators using a grey whitening weight function based on questionnaires. Initially, attributes are identified from extant literature review (Ikram et al. 2021).

The weight or relative importance to each attribute is evaluated using the grey Decision-Making Trial and Evaluation Laboratory (G-DEMATEL) approach (Menon and Ravi 2021). In real-world applications, the ambiguity grows as a result of poor subjective judgments and imprecise information. Non-quantifiable information, insufficient information, inaccessible information, and partial knowledge are examples of imprecise sources. Although traditional DEMATEL cannot successfully overcome these constraints, the grey systems theory-based DEMATEL technique looks to be a viable alternative.

Determination of attributes: Grey- Delphi

For the selection of prominent H2H challenges we have used grey-Delphi method which combines grey system theory and the Delphi Method to determine assessment indicators using a grey numbers based on questionnaires. Initially, H2H challenges are identified from extant literature review. A five-point grey interval questionnaire is distributed to the stakeholders. The linguistic terms in the scale include “Strong important (SI)” representing the numbers on grey scale as [4,5], “Important (I)” with grey value of [3,4], “Moderately important (MI)” having grey value [2,3], “Unimportant (UI)” with grey value of [1,2] and “Strongly unimportant (SUI)” with grey value of [0,1].

The preferences of each member are then collected and assessed. The grey system theory is used. The preferences of each member are then collected as grey number $\otimes x = \left[\underline{x}, \overline{x}\right] = \left[x^{'} \in x \mid \underline{x} \le x^{'} \le \overline{x} \right]$. For analyzing this grey number we whitenize its value using $\boxtimes = \alpha \times a_{\otimes} + (1-\alpha) b_{\otimes}$, $\alpha \in [0,1]$, where $a_{\otimes}$ and $b_{\otimes}$ are aggregate lower and upper values respectively .If the a coefficient is 0.5, $\boxtimes$ is known as equal-weight mean white nization

which is a commonly used value for α..The coefficient of 0.5, (equal-weight mean white nization) method is used to transform the grey numbers to transform them into crisp numbers. Following the analysis, if the value of any challenge is less than an agreed-upon threshold (2.85), that challenge is discarded; otherwise, it is regarded a significant and is included in the decision framework for this study.

Relative Importance of Attributes: Grey Dematel

The G-DEMATEL technique is utilized to determine the weight or significance of each attribute. Traditional DEMATEL allows the evaluation and determination of causal relationships among components, as well as the analytical determination of the degree of relationship or the intensity of impact. In real-world applications, the ambiguity grows as a result of poor subjective judgments and imprecise information. Non-quantifiable information, insufficient information, inaccessible information, and partial knowledge are examples of imprecise sources. The most significant advantage of grey system theory is that it allows for the inclusion of ambiguity and uncertainty in the assessment process. Computational steps of the grey-based DEMATEL are given below:

Step 1: The criteria for evaluation are specified, and a grey scale is developed to truly accommodate the uncertainty of human judgements. Linguistic scale are given as "Very highly influence" (VH) as [0.75, 1], "High influence" (HI) as [0.5, 0.75], "Low influence" (LI) as [0.25, 0.5], "Very low influence" (VLI) as [0, 0.25] and "No influence" (NI) as [0, 0].

Step 2: Calculating the direct relationship matrix to assess the link between the criteria denoted by $F= \{F_i, i=1,2, 3..., n\}$. A panel of experts is requested to perform pair-wise comparisons using the linguistic scale. The initial grey matrix "M" is generated.

$$M^E = \begin{matrix} F_1 \\ F_2 \\ \vdots \\ F_n \end{matrix} \begin{bmatrix} 0 & \otimes m_{12}^E & \cdots & \otimes m_{1n}^E \\ \otimes m_{21}^E & 0 & \cdots & \otimes m_{2n}^E \\ \vdots & \vdots & \cdots & \vdots \\ \otimes m_{n1}^E & \otimes m_{n2}^E & \cdots & 0 \end{bmatrix} \quad (1)$$

where E is the number of experts, $\otimes m_{ij}^E = [\underline{m}_{ij}, \overline{m}_{ij}]$ are grey numbers, $\otimes m_{ii}^E = [0,0]$ for $i=1,2,...,n$.

Step 3: The aggregate matrix *"Z"* is formed by taking the average of grey direct relation matrixusing Eq. (2) as given below.

$$Z = \left(\sum_{i=1}^{E} M^E \right) / E \quad (2)$$

Step 4: Creating and assessing a structural model: The linear scale transformation is modified to a normalization to translate the criterion scales into comparable scales. Let

$$\sum_{j=1}^{n} \otimes z_{ij} = [\sum_{j=1}^{n} \underline{z}_{ij}, \sum_{j=1}^{n} \overline{z_{ij}}] \quad (3)$$

And $p = \max_{1<i<n} \left(\sum_{j=1}^{n} \overline{z_{ij}} \right)$

Then, the normalized direct-relation grey matrix *GM* is equal to, $GM = p^{-1} \times Z$

And

$$GM = \begin{bmatrix} 0 & \otimes g_{12} & \cdots & \otimes g_{1n} \\ \otimes g_{21} & 0 & \cdots & \otimes g_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \otimes g_{n1} & \otimes g_{n2} & \cdots & 0 \end{bmatrix}$$

$$\text{Where } \otimes g_{ij} = \frac{\otimes z_{ij}}{p} = \left[\frac{\underline{z_{ij}}}{p}, \frac{\overline{z_{ij}}}{p} \right] \tag{4}$$

Step 5: After getting the GM, the grey total relation matrix R may be computed using the following equations:

$$\begin{aligned} &R = GM + GM^2 + \ldots + GM^E \\ &R = GM\left(I - GM\right)^{-1}, when \lim_{E \to \infty} GM^E = [0]_{n \times n} \end{aligned} \tag{5}$$

$$R = \begin{bmatrix} \otimes r_{11} & \otimes r_{12} & \cdots & \otimes r_{1n} \\ \otimes r_{21} & \otimes r_{21} & \cdots & \otimes r_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \otimes r_{m1} & \otimes r_{m2} & \cdots & \otimes r_{mn} \end{bmatrix}$$

$$\text{And } \otimes r_{ij} = \left[\underline{r_{ij}}, \overline{r_{ij}} \right] \tag{6}$$

and

$$Matrix\left[\otimes \underline{r_{ij}} \right] = \underline{GM} \times \left(I - \underline{GM} \right)^{-1}$$

$$Matrix\left[\otimes \overline{r_{ij}} \right] = \overline{GM} \times \left(I - \overline{GM} \right)^{-1}$$

Step 6: The grey numbers are now converted to crisp numbers using the following procedure (Opricovic et al. 2003).

$$\otimes \underline{r_{ij}} = \left(\otimes \underline{r_{ij}} - \min \otimes \underline{r_{ij}} \right) / \Delta_{\min}^{\max} \tag{7}$$

$$\otimes \overline{r_{ij}} = \left(\otimes \overline{r_{ij}} - \min \otimes \overline{r_{ij}} \right) / \Delta_{\min}^{\max} \tag{8}$$

Where $\Delta_{\min}^{\max} = \max \otimes \overline{r_{ij}} - \min \otimes \underline{r_{ij}}$

$$X_{ij} = \frac{\otimes \underline{r_{ij}} \left(1 - \otimes \underline{r_{ij}} \right) + \otimes \overline{r_{ij}} \times \otimes \overline{r_{ij}}}{1 - \otimes \underline{r_{ij}} + \otimes \overline{r_{ij}}} \tag{9}$$

$$z_{ij} = \min \otimes \underline{r_{ij}} + X_{ij} \Delta_{\min}^{\max} \tag{10}$$

where, z_{ij} are the crisp values. Then the sum of rows and columns are separately denoted as d and c within the total relation matrix R as in Eq. 20 and 21.

$$R = \left[r_{ij} \right], \qquad i, j \in \{1, 2, \ldots, n\}$$

$$d = \left(d_i \right)_{n \times 1} = \left[\sum_{j=1}^{n} r_{ij} \right]_{n \times 1} \tag{11}$$

and

$$c = \left(c_j \right)_{1 \times n} = \left[\sum_{j=1}^{n} r_{ij} \right]_{1 \times n} \tag{12}$$

Step 6: Evaluating the results: ($d + c$) total exposes the effects of the attributes, whereas (d – c) shows the causal linkages between the attributes. If ($d - c$) is positive, it means the attributes have a causal impact on others; if ($d - c$) is negative, it means the attribute is influenced by others.

Case Study

The case has been taken where the 9 decision makers in the field of marketing are asked for their opinion on the new H2H strategy. The new strategy is one which is also trying to incorporate the genuine concern for the customers while marketing products to them (Kim and Kim 2022).The question that arises is that why this strategy is not being able to be developed. With the insights of the decision makers the study has been completed. The 9 decision makers are all experienced in the field. Two of them are at Vice president levels with 20 years of experience are MBAs with specialization in marketing, one is an operations manager with 15 years of experience, with experience in developing various different marketing strategies in the field and with a masters in operations, two are marketing managers with 10 years of experience with MBA in marketing and finance , three of them are marketing and sales managers with 9 years of experience and MBA in marketing, one is an operations managers with 8 years experience in the industry with expertise in marketing. With their experienced inputs we have been able to utilize the integrated methodology of Grey-Delphi and Grey-DEMATEL to assess the current strategies which are in place and also find out the challenges for implementation of the H2H marketing strategy whether it is inward or outward strategy. The exact names of the companies and designations have not been disclosed due to reasons of confidentiality.

Results and Discussions

The two-step methodology has been incorporated to identify the challenges in the implementation of H2H marketing strategy and then highlighting those into the cause and the effect groups.

Grey-Delphi Results

In the first stage we apply Grey-Delphi methodology to identify the challenges. Table 1gives the attributes for the implementation of H2H (initial stage of Grey-Delphi).

Table 1 Rating of H2H Challenges

Notation	H2H challenges	DM 1	DM 2	DM 3	DM 4	DM 5	DM 6	DM 7	DM 8	DM 9
H2H1	Explosion of sales and communication channels	SUI	UI	SUI	UI	SUI	SUI	UI	UI	UI
H2H2	Keeping up to date with technology is a problem	I	MI	I	I	SI	I	I	I	SI
H2H3	Usage of products on temporary basis	MI	UI	UI	MI	SUI	SUI	UI	SUI	UI
H2H4	Sharing economy	MI	MI	I	I	I	MI	I	MI	I
H2H5	Loss of importance of ownership	SUI	SUI	UI	UI	SUI	UI	MI	UI	MI
H2H6	More knowledgeable customers	SI	SI	I	SI	I	I	I	I	I
H2H7	Influence of family friends etc more rather than message through advertising	SI	I	MI	MI	I	SI	MI	SI	I
H2H8	Collaborative actors (customers) are demanding	MI	MI	MI	MI	MI	MI	I	I	I
H2H9	Understanding and interaction with customer as a co creator	SI	SI	I	I	I	I	I	SI	SI
H2H10	Fuzzy front end innovation	UI	MI	UI	MI	MI	UI	MI	UI	UI
H2H11	Need to build long lasting relationship	I	MI	I	MI	MI	MI	MI	I	I
H2H12	Focus more on retention and thinking about people	I	I	SI	I	SI	SI	SI	SI	SI
H2H13	Volume of Information is quite a bit	MI	MI	I	I	SI	SI	MI	I	I

After discussion and elimination process followed in the Grey-Delphi methodology Table 2 provides the list of identified attributes selected through grey-Delphi approach.

Table 2 Identified challenges

Challenge Original Notation	Accept/Reject	New Notation
H2H1	Reject	-
H2H2	Accept	NH1
H2H3	Reject	-
H2H4	Accept	NH2
H2H5	Reject	-
H2H6	Accept	NH3
H2H7	Accept	NH4
H2H8	Reject	-
H2H9	Accept	NH5
H2H10	Reject	-

H2H11	Reject	-
H2H12	Accept	NH6
H2H13	Accept	NH7

Grey-DEMATEL Results

In the second phase of the integrated approach the evaluation of the identified challenges is done through the Grey-DEMATEL Approach. The Grey-DEMATEL approach will highlight the challenges in the cause group and the effect groups. We highlight systematically the results step-wise of GREY-DEMATEL. We show here the results with respect to the steps as mentioned in the methodology section.

Table 3 and 4 shows the linguistic judgements for decision maker 1 and decision maker 2. Similar tables are filled in by the other 7 decision makers in the system.

Table 3 Stakeholder 1 Linguistic Judgements

	NH1	**NH2**	**NH3**	**NH4**	**NH5**	**NH6**	**NH7**
NH1	N	H	L	L	H	L	VL
NH2	N	N	VL	H	L	L	L
NH3	N	N	N	H	VL	H	VL
NH4	VL	L	L	N	L	VH	VL
NH5	H	L	VL	VL	N	L	L
NH6	L	VH	H	L	H	N	N
NH7	VL	L	L	VH	H	VH	N

Table 4 Stakeholder 2 Linguistic Judgements

			Stakeholder 2				
	NH1	**NH2**	**NH3**	**NH4**	**NH5**	**NH6**	**NH7**
NH1	N	H	L	VH	N	N	L
NH2	L	N	VL	H	VH	H	L
NH3	H	VH	N	L	L	H	L
NH4	VL	VL	VH	N	VL	L	H
NH5	VH	VH	L	L	N	H	L
NH6	H	H	VH	VH	H	N	H
NH7	VH	L	N	H	H	VH	N

Table 5 describes the consolidated matrix of average of upper limit and lower limit of grey numbers given by all the decision makers.

Table5 Consolidated Matrix of Average of Upper Limit and Lower Limit

	NH1	**NH2**	**NH3**	**NH4**	**NH5**	**NH6**	**NH7**
NH1	[0,0]	[0.5,0.75]	[0.25,0.50]	[0.5,0.75]	[0.25,0.38]	[0.13,0.25]	[0.13,0.38]
NH2	[0.13,0.25]	[0,0]	[0,0.25]	[0.5,0.75]	[0.5,0.75]	[0.38,0.63]	[0.25,0.50]

NH3	[0.25,0.38]	[0.38,0.5]	[0,0]	[0.38,0.63]	[0.13,0.38]	[0.5,0.75]	[0.13,0.38]
NH4	[0,0.25]	[0.25,0.38]	[0.5,0.75]	[0,0]	[0.13,0.38]	[0.5,0.75]	[0.25,0.50]
NH5	[0.63,0.88]	[0.5,0.75]	[0.13,0.38]	[0.13,0.38]	[0,0]	[0.38,0.63]	[0.25,0.50]
NH6	[0.38,0.63]	[0.63,0.88]	[0.63,0.88]	[0.5,0.75]	[0.5,0.75]	[0,0]	[0.25,0.38]
NH7	[0.38,0.63]	[0.25,0.50]	[0.13,0.25]	[0.63,0.88]	[0.5,0.75]	[0.75,1]	[0,0]

Table 6 describes the consolidated matrix G

Table 6 Consolidated matrix G

	NH1	NH2	NH3	NH4	NH5	NH6	NH7
NH1	[0,0]	[0.12,0.18]	[0.06,0.12]	[0.12,0.18]	[0.06,0.09]	[0.03,0.06]	[0.03,0.09]
NH2	[0.03,0.06]	[0,0]	[0,0.06]	[0.12,0.18]	[0.12,0.18]	[0.09,0.15]	[0.06,0.12]
NH3	[0.06,0.09]	[0.09,0.12]	[0,0]	[0.09,0.15]	[0.03,0.09]	[0.12,0.18]	[0.03,0.09]
NH4	[0,0.06]	[0.03,0.09]	[0.12,0.18]	[0,0]	[0.03,0.09]	[0.12,0.18]	[0.06,0.12]
NH5	[0.15,0.21]	[0.12,0.18]	[0.03,0.09]	[0.03,0.09]	[0,0]	[0.09,0.15]	[0.06,0.12]
NH6	[0.09,0.15]	[0.15,0.21]	[0.15,0.21]	[0.12,0.18]	[0.12,0.18]	[0,0]	[0.06,0.09]
NH7	[0.09,0.15]	[0.06,0.12]	[0.03,0.06]	[0.15,0.21]	[0.12,0.18]	[0.18,0.24]	[0,0]

Table 7 gives the total relation matrix

Table 7 Total Relation matrix

	NH1	**NH2**	**NH3**	**NH4**	**NH5**	**NH6**	**NH7**
NH1	4.49	6.70	5.36	7.71	5.64	7.09	4.48
NH2	5.45	7.09	6.24	9.16	6.81	8.79	5.03
NH3	5.05	6.86	5.17	8.32	6.39	7.92	4.73
NH4	5.34	7.44	5.62	7.52	6.45	8.02	4.66
NH5	6.47	9.46	7.29	11.47	7.16	10.57	5.83
NH6	9.08	13.84	10.03	17.23	11.51	13.52	7.61
NH7	8.81	13.60	9.20	16.13	11.01	14.72	6.85

Table 8 highlights the factors which have been segregated into cause and effect

Table 8 Cause and Effect Groups

	d	r	d+r	d-r	Cause/Effect
NH1	19.93	49.67	69.60	-29.74	Effect
NH2	36.38	46.44	82.81	-10.06	Effect
NH3	39.11	39.50	78.61	-0.39	Effect
NH4	27.81	50.42	78.23	-22.62	Effect
NH5	43.56	33.48	77.05	10.08	Cause
NH6	66.36	38.60	104.96	27.76	Cause
NH7	54.43	29.46	83.90	24.97	Cause

The integrated two step methodology helps us to identify the challenges in implementation of H2H strategy and further segregate into the cause-and-effect groups. The division into cause-and-effect groups helps to analyse which of the factors will influence the other in order to be able to implement the H2H strategy.

Conclusion

In this paper, the aim is to ascertain the sustainability of the H2H marketing. This strategy theoretically combines the design thinking, service dominant logic and digitalization. In such a combined structure, will be able to achieve the implementation which would be sustainable for a long term. We assess this situation based on the integrated Grey-Delphi and Grey-DEMATEL approach such that we are able to determine the major causes for not being able to implement the H2H marketing strategy. The limitation of the study is that currently the decision makers have been taken from varied industries and an overall picture has been taken. For accurate results the decision should be further based on different industries. Marketing strategy should be as per type of industry and product. The limitations of this study could be future scope of research.

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Analysis of Influential Factors for the Sustainable Development of Electric Vehicles Using Fuzzy Dematel Method

Niranjan Kumar, Diwakar Suman and Sonu Rajak

Abstract

The rampant increase of environmental issues due to fuel consumption and emission of greenhouse gas has to lead the way for an automobile company to think about Electric vehicles over combustion engines that operate on fossil fuels like diesel, petrol, and CNG. As of today's environmental problems, EVs aspects zero emissions and can decrease the dependence on fuel. EV has been seen as one of the potential alternatives in the transportation sector because now a day's transportation sector is indeed one of the leading and most challenging greenhouse gas polluters. Hence, it is requisite to examine the influential factors that influence customers aim to buy EVs.The paper is based on identifying the factors that may influence the development of EVs and also examines the various aspects using Fuzzy-DEMATEL (Decision making trial and evaluation laboratory). This analysis identified the influential factors such as cost effectiveness, impact on environment, consumer perspective, charging infrastructure, environmental impact, vehicle design and performance, lack of charging infrastructure, technological advancement, energy security, driving comfort and safety, battery type and technology, battery swapping and its longevity and maintenance plan of electric vehicle using Fuzzy-DEMATEL. The result of the analysis helps the industry to modify the policy to design of electric vehicles.

Keywords: *Sustainable product design; Sustainability; Electric Vehicle; Decision-making; Fuzzy DEMATEL*

Introduction

Background of Electric Vehicle

In recent study sustainable development of EV is very much important in transportation because electric vehicle has better efficiency and power consumption performance and it reduces the negative impact and air pollution on the environment. Therefore electric vehicle replaces internal combustion engine. Electric automobiles are fully or partially depend on battery packs and powered by electric motor. Electric vehicle has better power consumption performance and it has fewer moving parts to maintain therefore EVs are less costly.There are many types of electric vehicles are as:

A. BEVs (Battery electric vehicle)
B. HEVs (Hybrid electric vehicle)
C. PHEVs (Plug-In Hybrid Electric vehicle)
D. FCEVs (Fuel cell electric vehicle)

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A. BEVs (Battery electric vehicle)

Battery electric vehicle is a type of electric vehicle that uses electric motor and controllers in place of internal combustion engine for power transmission. The EV has been developed by utilizing different type of batteries, like NiMH (Nickel Metal Hydride) or lead-acid battery but currently lithium-ion batteries replaces the both due to high range of charging storage capacity. The energy is stored in the form of chemical energy in a battery and it converted in AC power by the help of electric motor. The controller controls the speed of changing power frequency from inverter to electric motor. BEV comprises electric motor, controller,inverter, battery and drive train. TATA Nixon, Hyundai Kona, Tesla Model 3 and TATA Tigor are examples of BEVs.

B. HEVs (Hybrid electric vehicle)

A hybrid vehicle is a type of EVs that combines an electric-motor engine and a conventional internal combustion engine system. Internal combustion engine and regenerative braking system are used to charge the battery in place of plugged in. It is powered by internal combustion engine and electric motor. The main component of HEV are gasoline tank, electric motor, motor controller, battery pack, inverter and control module. It has both technology BEV and ICEV to run the engine. Toyota cruiser, Honda city eHEV and Toyota prius are example of HEV cars.

C. PHEVs (Plug-In Hybrid Electric Vehicle)

PHEVs are driven by two mode; electric mode which uses battery to transmitting power or hybrid mode which uses electric as well as design as a working substance. PHEVs has both feature internal combustion engine and electric motor, it works alternatively. It has rechargeable battery pack and it charged by engine, externally changeable unit and regenerative breaking system. PHEVs have many component battery, electric motor, controller and battery charger. Examples of PHEVs are BMW 3-Series, Toyota Corolla and Volvo XC40.

D. FCEVs (Fuel cell electric vehicle)

FCEV is a type of EV that uses small battery and fuel cell to generate power. It generate electricity by the compressed hydrogen. FCEV are zero-emission vehicle. The main component of FCEVs are battery, power control unit, fuel cell converter, motor and high pressure hydrogen tanks. Tank storing hydrogen as a fuel and working pressure of tank is high (700 bar). A nickel-metal hydride battery which stores energy to run electric motor. Power control unit controls fuel cell output and drive battery charging. Examples of FCEVs are Toyota Mirai and Hyundai ix35 FCEV.

Need for study

The aim of this paper is to identify factors that may influence the long-term development of electric vehicles and to analyse those aspects using the Fuzzy-DEMATEL method. The voyage

of electric car development to reach sustainability is also discussed in this paper. EVs are today recognised as an innovation in the automotive fleet, a developing sustainable option with significant potential, following the lengthy history of the transportation sector. To fully realise its potential, investigations and research into the development and sustainability of electric vehicles must continue.There are a few key considerations to make in order to fully comprehend the context of this work. It can help us understand the evolution of EV and its technological advancement, advantages over ICEV (Internal Combustion Engine Vehicles), major reasons for shifting ICEV to EV, various factors that can influence EV's sustainable development, multi-criteria decision-making approach, and it will help us understand the needs of EV's sustainable development by balancing our environmental, economic, social, and technological needs.

GHG (greenhouse gases) and particulates are undesired by-products of the burning of fossil fuels for energy conversion to power the vehicle in traditional motor vehicles. The uncontrolled and unanticipated surge in the number of ICE (internal combustion engine) cars in previous decades has sparked substantial concerns about environmental degradation, significant oil reliance, decreasing fossil reserves, rising GHG emissions, and the resulting global warming. [1]. The severity of climate change caused by greenhouse gas and particle emissions has reached an alarming level, as seen by the present air quality index and the temperature increase index, which result in life-threatening pollution, global warming, and glacier melting [2]. The Paris Agreement, signed in December 2015, established aims for 195 countries to combat global warming [3]. The rate of CO2 emissions from the transportation sector is expected to grow by 92 percent by 2020 compared to 1990 [4].The International Energy Agency (IEA) has established future energy mandate criteria to keep global mean temperature rise to 2°C by 2050 [5].To slow the increasing effects of climate change, immediate preventative measures and climate policies are essential. With the transportation industry's significant contribution to the emission of greenhouse gases and particulates into the atmosphere, the transportation sector has been developing at a worldwide level in recent years to respond to environmental issues and energy-security actions [6]. In this context, to respond the climate change, most of the countries are considering the sustainable approach by the adoption of Electric power-based vehicles or electric vehicles (EV). The major objective is to develop alternative fuels and bring clean technical innovation to automobiles, with the goal of lowering GHG emissions while improving vehicle performance. Electrification of the transportation industry is a long-term solution with multiple benefits. EVs have the potential to improve energy security by diversifying energy sources, promote economic growth by generating new progressive businesses, and, most importantly, protect the environment by cutting tailpipe emissions [7]. EVs outperform the ICEVs (Internal Combustion Engine Vehicles) because of the application of more effectual power trains and electric powered motors. Governments all across the globe are taking steps to expand the use of electric vehicles by developing new rules and executing them.Actions made to promote EVs as a

sustainable choice for the vehicle fleet include purchase cost discounts, charging infrastructure development, and public knowledge of the advantages of EVs to dispel misunderstandings about their durability and performance [8]. One of the reasons for their interest in EVs is the uncontrollable rise in fuels costs. Studying such elements has now become an exciting research field for the long-term development of electric vehicles.

Objective of the Work

The Objectives of this paper are as follows:

1. To determine the factors that influencethe sustainable development of EVs. The aim of the study is toidentify the influential factors towards electric vehicles adoption over ICEVs.
2. The Fuzzy-DEMATEL Techniques are used to find the key influential factors and establishing interaction between factors which will indicate the degree of the several factors are impacting one another.
3. To create a decision-making framework that may be used by researchers and policymakers in the process of establishing EV policies that have consequences for future research.

The rest of the papers are structured as follows: Section 2 reviewed the literature on sustainable development. The Fuzzy DEMATEL method has been explained in the Section 3. The results are shown in Section 4. Finally, the conclusions and managerial Implications are drawn in the Section 5.

Literature Review

Given the goal of this research, which is to understand the subject or domain it focuses on, previous studies have been conducted to get an overview of sustainable development, influential factors for the sustainable development of electric vehicles (EVs), and the MCDM (multi-criteria decision making) methodology that has been used for the analysis of the factors which have been selected.

Sustainable Development

Sustainable development aims to minimise the adverse environmental impacts while maximising social and economic benefits [26]. Sustainable product development gives sustainability to entire product life from product planning, material selection, manufacturing to end of life [27]. It is possible to describe sustainable development that satisfies the requirements of the current generation without compromising the capacity of future generations to satisfy their own demands [28]. This is the definition of sustainable development. It has a close relationship with the normative idea of sustainability.

In order for an EV to be considered as a sustainable alternative, it must be feasible to create and/or it should be used in a manner that does not cause damage or destruction to the surrounding environment. EVs can be considered a substitute or an alternative to ICEVs

because there will be more uses of electric vehicles, which will reduce the dependency upon the depletion of fossil fuel resources and it can create a balance in a sustainable manner [30]. Battery that is used in electric vehicles is made from the elements that are available as non-renewable resources, however, the use of non-renewable energy can have the limitations to a certain extent [31].The sustainable development may be realized by recognizing the integration of the three major needs for the sustainable development, they are:

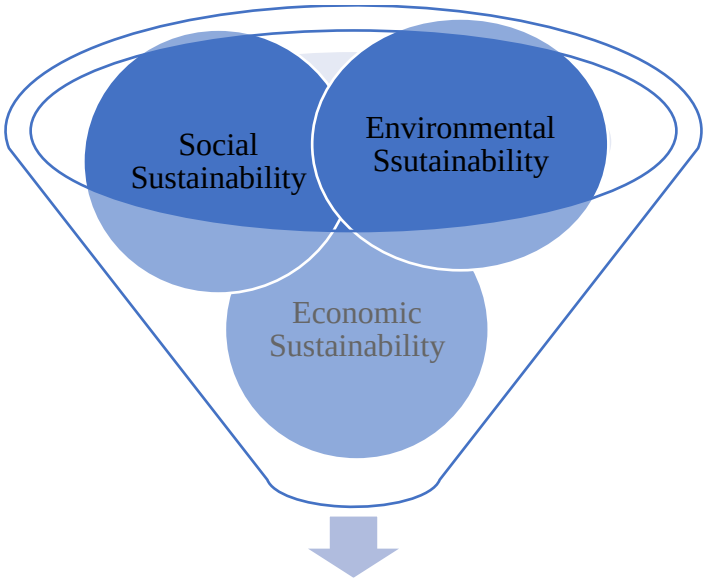

Figure 1 Three pillars of sustainable development

Social Sustainability

For the purpose of achieving social sustainability, the primary emphasis is being placed on social concerns such as health, safety, and dependability, as well as the progression of society toward a knowledge economy and other related topics [32]. Despite this, in the viewpoint of the adoption of new technology for persons, it evaluates an industry's involvement with its employees, customers, suppliers, and the local community, all of which are significant variables to consider for the sustainable development of the sector [33]. As an alternative, electric vehicles (EVs) may, to some degree, meet the requirements of social sustainability.

Environmental Sustainability

Environmental sustainability is to control natural resources and maintain global ecosystems to promote health and welfare in the future.Because the effects of many actions that influence the environment are not performed immediately[34]. Electric cars, which are an alternative that came in the marketto prevent the depletion of fossil fuel reserves that generates tailpipe pollution, are now being considered as an option that is sustainable [35].

Economic Sustainability

The economic sustainability refers to business methods that, in addition to supporting the long-term growth of an organisation or nation's economy, also safeguard its social fabric, cultural traditions, and natural resources [36]. Even though there is a fairly widespread understanding of the types of business practises that contribute to climate change (such as the burning of fossil fuels, the creation of food waste, and the utilisation of harmful manufacturing methods), the goal of economic sustainability is one that very few organisations are able to achieve at this time [37].Electric vehicles (EVs) give economic advantages to the state by lowering the cost of fuel and moving use away from oil that is imported and toward sources of energy that are generated more locally [38]. These savings on fuel generate extra revenue that may be spent wherever the individual chooses, the majority of which will be spent within the local economy, this results in the creation of more employment within the state and when electric vehicles reach a greater market penetration level, the money saved on fuel might result in the creation of thousands of employments as it is an emerging sector [39].

The integration of these three major goals of sustainability is responsible for the sustainable development. On the basis of the literature survey which includes the definitions and aspects of social development, the influential factors for the sustainable development of EVs are selected for the analysis of this study and those factors with the descriptions are listed in the Table 1.

Table 1 List of Factors

Code	Factors	Description	References
FE 1	Emission	It is necessary to find a solution to the problem of substantial environmental harm that may be caused by the emissions that are generated by the transportation based on ICEs (I.C. Engines) and with EVs the tailpipe emission is reduced [40].	[40]
FE 2	Impact on environment	The long-term damage to the environment caused by a series of damaging actions cannot be sustained. There are several ways to quantify the environmental impact of consumer electronics-based technology, also allowing for an evaluation of the EV's sustainability [41],[42].	[41]
FE 3	Cost	Battery costs account for a large portion of the cost of EVs, which is why reducing the cost of the batteries is an important step toward attaining sustainable objectives [44].	[44]

FE 4	Charging infrastructure	Until EVs are scalable, it will be difficult to ensure long-term viability of charging operations as use of EVs grows. EV charging at a large scale requires careful design of the electric distribution system and grid infrastructure to assure power availability at charging stations. The growth of the charging infrastructure will be aided by factors such as power, location, charger type, and technology used [45].	[45]
FE 5	Grid Optimization	By adopting the idea of V2G, grid optimization may be achieved, which is a sustainable method to energy conservation, to put it another way, vehicle to grid allows electric vehicles to return unused battery capacity to the grid, which may then be utilised to supplement intermittent renewable energy sources or to help meet demand during periods of high demand [47].	[47]
FE 6	Vehicle design and performance	Reduced fuel consumption and reduced emissions may both be achieved via the use of lightweight materials and electric drive trains. E-vehicles may benefit from both electric vehicles (EVs) and lightweight design to lessen their environmental effect, which is considered a step forward [48].	[48]
FE 7	Consumer's perspective	The cost of the vehicle and the misconception can affect the EVs therefore, awareness about EVs sustainability is needed [49].	[49]
FE 8	Govt. regulations, policies and schemes	It is the duty of the organisations to fulfil rules of the authorities around the world and govt facilitate application of relevant sustainability ideas by encouraging the companies to adopt sustainability along with their practises [50].	[50]
FE 9	Energy security	In order to maintain the trend of reducing the amount of imported petroleum, continuous use of more energy efficient automobiles like hybrid and plug-in electric vehicles is a practical strategy. Sustainability is another advantage of employing an energy source like electricity for transportation [51].	[51]

FE 10	Driving comfort and safety	In terms of driving comfort, electric vehicles (EVs) are superior than fossil fuel-powered vehicles (ICEVs) in terms of noise reduction, rapid acceleration, and simple handling and in terms of safety the various factors of electric vehicle safety may be taken into account, including: electrical safety, functional safety, battery charging safety, vehicle repair, maintenance, and instruction [52].	[52]
FE 11	Battery Types and technology	As an energy storage system, batteries, are essential for all-electric vehicles, plug-in hybrid electric vehicles (PHEVs), and and hybrid electric vehicles (HEVs). Mainly, Lithium- ion based battery is used to power the vehicles and the solid-state batteries will be adopted which will offer high performance [53].	[53]
FE 12	Battery Swapping and its Longevity	The battery swapping refers to a technique of charging battery-powered EVs that involves switching out the EV's depleted or partly charged batteries with fully charged ones, either manually or mechanically and ecosystem based on the battery swapping which can be sustainable approach [54].	[54]
FE 13	Range Improvements	Range improvement is really a milestone for the EV technology but by adopting the battery swapping policy and with better or smart charging infrastructure range can be improved [55].	[44]
FE 14	Technological Advancement	The new electric cars are safer, have more power, cost less, and are more reliable. EV technology is being worked on by almost every vehicle company in the world, and many other industries are looking for ways to use it in their own products [56].	[56]
FE 15	Maintenance plan	In terms of maintenance EV requires less maintenance as it comes with lesser parts than the ICEV [57].	[57]

These selected factors on the basis of the literature review will be used here for the analysis by applying the methodology discussed in next section.

Methodology

The literature study provides an overview of how alternative approaches to EV sustainability are developed by utilising the elements that have been analyzed. Various methodologies have been utilised in previous research to establish the cause-and-effect link between characteristics or criteria that might impact the long-term development of electric vehicles. This research evaluates the consistency of the strategy by examining the many variables that lead to influencing factors for the long-term growth of electric vehicles. Researchers used the hybrid MCDM (multi criteria decision-making model) to deal with the cause-and-effect linkages of variables by merging the Fuzzy set and DEMATEL (Decision Making Trial and Evaluation Laboratory) to look at a set of quantitative and qualitative analyses of important components.

Fuzzy Dematel Approach

This study led to the analysis using the ambiguous fuzzy DEMATEL, which is the suggested method to identify the factors described in practises in the EVs industry, external drivers and performances that can influence the sustainable development of EV, as well as their factors inter-relationship evaluation. This evaluation will be carried out as a result of this study. This study will explain the alterations and loss of information in human perception by translating linguistic tendencies to a set of fuzzy numbers, which will be made possible thanks to the incorporation of the theory of fuzzy sets. Through application of the fuzzy DEMATEL methodology, the research identifies direct and indirect influences between the elements, as well as the causal link between them and the degree to which they impact one another [58]. The fuzzy DEMATEL MCDM approach does not call for an appropriate quantity of data to be collected [59]. This approach involves gathering information from knowledgeable individuals or experts in the form of questionnaires by having conversations and on the basis of brainstorming about the subject matter under investigation.

The process of making decisions has with it its own weight of significance when it comes to resolving any and all types of issues, all of which call for appropriate answers to issues pertaining to decision making [60]. However, if there is a tough issue that is connected to decision making, the strategy may need to be modified in accordance with the level of complexity of the problem, which may call for the participation of a group of experts and people who make decisions. The evaluation that is provided by experts as well as decision makers on a qualitative topic or problem is consistently conveyed through a linguistic mode of expression in the form of questionnaires from certain specific persons and is defined more by their experience and competence than by hard-and-fast ideals more often than not [61]. The DEMATEL methodology was discovered to be an appropriate method for obtaining the relationships involving interdependencies as well as the degree of interdependence between the factors, while the fuzzy logic concept shows a partial truth by putting numbers between 0 and 1, which constructs a fuzzy set [61]. However, the DEMATEL technique by itself does not

take into account human perceptions, subjectivity, or the haziness of the data that is provided. As a result, it is advised that the DEMATEL approach be used with fuzzy set theory in these kinds of circumstances. The employment of this integrated model, which incorporates fuzzy set theory, that contains fuzzy language concepts, and DEMATEL. When this combined technique is performed, it enables researchers to study the causal links established, and it also helps define the degree of impact between the elements.

The important calculative stages of the fuzzy-DEMATEL model are taken for this research work as shown in various steps below, are basically identical to a significant number of studies [61].

Step A: Create the format for the questionnaire using the fuzzy linguistic terms. The scale of linguistic variables is developed in order to represent the level of impact that is present. The next phase is for specialists to provide their perspectives on the elements that are at their disposal based on the questionnaire. Instead of using an integer scale to determine the degree of direct interaction between the components, language phrases or linguistic terms are used to reflect human subjectivity, perspective, or judgement. This is done rather than finding the degree of direct influence between the factors. Following this, the triangle fuzzy sets are presented, and they are utilised to derive the degree of effect; hence, $\breve{m} = (u, v, w)$is a set of triangular fuzzy numbers in matrix $\ddot{M}$, where u is the least possible value, v is the most possible value, and w is the highest possible value. The Table 2 provides an overview of the linguistic words as well as the influence score together with the fuzzy numbers that correlate to them.

Step B: After collecting feedback from the experts through questionnaire and brainstorming, evaluations are compiled. Using the fuzzy linguistic scale that was developed in step A, the four experts were asked to perform pair wise comparisons in order to obtain the interactive degree of influence between each pair of classified factors. These comparisons were performed with the help of the fuzzy linguistic scale. Following this step, a fuzzy matrix known as ($\ddot{M}^{y}$) is constructed on the basis of evaluation of each expert. In all, there are y fuzzy matrices created, with $y = 1,2 \ldots k$. In this case, there will be 4 experts. In the fuzzy matrix that was obtained, $\breve{m} = (u_{ij}, v_{ij}, w_{ij})$, is a set of triangular fuzzy numbers that indicates the y^{th}expert's fuzzy evaluation regarding the influential degree to which factor i has a direct effect on factor j. These fuzzy evaluations are based on the triangular fuzzy numbers.

Step C: When the equation (1) is applied, the average fuzzy matrix $\ddot{M}'$ is obtained, and this result may be referred to as the fuzzy direct-relation matrix.

$$\ddot{M}' = \frac{\breve{m}_1 + \breve{m}_2 + \cdots + \breve{m}_y}{y} \quad (1)$$

Step D: Then, the normalized direct-relation fuzzy matrix $\widetilde{S}'$ is obtained using equation (2)

$$\widetilde{S}'_{ij} = \frac{\ddot{M}'}{l} = \left(\frac{u_{ij}}{l}, \frac{v_{ij}}{l}, \frac{w_{ij}}{l}\right) \quad (2)$$

Here, $l = max$(sum of the all particular row, sum of the all column values)

Step E: Next, the de fuzzification of normalized direct-relation matrix $\widetilde{S}'$is done by applying equation (3) and obtained matrix $\widetilde{S}''_{ij}$.

$$t'_{ij} = \frac{[(w'_{ij} - u'_{ij}) + (v'_{ij} - u'_{ij})]}{3} + u'_{ij} \quad (3)$$

Where

$$= \frac{u_{ij}}{l},\ v'_{ij} = \frac{v_{ij}}{l},\ w'_{ij} = \frac{w_{ij}}{l}$$

$$\widetilde{S}''_{ij} = \begin{bmatrix} t'_{11} & t'_{12} & \dots & t'_{1n} \\ t'_{21} & t'_{22} & \dots & t'_{2n} \\ \vdots & \vdots & \ddots & t'_{3n} \\ t'_{m1} & t'_{m2} & \dots & t'_{mn} \end{bmatrix}$$

Step F: Following completion of the calculations described above, the total-relation fuzzy matrix $\grave{T}$is generated by the use of the equation (4).

$$\grave{T} = \widetilde{S}''(I - \widetilde{S}'')^{-1} \quad (4)$$

Where

I= Identity Matrix

$$\grave{T} = \begin{bmatrix} t''_{11} & t''_{12} & \dots & t''_{1n} \\ t''_{21} & t''_{22} & \dots & t''_{2n} \\ \vdots & \vdots & \ddots & t''_{3n} \\ t''_{m1} & t''_{m2} & \dots & t''_{mn} \end{bmatrix}$$

Step G: Total the rows and columns of the relation matrix $\grave{T}$. It follows that the direct and indirect effects of component i on other components are equal to the total of r_i , which is the i^{th}row in matrix $\grave{T}$. If the total of the j^{th}column in matrix $\grave{T}$ is c_j, then $c_j$shows the direct and indirect impacts of the other components on factor j^{th}"Prominence" refers to the aggregate of the individual influences that each of the components ($r_i$and c_j) has had.

$$\grave{T} = [t''_{ij}]_{n \times n} \qquad i, j = 1,2, \dots n \quad (5)$$

$$r_i = \sum_{1 \le j \le n}^{n} t''_{ij} \qquad \forall i \quad (6)$$

$$c_j = \sum_{1 \le i \le n}^{n} t''_{ij} \ \forall j \quad (7)$$

Step H: The causal diagram is constructed by first charting the values $(r_i + c_j)$ on the horizontal axis and then plotting the values $(r_i - c_j)$ on the vertical axis.The horizontal axis “Prominence” refers the importance degree of the factor, whereas the vertical axis “Relation”

shows the extent of the influence. The degree to which a factor is important is shown along the horizontal axis, and the extent to which it has an impact is shown along the vertical axis. If the value of the vertical axis $(r_i - c_j)$ is positive, the factor is regarded to be part of the causal group; if the value of the vertical axis is negative, the factor is considered to be part of the effect-group. The ability of causal diagrams to simplify difficult interactions between components into a rational structural model that can be comprehended quickly and easily is one of the reasons they are so valuable in the context of finding solutions to problems.

Table 2 The fuzzy linguistic scale that is used for the ratings of the respondents [61]

Abbreviation	Linguistic terms	Influential score	Corresponding Triangular Fuzzy Numbers
N	No influence	0	(0.0, 0.1, 0.3)
VL	Very low influence	1	(0.1, 0.3, 0.5)
L	Low influence	2	(0.3, 0.5, 0.7)
I	Influence	3	(0.5, 0.7, 0.9)
HI	High influence	4	(0.7, 0.9, 1.0)
VH	Very high influence	5	(0.9, 1.0, 1.0)

To present the assessment in a language way, as human perception is in a linguistic manner, is fairly challenging, thus each linguistic phrase receives an influencing score. The meaning of fuzzy is vague and not précised. The following is an introduction to the implementation of the Fuzzy DEMATEL technique for the purpose of analysing the elements that influence the sustainable development of EVs. The Steps involved in the implementation of the methodology is shown in Fig. 2.

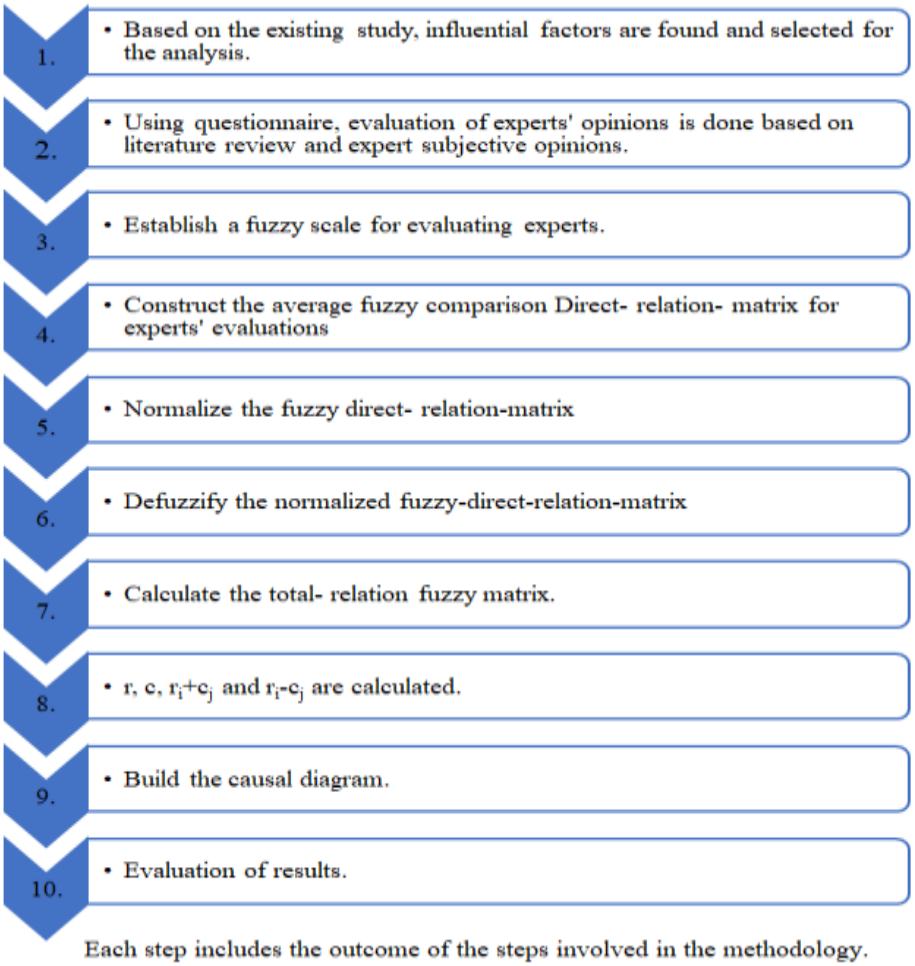

Figure 2 Steps involved in the implementation of the methodology

Step 1: Determine the influential factors: How the sustainable development of electric vehicle can be influenced for this, 15 influential factors related to EVs sustainability were collected and shown in Table 1.

Step 2: The Questionnaire is framed and the four experts were invited.

Step 3: For the evaluation of the factors and their evaluation is done using fuzzy linguistic scale.The input taken from the four experts and shown in the Tables 3 to 6.

Table 3 Expert (1)input

	FE 1	FE 2	FE 3	FE 4	FE 5	FE 6	FE 7	FE 8	FE 9	FE 10	FE 11	FE 12	FE 13	FE 14	FE 15
FE 1	N	VH	H	VL	N	VH	VH	VL	L	H	H	M	M	N	VL
FE 2	N	N	H	M	M	VH	VH	L	N	H	L	VL	VH	VL	N
FE 3	L	VL	N	VH	VH	H	H	H	H	H	H	L	M	L	VL
FE 4	VL	VL	H	N	H	VH	M	VL	L	H	M	H	L	L	N
FE 5	M	M	M	H	N	M	L	H	L	L	H	L	H	M	VL
FE 6	N	N	H	M	L	N	M	H	H	M	L	VH	H	VH	VH
FE 7	VL	VL	VH	H	L	H	N	VL	H	M	L	L	M	N	N
FE 8	L	L	H	M	M	H	L	N	M	M	VL	H	VL	N	H
FE 9	N	N	VL	H	M	M	L	H	N	H	M	VH	M	H	H
FE 10	N	N	M	M	M	VH	M	M	H	N	VL	H	N	VL	M
FE 11	M	M	L	N	N	L	M	N	VL	VL	N	VL	VH	H	N
FE 12	N	N	M	VL	VL	H	H	H	M	M	N	N	N	M	N
FE 13	VH	VH	N	VH	VH	M	L	VL	VL	VL	H	VL	N	VH	N
FE 14	VL	VL	N	M	M	H	N	VL	L	M	M	L	H	N	VL
FE 15	N	N	L	N	VL	H	N	M	VL	L	N	N	N	VL	N

Table 4 Expert (2)input

i▼j►	FE 1	FE 2	FE 3	FE 4	FE 5	FE 6	FE 7	FE 8	FE 9	FE 10	FE 11	FE 12	FE 13	FE 14	FE 15
FE 1	N	H	H	L	VL	H	M	VL	L	H	H	M	M	N	VL
FE 2	VL	N	M	M	M	VH	H	L	N	H	L	L	VH	VL	N
FE 3	VL	VL	N	H	H	H	H	L	M	H	H	L	M	L	N
FE 4	VL	VL	L	N	H	H	M	VL	L	M	M	H	L	L	N
FE 5	L	L	M	H	N	M	L	H	L	L	H	L	VH	M	VL
FE 6	N	N	VH	M	L	N	M	H	H	M	L	M	H	H	VH
FE 7	N	N	VH	L	L	VH	N	VL	VH	M	L	L	M	N	L
FE 8	VL	VL	M	M	M	VH	L	N	M	H	VL	H	VL	N	H
FE 9	N	N	VL	H	M	VH	M	H	N	H	M	VH	M	H	H
FE 10	N	N	M	M	L	VH	M	M	H	N	VL	H	N	VL	M
FE 11	M	M	L	N	N	L	M	N	VL	L	N	VL	VH	H	N
FE 12	N	N	M	VL	L	VH	H	H	M	M	N	N	N	M	N
FE 13	H	VH	N	VH	VH	M	M	VL	VL	VL	H	VL	N	VH	N
FE 14	VL	VL	N	M	M	H	N	VL	L	M	M	L	H	N	VL
FE 15	N	N	L	N	VL	H	N	M	VL	L	N	N	N	L	N

Table 5 Expert (3)input

i▼j►	FE 1	FE 2	FE 3	FE 4	FE 5	FE 6	FE 7	FE 8	FE 9	FE 10	FE 11	FE 12	FE 13	FE 14	FE 15
FE 1	N	VH	H	VL	VL	H	H	VL	L	H	H	H	M	N	VL
FE 2	N	N	VH	M	M	H	M	L	N	H	L	VL	VH	VL	N
FE 3	VL	VL	N	H	VH	M	H	H	M	H	H	L	M	L	VL
FE 4	VL	VL	M	N	H	H	H	VL	L	H	L	H	L	L	N
FE 5	L	M	H	H	N	H	L	H	L	L	H	L	H	M	L
FE 6	N	VL	H	M	L	N	M	H	H	M	VL	VH	H	VH	VH
FE 7	H	H	VH	H	L	M	N	VL	H	M	L	L	M	VL	N
FE 8	L	L	M	M	L	H	L	N	M	M	L	H	VL	N	VH
FE 9	N	N	VL	H	M	M	H	H	N	H	M	VH	M	L	H
FE 10	N	N	M	L	M	VH	M	M	H	N	VL	H	N	VL	M
FE 11	H	H	L	N	N	L	M	N	L	VL	N	VL	VH	H	N
FE 12	N	N	M	VL	VL	H	H	VH	M	M	N	N	N	M	N
FE 13	VH	VH	N	H	H	M	L	VL	VL	VL	H	VL	N	VH	L
FE 14	VL	VL	N	M	M	H	N	VL	L	M	L	L	VH	N	VL
FE 15	N	N	L	N	L	H	N	M	VL	L	N	N	N	VL	N

Table 6 Expert (4)input

i▼j►	FE 1	FE 2	FE 3	FE 4	FE 5	FE 6	FE 7	FE 8	FE 9	FE 10	FE 11	FE 12	FE 13	FE 14	FE 15
FE 1	N	VH	H	VL	VL	VH	VH	VL	L	H	H	M	H	N	L
FE 2	N	N	H	M	M	H	H	L	N	H	L	VL	VH	VL	N
FE 3	L	VL	N	VH	H	H	H	H	H	H	M	L	M	L	VL
FE 4	VL	VL	H	N	H	VH	M	VL	M	H	M	H	L	VL	N
FE 5	L	L	M	H	N	M	L	M	L	L	H	L	H	M	VL
FE 6	N	N	H	L	L	N	M	H	H	M	L	H	H	VH	VH
FE 7	VL	VL	M	M	L	H	N	VL	H	M	L	L	M	N	N
FE 8	L	L	H	L	M	H	L	N	M	M	VL	H	VL	N	VH
FE 9	N	N	VL	H	M	H	L	H	N	H	M	VH	M	H	H
FE 10	N	N	M	M	M	H	L	M	H	N	VL	H	N	L	M
FE 11	L	M	L	N	VL	L	M	N	VL	VL	N	VL	VH	VH	N
FE 12	N	N	L	VL	VL	H	H	H	H	M	N	N	N	M	N
FE 13	H	H	N	VH	VH	M	M	VL	VL	VL	H	L	N	VH	N
FE 14	M	L	N	M	M	H	N	VL	L	M	M	L	H	N	VL
FE 15	N	N	L	N	VL	H	N	M	L	VL	N	N	N	VL	N

Step 4 Constructfuzzy comparison direct-relation- matrix The linguistic term is converted to fuzzy linguistic scale and shown in Tables 7 to 10.

Table 7 Fuzzy comparison direct-relation-matrix 1

i▼j►	FE 1			FE 2			...			FE 15		
FE 1	0	0.1	0.3	0.9	1	1	...	...	...	0.1	0.3	0.5
FE 2	0	0.1	0.3	0	0.1	0.3	...	...	...	0	0.1	0.3
FE 3	0.3	0.5	0.7	0.1	0.3	0.5	...	...	...	0.1	0.3	0.5
FE 4	0.1	0.3	0.5	0.1	0.3	0.5	...	...	...	0	0.1	0.3
FE 5	0.5	0.7	0.9	0.5	0.7	0.9	...	...	...	0.1	0.3	0.5
FE 6	0	0.1	0.3	0	0.1	0.3	...	...	...	0.9	1	1
FE 7	0.1	0.3	0.5	0.1	0.3	0.5	...	...	...	0	0.1	0.3
FE 8	0.3	0.5	0.7	0.3	0.5	0.7	...	...	...	0.7	0.9	1
FE 9	0	0.1	0.3	0	0.1	0.3	...	...	...	0.7	0.9	1
FE 10	0	0.1	0.3	0	0.1	0.3	...	...	...	0.5	0.7	0.9
FE 11	0.5	0.7	0.9	0.3	0.5	0.7	...	...	...	0	0.1	0.3
FE 12	0	0.1	0.3	0	0.1	0.3	...	...	...	0	0.1	0.3
FE 13	0.9	1	1	0.9	1	1	...	...	...	0	0.1	0.3
FE 14	0.1	0.3	0.5	0.1	0.3	0.5	...	...	...	0.1	0.3	0.5
FE 15	0	0.1	0.3	0	0.1	0.3	...	...	...	0	0.1	0.3

Table 8 Fuzzy comparison direct-relation-matrix 2

i▼j►	FE 1			FE 2			...			FE 15		
FE 1	0	0.1	0.3	0.7	0.9	1	...	...	...	0.1	0.3	0.5
FE 2	0.1	0.3	0.5	0	0.1	0.3	...	...	...	0	0.1	0.3
FE 3	0.1	0.3	0.5	0.1	0.3	0.5	...	...	...	0	0.1	0.3
FE 4	0.1	0.3	0.5	0.1	0.3	0.5	...	...	...	0	0.1	0.3
FE 5	0.3	0.5	0.7	0.3	0.5	0.7	...	...	...	0.1	0.3	0.5
FE 6	0	0.1	0.3	0	0.1	0.3	...	...	...	0.9	1	1
FE 7	0	0.1	0.3	0	0.1	0.3	...	...	...	0.3	0.5	0.7
FE 8	0.1	0.3	0.5	1	0.3	0.5	...	...	...	0.7	0.9	1
FE 9	0	0.1	0.3	0	0.1	0.3	...	...	...	0.7	0.9	1
FE 10	0	0.1	0.3	0	0.1	0.3	...	...	...	0.5	0.7	0.9
FE 11	0.5	0.7	0.9	0.5	0.7	0.9	...	...	...	0	0.1	0.3

FE 12	0	0.1	0.3	0	0.1	0.3	...	...	...	0	0.1	0.3
FE 13	0.7	0.9	1	0.9	1	1	...	...	...	0	0.1	0.3
FE 14	0.1	0.3	0.5	0.1	0.3	0.5	...	...	...	0.1	0.3	0.5
FE 15	0	0.1	0.3	0	0.1	0.3	...	...	...	0	0.1	0.3

Table 9 Fuzzy comparison direct-relation-matrix 3

i▼j►	**FE 1**			**FE 2**			**...**			**FE 15**		
FE 1	0	0.1	0.3	0.9	1	1	**...**	**...**	**...**	0.1	0.3	0.5
FE 2	0	0.1	0.3	0	0.1	0.3	**...**	**...**	**...**	0	0.1	0.3
FE 3	0.1	0.3	0.5	0.1	0.3	0.5	**...**	**...**	**...**	0.1	0.3	0.5
FE 4	0.1	0.3	0.5	0.1	0.3	0.5	**...**	**...**	**...**	0	0.1	0.3
FE 5	0.3	0.5	0.7	0.5	0.7	0.9	**...**	**...**	**...**	0.3	0.5	0.7
FE 6	0	0.1	0.3	0.1	0.3	0.5	**...**	**...**	**...**	0.9	1	1
FE 7	0.7	0.9	1	0.7	0.9	1	**...**	**...**	**...**	0	0.1	0.3
FE 8	0.3	0.5	0.7	0.3	0.5	0.7	**...**	**...**	**...**	0.9	1	1
FE 9	0	0.1	0.3	0	0.1	0.3	**...**	**...**	**...**	0.7	0.9	1
FE 10	0	0.1	0.3	0	0.1	0.3	**...**	**...**	**...**	0.5	0.7	0.9
FE 11	0.7	0.1	1	0.7	0.9	1	**...**	**...**	**...**	0	0.1	0.3
FE 12	0	0.1	0.3	0	1	0.3	**...**	**...**	**...**	0	0.1	0.3
FE 13	0.9	1	1	0.9	1	1	**...**	**...**	**...**	0.3	0.5	0.7
FE 14	0.1	0.3	0.5	0.1	0.3	0.5	**...**	**...**	**...**	0.1	0.3	0.5
FE 15	0	0.1	0.3	0	0.1	0.3	**...**	**...**	**...**	0	0.1	0.3

Table 10 Fuzzy comparison direct-relation-matrix 4

i▼j►	FE 1			FE 2			...			FE 15		
FE 1	0	0.1	0.3	0.9	1	1	...	...	...	0.3	0.5	0.7
FE 2	0	0.1	0.3	0	0.1	0.3	...	...	...	0	0.1	0.3
FE 3	0.3	0.5	0.7	0.1	0.3	0.5	...	...	...	0.1	0.3	0.5
FE 4	0.1	0.3	0.5	0.1	0.3	0.5	...	...	...	0	0.1	0.3
FE 5	0.3	0.5	0.7	0.3	0.5	0.7	...	...	...	0.1	0.3	0.5
FE 6	0	0.1	0.3	0	0.1	0.3	...	...	...	0.9	1	1
FE 7	0.1	0.3	0.5	0.1	0.3	0.5	...	...	...	0	0.1	0.3
FE 8	0.3	0.5	0.7	0.3	0.5	0.7	...	...	...	0.9	1	1
FE 9	0	0.1	0.3	0	0.1	0.3	...	...	...	0.7	0.9	1
FE 10	0	0.1	0.3	0	0.1	0.3	...	...	...	0.5	0.7	0.9
FE 11	0.3	0.5	0.7	0.5	0.7	0.9	...	...	...	0	0.1	0.3
FE 12	0	0.1	0.3	0	0.1	0.3	...	...	...	0	0.1	0.3
FE 13	0.7	0.9	1	0.7	0.9	1	...	...	...	0	0.1	0.3
FE 14	0.5	0.7	0.9	0.3	0.5	0.7	...	...	...	0.1	0.3	0.5
FE 15	0	0.1	0.3	0	0.1	0.3	...	...	...	0	0.1	0.3

Step 5.: Obtain normalized fuzzy-direct-relation-matrix and shown in Table 11.

Table 11. Normalized fuzzy-direct-relation-matrix

i▼j►	FE 1			FE 2			...			FE 15		
FE 1	0	0.0034	0.0103	0.0292	0.0335	0.0343	...	...	...	0.0052	0.012	0.0189
FE 2	0.0009	0.0052	0.012	0	0.0034	0.0103	...	...	...	0	0.0034	0.0103
FE 3	0.0069	0.0137	0.0206	0.0034	0.0103	0.0172	...	...	...	0.0026	0.0086	0.0155
FE 4	0.0034	0.0103	0.0172	0.0034	0.0103	0.0172	...	...	...	0	0.0034	0.0103
FE 5	0.012	0.0189	0.0258	0.0137	0.0206	0.0275	...	...	...	0.0052	0.012	0.0189
FE 6	0	0.0034	0.0103	0.0009	0.0052	0.012	...	...	...	0.0309	0.0343	0.0343
FE 7	0.0077	0.0137	0.0197	0.0077	0.0137	0.0197	...	...	...	0.0026	0.0069	0.0137
FE 8	0.0086	0.0155	0.0223	0.0163	0.0155	0.0223	...	...	...	0.0275	0.0326	0.0343
FE 9	0	0.0034	0.0103	0	0.0034	0.0103	...	...	...	0.024	0.0309	0.0343
FE 10	0	0.0034	0.0103	0	0.0034	0.0103	...	...	...	0.0172	0.024	0.0309

FE 11	0.0172	0.0172	0.03	0.0172	0.024	0.03	...	...	...	0	0.0034	0.0103
FE 12	0	0.0034	0.0103	0	0.0112	0.0103	...	...	...	0	0.0034	0.0103
FE 13	0.0275	0.0326	0.0343	0.0292	0.0335	0.0343	...	...	...	0.0026	0.0069	0.0137
FE 14	0.0069	0.0137	0.0206	0.0052	0.012	0.0189	...	...	...	0.0034	0.0103	0.0172
FE 15	0	0.0034	0.0103	0	0.0034	0.0103	...	...	...	0	0.0034	0.0103

Step 6: Defuzzification of the normalized fuzzy-direct-relation-matrix is shown in Table 12.

Table 12: Defuzzified normal fuzzy-direct-relation-matrix

i▼j►	FE 1	FE 2	FE 3	FE 4	FE 5	FE 6	FE 7	FE 8	FE 9	FE 10	FE 11	FE 12	FE 13	FE 14	FE 15
FE 1	0.00458	0.03233	0.029757	0.01202	0.00887	0.03147	0.03004	0.00973	0.01717	0.02976	0.02976	0.02546	0.02546	0.00458	0.01202
FE 2	0.00601	0.00458	0.029185	0.02403	0.02632	0.03147	0.02918	0.0166	0.00458	0.02976	0.01717	0.01202	0.03319	0.0103	0.00458
FE 3	0.01373	0.0103	0.004578	0.03147	0.03147	0.02833	0.02976	0.02604	0.0269	0.02976	0.02833	0.01717	0.02403	0.01717	0.00887
FE 4	0.0103	0.0103	0.025179	0.00458	0.02976	0.03147	0.02546	0.00973	0.01888	0.02833	0.02232	0.02976	0.01717	0.01545	0.00458
FE 5	0.01888	0.0206	0.025465	0.02976	0.00715	0.02546	0.01717	0.02804	0.01717	0.01717	0.02976	0.01717	0.03062	0.02403	0.01202
FE 6	0.00458	0.00601	0.030615	0.02232	0.01717	0.00458	0.02403	0.02947	0.02976	0.02403	0.01545	0.03004	0.02976	0.03233	0.03319
FE 7	0.01373	0.01373	0.030901	0.02518	0.01717	0.02918	0.00458	0.00973	0.03062	0.02403	0.01717	0.01717	0.02403	0.00601	0.00773
FE 8	0.01545	0.01803	0.026896	0.02232	0.02232	0.03062	0.01717	0.00401	0.02403	0.02546	0.01202	0.02976	0.0103	0.00458	0.03147
FE 9	0.00458	0.00458	0.0103	0.02976	0.02403	0.02775	0.02203	0.02947	0.00458	0.02976	0.02403	0.03319	0.02403	0.02661	0.02976
FE 10	0.00458	0.00458	0.024034	0.02232	0.02232	0.03233	0.02232	0.02346	0.02976	0.00458	0.0103	0.02976	0.00458	0.01202	0.02403
FE 11	0.02146	0.02375	0.017167	0.00458	0.00601	0.01717	0.02403	0.00401	0.01202	0.01202	0.00458	0.0103	0.03319	0.03062	0.00458
FE 12	0.00458	0.00715	0.022318	0.0103	0.01202	0.03062	0.02976	0.03033	0.02546	0.02403	0.00458	0.00458	0.00458	0.02403	0.00458
FE 13	0.03147	0.03233	0.004578	0.03233	0.03233	0.02403	0.0206	0.00973	0.0103	0.0103	0.02976	0.01202	0.00458	0.03319	0.00773
FE 14	0.01373	0.01202	0.004578	0.02403	0.02403	0.02976	0.00458	0.00973	0.01717	0.02403	0.02232	0.01717	0.03062	0.00458	0.0103
FE 15	0.00458	0.00458	0.017167	0.00458	0.01202	0.02976	0.00458	0.02346	0.01202	0.01545	0.00458	0.00458	0.00458	0.01202	0.00458

Step 7: Calculate the total- relation fuzzy matrix is shown in Table 13.

Table 13 Total- relation fuzzy matrix

i▼j►	FE 1	FE 2	FE 3	FE 4	FE 5	FE 6	FE 7	FE 8	FE 9	FE 10	FE 11	FE 12	FE 13	FE 14	FE 15
FE 1	0.62688	-0.5005	-0.56819	0.55641	0.07699	-0.0293	0.58171	0.54319	0.27823	-0.35503	-0.4059	-0.4282	-0.2411	-0.2759	-0.3183
FE 2	0.00427	1.01288	-0.04399	-0.2438	-0.1839	-0.2436	-0.1609	-0.1717	-0.1457	0.00282	-0.0231	-0.045	0.02407	-0.0121	-0.0426
FE 3	0.0766	0.08818	1.042077	-0.3065	0.12172	0.07806	-0.3473	-0.4529	-0.463	0.18798	0.18294	0.07685	-0.101	-0.1776	-0.2872
FE 4	0.14117	0.18104	0.063043	0.84296	0.27892	0.12565	-0.3571	-0.468	-0.5327	-0.16794	-0.3246	-0.4447	0.21155	0.09812	-0.1316
FE 5	-0.1488	-0.1916	-0.20149	0.09145	0.681	-0.2673	0.41486	0.46511	0.39391	-0.00428	0.02422	-0.0263	-0.4669	-0.5473	-0.4995
FE 6	-0.1971	-0.2964	-0.33217	-0.0428	-0.3912	0.58915	0.38964	0.28386	0.07562	-0.12035	-0.1427	-0.1173	0.03579	0.05341	0.05155

FE 7	-0.1658	-0.2463	-0.28442	-0.0257	-0.3199	-0.3512	1.35744	0.23559	0.02263	-0.21429	-0.2361	-0.2259	0.09813	0.11562	0.09869
FE 8	0.07627	0.09632	-0.08768	0.60894	0.15301	-0.0536	-0.3571	0.51004	-0.5845	-0.19004	-0.3714	-0.5184	0.14941	-0.0128	-0.2638
FE 9	-0.0438	-0.0969	-0.05471	-0.3034	-0.1202	-0.066	-0.3412	-0.2483	0.87219	0.19597	0.24048	0.22055	-0.0758	-0.0457	0.03995
FE 10	-0.1492	-0.2171	-0.18663	-0.1848	-0.2971	-0.2477	-0.0121	0.06144	0.1547	1.00279	0.03909	0.10652	-0.0407	0.01555	0.08722
FE 11	0.07984	0.08348	0.038977	0.24993	0.09516	0.07817	0.24957	0.21505	0.06151	-0.34797	0.57544	-0.4531	-0.355	-0.4666	-0.5045
FE 12	-0.0868	-0.1169	-0.09112	-0.1506	-0.1545	-0.1285	-0.0765	-0.0351	0.04873	-0.1851	-0.1477	0.8894	0.08399	0.13997	0.18152
FE 13	0.47904	0.34103	-0.10749	0.50114	0.72125	0.15964	-0.0949	-0.455	-0.8992	0.05669	-0.275	-0.7602	0.6519	-0.8412	-1.3943
FE 14	0.01266	0.0569	0.083224	-0.3202	0.04222	0.0807	-0.2955	-0.3436	-0.289	0.0647	0.11735	0.17345	-0.1342	0.87618	-0.0604
FE 15	-0.1184	-0.0989	0.023487	-0.2035	-0.1735	-0.0396	-0.1364	-0.0142	0.15566	-0.13447	-0.1102	0.01133	0.00365	0.15443	1.29447

Step 8: r_i,c_j,r_i+c_j and $r_i-c_j$are calculated and shown in Table 14.

The influence degree, affected degree, centrality and cause degree for each factor is also shown in Table 14.

Table 14 The influence degree, affected degree, centrality and cause degree for each factor

Code	Factors	r_i	c_j	$r_i + c_j$	$r_i - c_j$	Category
FE 1	Emission	-0.459	0.5868	0.1278 (4)	-1.046 (13)	Net effect
FE 2	Impacton environment	-0.272	0.0952	-0.177 (6)	-0.368 (9)	Net effect
FE 3	Organizational Initiative	-0.281	-0.707	-0.988 (11)	0.426 (6)	Net cause
FE 4	Charging infrastructure	-0.484	1.0696	0.5854 (2)	-1.554(14)	Net effect
FE 5	Grid Optimization	-0.283	0.53	0.2471 (3)	-0.813 (10)	Net effect
FE 6	Vehicle design and performance	-0.161	-0.315	-0.476 (7)	0.1544 (8)	Net cause
FE 7	Consumer's perspective	-0.142	0.8143	0.6728 (1)	-0.956 (11)	Net effect
FE 8	Govt. regulations, policies and schemes	-0.845	0.1254	-0.72 (9)	-0.971 (12)	Net effect
FE 9	Energy security	0.1732	-0.851	-0.678(8)	1.0241 (3)	Net cause
FE 10	Driving comfort and Safety	0.1319	-0.209	-0.077(5)	0.3404 (7)	Net cause
FE 11	Battery Technology	-0.400	-0.857	-1.257 (13)	0.4572 (5)	Net cause
FE 12	Battery Swapping and its Longevity	0.1708	-1.541	-1.37 (14)	1.7119 (2)	Net cause
FE 13	Range Improvements	-1.917	-0.156	-2.073 (15)	-1.76 (15)	Net effect
FE 14	Technological Advancement	0.0645	-0.926	-0.861 (10)	0.9903 (4)	Net cause
FE 15	Maintenance plan	0.6139	-1.749	-1.135 (12)	2.3626 (1)	Net cause

Step 9.: Build the causal diagram

The Causal Diagram is shown in Fig. 3.

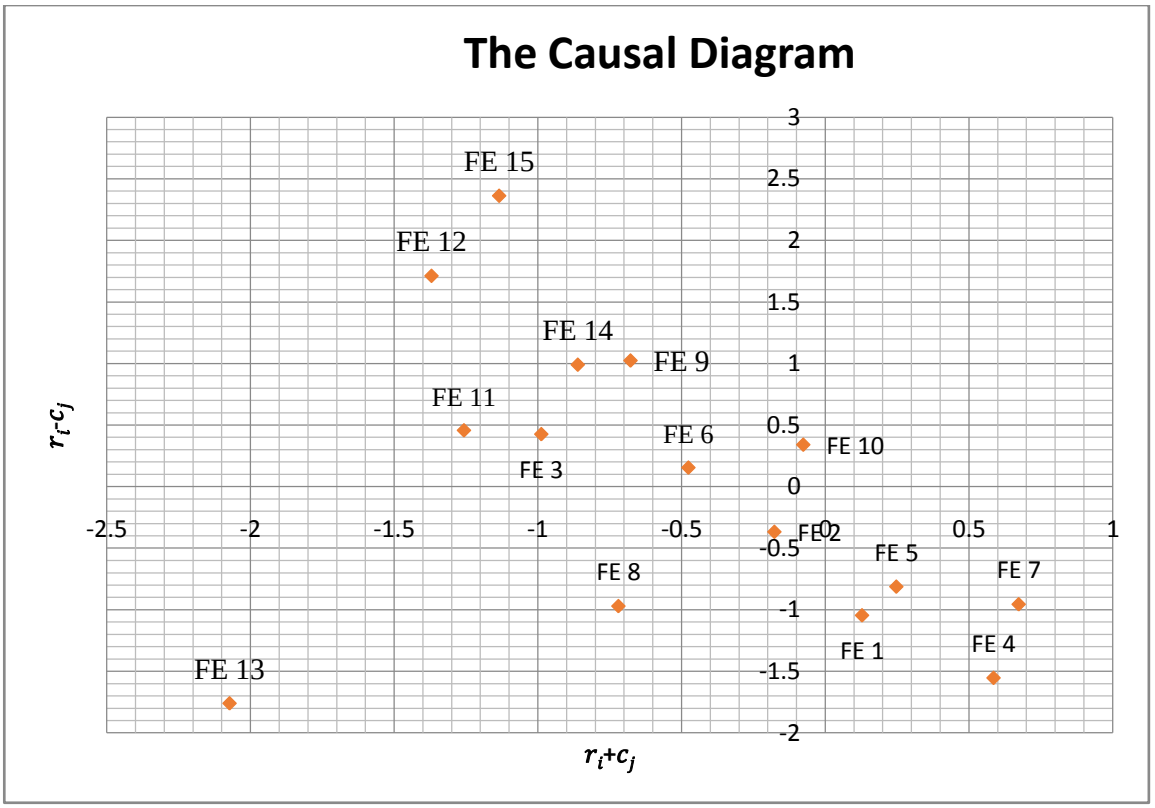

Fig 3. The causal diagram

1. Results and Discussions

sThis research utilized the theoretical model to find the influential factors that are used to influence customer's intention to buy electric vehicles. This study included 15 influential factors for the sustainable development of electric vehicles. The integration of Fuzzy logic and DEMATEL methodologies is applied to determine the cause-and-effect connection among the many aspects that contribute to sustainable development. In order to exclude impacts that were not very noteworthy, a threshold value of -0.018175783 was chosen as the threshold by taking average of the total-relation matrix can be used to decide the interrelationship. The integration of fuzzy logic with DEMATEL methodology has resulted in considerable contributions toward identifying the most important aspects of a situation. The following is an order of priority for the factors, determined by the values of r i+c j: FE 7> FE 4> FE5> FE 1> FE 10>FE 2> FE 6> FE 9> FE 8>FE 14> FE 3> FE15>FE 11>FE12>FE 13. According to this ranking, (F7) is the most important factor for the sustainable development of EVs, similarly, FE 4 and rest of the factors are prioritized accordingly.From this research,it is clear that consumer perspectives and charging infrastructure are the most important influential factors for the

development of EVs. These factors have different degrees of influence on thedevelopment ofelectric vehicles. The influential factors Grid optimization and emission are also key important factors that influenceconsumer perception towards electric vehicles adoption. The result can be used by manufactures of the automobile industry that dealing with electric vehicle and sustainability. This study could help automobile industry to develop EVs to overcome currently existing barrier. This result will help to understand the future implications of this work.

2. Conclusions and Managerial Implications

Theimportant contribution of this research is that it has created a theoretical model regarding influential factors towards electric vehicle adoption by consumers.On the basis of the study it can be concluded that the analysis of influential factors which were selected, it has own impact on the sustainable development of the EV and its industry. This paper has aimed to prioritize the orderof influential factors for the sustainable development of electric vehicles using the Fuzzy DEMATEL MCDM technique.The conclusion of this paper is to create a decision-making framework that can be used by policymakers and researchers for establishing new EV policies forfuture research areas. According to the result, the consumer's perspective and charging infrastructure are the most powerful influential factors in India to prompt their motive to purchase EVs.Energy experts may concentrate on one or more essential aspects like Grid Optimization influential factor to affect the long-term development of electric vehicles as a result,electric vehicles utilize electricity as their primary source of power.This study hasanalysed the total 15 influential factors for the sustainable development of EVs. Most of the researchers previously had taken the consumer's perspectiveas an influential factor for research but this study also focussed on improving government regulation policy for future research.

The limitation of this research did not consider social or economic conditions, therefore future studies canfocuson customers with different earnings and from different region. A total of 15 influential factors have been considered in this study, in future more than 15 factors can be considered for the study. Also, in The present study data is taken in the fuzzy form, in future grey based data can be utilised for the analysis.

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Society 5.0: The Way Forward

Vernika Agarwal[1] and Snigdha Malhotra[2*]

Abstract

The foundation of Society 5.0 is the recent improvement in technology around the world to link more people and things for knowledge sharing. The advent of Society 5.0 has resulted in a significant societal shift in the direction of achieving a responsible, human-centred society. The adoption by emerging economies is necessary but slow. There is a very less scholarly investigation in Society 5.0. The study focuses on investigating the elements that influence the implementation of Society 5.0 and evaluating how these factors are prioritized in the emerging economy context. An extensive literature search was done to identify the challenges ahead of emerging economies. Structured interviews with industry experts and policymakers helped us to validate these challenges and reach to final 18 challenges for further evaluation. Interpretive Structure Modelling was used to prioritize these challenges in order to determine the most important ones to be utilized by economies and policymakers.

Keywords*: Emerging Economy, Interpretive structure Modelling, MICMAC, Society 5.0, Technology*

Introduction

The way we live, act, and interact with one another is currently changing dramatically due to technological advancements. The extent, scale, and complexity of this transformation are unprecedented in human history.It will amplify theindustrial competitiveness to establish a society more attuned to individual needs (Bartoloni et al. 2022). The concept of society 5.0, which aspires to integrate the human-centric approach in the business environment to deliver both economic development and solutions to social problems concurrently, best captures this shift (Potočan et al. 2020). The overflowing of the data in the present scenario and the paradigm shift towards sustainability is another major issue which is pressing the need for society 5.0.

The nation's current industrial, economic, and social infrastructure is under pressure from an abundance of data to store, identification of relevant and real data to analyse, limited scope of action due to physical capability, and a lack of laws and policies, which prevents them from taking adequate measures to resolve any critical issues in a timely manner. Life expectancy, economic development, international competition, and social and regional injustices are all on the rise along with globalisation. Green energy, climate control, and social innovation are crucial in all sectors of the economy. In order to address societal challenges like declining birth rates, an ageing population, and environmental and energy concerns, society 5.0 must be implemented. The emphasis is on the fourth industrial revolution's new technology and its huge possibilities for collecting data (Ciasullo et al. 2022). People, things, and systems are all connected to catalyse the development of Society 5.0, combining cyberspace and physical space, by collecting big data from several sources via sensors and devices.

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Numerous elements that affect the adoption of society 5.0 in the world economies are covered in the literature. Inadequate information technology infrastructure, cultural disparities among participating organisations, a lack of clear policies, a lack of knowledge management systems, and a lack of trust between actors are some of the main problems mentioned in the literature as obstacles to the emergence of Society 5.0.In order to achieve sustainability in all aspects of their functioning, supply chains are supported as part of the transition to society 5.0 (Gladden, 2019). The advancement of society 5.0 is influenced by current sustainable supply chain practises such an effective code of ethics, sustainable human resources, customer relationship management, environmental preservation, sustainable supply chains, and quality management. Although the literature has stressed the idea of society 5.0 and its connection to sustainability, it is lacking in understanding of the factors affecting its implementation.

The digital architecture supports the assimilation of information on a horizontal dimension covering various sectors such as agriculture, energy, transportation, health infrastructure, and so on as well as a vertical dimension covering individual attributes such as medical history, educational background, consumption patterns, and so forth in order to enable the interaction of physical and cyberspace.The encouragement of job mobility is another aspect of smart growth that helps to create a culture where different and flexible work styles are accepted and where everyone can actively participate in the advancement of society. In Society 5.0, the new value produced by social innovation crosses language, age, gender, and geographic barriers to enable the personalization of goods and services to satisfy a wide range of customer needs.It exhibits the capacity to address a broad range of issues in sectors including manufacturing, energy, disaster management, agriculture, food, healthcare, and many more. Anxiety among academics and partitioners has been raised by the implementation of society 5.0 in international marketplaces.

Despite the tremendous benefits of society 5.0, its relevance in an emerging economy like India is still questionable. A lack of an appropriate information technology infrastructure, cultural differences between the organisations involved, a lack of clear policies, a lack of knowledge management systems, and a lack of trust between actors are among the main problems mentioned in the literature that hinder the emergence of Society 5.0.More collaboration between policymakers and technology providers is required than what is currently taking place. A bottom-up strategy with citizen-oriented technologies and a problem-solving mindset must eventually replace the top-down method or government initiative if Society 5.0 is to succeed. The adoption of society 5.0 in a rising country like India is challenging because of socioeconomic limitations, although the literature hasn't addressed this problem. The study makes a number of contributions, including:

- Identification of the impediments affecting society 5.0 implementation.
- Categorization of the impediments for society 5.0 based on their influential and reliance power.
- Construction of hierarchical diagraph to understand the relationship between the impediments.

To achieve the objective the paper uses qualitative data through interviews conducted within the Indian manufacturing sector.

The following sections make up the paper: In the style of a case study, sections 2 and 3 cover the research methodology and research process, including semi-structured interviews and the ISM approach. Section 4 elaborates on the data analysis and outcomes, followed by Section 5's conclusion and future scope.

Case Study

The research takes a four-step strategy. The study began with:

- a literature analysis to identify the issues faced by economies for implementing Society 5.0,
- choosing appropriate stakeholders and conducting interviews to demonstrate how the difficulties are interconnected.
- Building the ISM Model and analysing the interconnectedness and motivation behind each difficulty are steps in the process.

The research flow for this project is shown in Figure 1. A thorough literature review helped in the first step's creation of a list of 19 challenges. The second step involved finding subject-matter experts and conducting one-on-one semi-structured interviews with them. Thanks to the interviews, we were able to confirm the issues raised in the literature and illustrate how they interacted with one another. In the third step, a challenge hierarchy structure was created using ISM. The fourth step, Matriced' impactscroisés multiplication appliquée á un classement (MICMAC) Analysis, revealed driving concerns, reliance challenges, autonomous obstacles, and connection challenges.

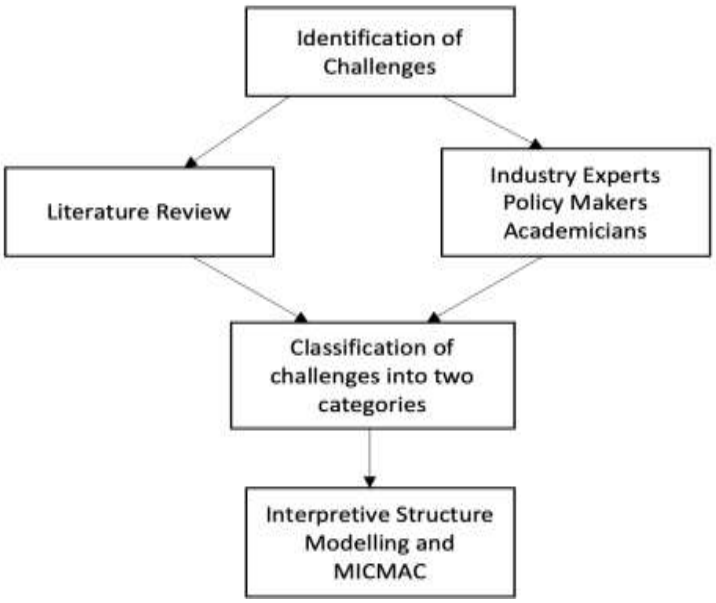

Figure 1 Research Process

The steps of development of ISM for this study, are as follow:

Identifying the Societal Challenges 5.0 Implementation Issues that Economies Adopting: A Literature Review

The research began by identifying potential barriers to Society 5.0 implementation in emerging economies. Twenty-one difficulties were identified thanks to the papers used in the study. The difficulties were initially divided into two categories using the Delphi technique: (a) technological challenges and (b) organisational challenges. The Delphi technique for group issue-solving ensured feedback from experts and academics. Furthermore, the literature evaluation assisted in identifying eleven technological and organisational difficulties, which served as the foundation for subsequent research. The difficulties discovered using study technique 1 are listed in Table 1.

Table 1 List of challenges

Technical & Organisational Challenges	Inadequate technology interactions and misconnections (TO1)	Nair et al. 2021
	Redesigning present technologies (TO2)	Kholili (2021)
	Insufficient AI applications (TO3)	Kholili (2021)
	Lack of integrating disruptive technologies (TO4)	own
	Problem of Data Management and security (TO5)	Fukuda (2020)
	Creating change enabling work culture (TO6)	Roblek et al. 2020
	Link between various departments (TO7)	Nair et al. 2021
	Widening skill gap (TO8)	Agarwal et al. 2021
	Employee Resistance (TO9)	Paschek (2020)
	Honing and encouraging new talent (TO10)	Kholili (2021)
	Training (TO11)	Agarwal et al. 2021
Innovation Challenges	Lack of Innovation Policy by government (IO1)	Nair et al. 2021
	Insufficient funds and grants (IO2)	Wahyuningtyas et al. 2022
	Lack of IT Infrastructure (IO3)	Nair et al. 2021
	Problem of energy consumption (IO4)	Kholili (2021)
	Lack of Entrepreneurial policies (IO5)	Roblek et al. 2020
	Digital Capabilities and Digital Orientation (IO6)	Paschek (2020)
	Digital Innovation Culture (IO7)	Roblek et al. 2020

Identification of Key Stakeholders for a Semi-Structured Interview Describing Interdependencies

Semi-structured one-on-one interviews were conducted as the study's second method of sampling participants. Based on previously relevant literature, the interview approach was adopted by the study's researchers. We made an interview guide and used it. The interview guide included open-ended questions regarding the challenges of putting Society 5.0 into practise.

Ten academics and professionals were approached and informed of the aim of the study. Five specialists were given permission to take part in the study. The experts have prior knowledge of Society 5.0 planning, either directly or indirectly. The range of work experience was more than

five years to more than twenty years. Information on the participants is listed in Table 2. With the participant's permission, all interviews were conducted using Zoom and audio recorded before being transcribed. The length of each interview was often around 30 minutes. The reach ability matrix was able to capture the context of the challenges thanks in part to the interview approach. We were able to model the interrelationship and understand why it existed thanks to the expert's point of view. All expert viewpoints were taken into account.

Table 2 Details of Interviewees

Interviewer	Designation	Work Experience
1	Member, NITI Ayog	30 years
2	National In charge	25 years
3	Head, Advance Intelligence Computing	17 years
4	Transit and Smart City Initiative	10 years
5	Software Engineer	12 years

Developing the ISM Model

ISM methodology, transitivity and reach ability are two key principles. If a factor I identifies with a factor 'j' and the factor 'j' identifies with factor 'k', then the factor I identifies with factor 'k'. As a result, it will be easier to match the data's consistency level. The ISM approach is based on the principle of reach ability. A binary matrix is used to identify pair-wise interrelations.

If a factor I influences another factor 'j,' then '1' is allocated in cell I j) of the reach ability framework, and if that factor I does not aid 'j,' then '0' is allocated in cell I j) of the reach ability grid. The attribute of transitivity also allows for inference to fill a portion of the reach ability grid's cells. Because I j) = 1 and (j, k) = 1 in terms of matrix entries, I k) = 1. The next sub-sections go through the next steps in the development of the ISM model.

Structural Self-Interaction Matrix

ISM procedure recommends the utilisation of the expert assessments to understand the logical connections between the factors are created. Considering the relationships between the factors, the association and direction of the entries are questioned using the four symbol approach of:

V factor *'i'* will help factor *'j'.*

A factor *'j'* will help factor *'i'.*

X factor *'i'* and *'j'* will help each other.

O factor *'i'* and *'j'* are unrelated.

Based on the contextual relationships, the structural self-interaction matrix (SSIM) is developed for the identified variables.

Reach Ability Matrix

By replacing V, A, X, and O by '1' and '0', the SSIM is transformed into a paired network known as the initial reach ability grid. The final reach ability is made by integrating the transitivity in the matrix. We can also obtain the influencing and reliance force for each factor by counting the '1' in each row and column. The entire number of other difficulties influenced by a challenge is known as its influencing power, while the total number of other challenges affecting it is known as its dependence power. MICMAC makes it possible to find indirect linkages and loops between difficulties. The following four categories define the classification of all difficulties, according to MICMAC:

- **Dependent Challenges**
  These issues have a lot of reliance power but not a lot of driving force. Linkage issues have a deliberate impact on dependent and driving challenges, but their impact on other variables is minimal. As a result, if we address the driving and linkage issues, the dependant issue will be handled as well.

- **Autonomous Challenges**
  These challenges have a low level of reliance and motivation. These are the difficulties that are neither easily affected by others nor easily affected by other challenges.

- **Linkage Challenges**
  These challenges have a lot of reliance and driving force. They are quite sensitive. Action on these issues will, in turn, have an impact on other issues and aspects in one way or another.

- **Driving challenges**
  These difficulties have a low reliance power but a high driving power. They have a great deal of power over other factors. As a result, they are more important, and governments must pay more attention to them.

Level Partitions

The reach ability and antecedent set for each of the factors are provided in the final reach ability matrix. The variable in question as well as a number of other factors that it might assist with make up the reach ability set for that particular variable. The antecedent set consists of the variable itself and any additional conditions that might help in obtaining it. This implies that for all the items the intersection of these sets. Since it would not aid in obtaining any other factor above their level, the top-level factor in the ISM pecking order is the variable for which the reach ability and intersection sets are equal. The top-level component is then eliminated from the list of remaining variables after being found. In this way, it would be situated at the top of the ISM chain of command. Up until the level of each of the components is established,

this emphasis is repeated. The final ISM model and the digraph are built using the levels that have been discovered.

Formation of ISM-based Model

The final reach ability matrix is used to create the structural model.

Building the Reach Ability Matrix

During the scheduled interview rounds, the professionals were encouraged to recognise the connections between difficulties. Experts have diverse perspectives on the relationship between various difficulties based on their experiences. In this case, interview findings are returned with a request to reconsider their response.

According to Hasan et al. (2019), interrelationships between every two challenges are divided into the following categories:

- We put the (x,y) and (y,x) entries in the Reach ability Matrix as 1 and 0 accordingly when Challenge x has a direct influence on Challenge y whereas Challenge y has no direct influence on Challenge x.
- When the challenge x has no impact on the challenge y but the challenge y has a direct impact on the challenge x, we put 0 and 1 in the (x,y) and (y,x) entries in the Reachability Matrix, respectively.
- When the challenges x and y are unconnected and a change in one does not affect the other, the (x,y) and (y,x) values in the Reach ability Matrix are both stated as 0.
- We put 1 in both the (x,y) and (y,x) entries in the Reach ability Matrix when the challenge x has a direct influence on the challenge y and vice versa.

The hierarchical relationships between 11 technical and organisational issues and 7innovation challenges are constructed in a Reach ability Matrix using the hybrid method of ISM and MICMAC. Tables 3 and 4 provide the reach ability matrix for technological and organisational difficulties, respectively.

Table 3 The Reach ability Matrix (R1) between the technical and organisational challenges

	TO11	TO10	TO9	TO8	TO7	TO6	TO5	TO4	TO3	TO2	TO1
TO1	O	O	A	X	V	V	O	X	V	V	X
TO2	V	O	A	X	V	V	V	A	V	X	
TO3	V	A	A	V	V	V	V	A	X		
TO4	O	A	A	X	A	V	A	X			
TO5	O	O	O	V	V	V	X				
TO6	A	A	A	A	A	X					
TO7	A	A	A	X	X						
TO8	A	A	A	X							
TO9	V	V	X								
TO10	V	X									

TO11	X										

Table 4 The Reach ability Matrix (R2) between the Innovation Challenges

	IO7	**IO6**	**IO5**	**IO4**	**IO3**	**IO2**	**IO1**
IO1	V	V	V	V	V	V	X
IO2	O	A	A	A	X	X	
IO3	O	A	A	A	X		
IO4	A	O	V	X			
IO5	O	X	X				
IO6	O	X					
IO7	X						

Transitivity Links and Final Reach Ability Matrix

The presence of contextual interconnections in the first reach ability matrix hinted at direct connections. On the other hand, proper transitivity checks may reveal a lot of indirect linkages. The transitivity links are discovered using the following rule: if "X influences Y" and "Y impacts Z," then "X influences Z."Each recognised transitive relationship is updated and stored in the interpretive knowledge base as a 'transitive link.' The links between the parts are also noted. The expert team considers the transitive ties with a meaningful interpretation for future inquiry, while insignificant relationships are removed. The final reach ability matrix is a matrix with direct relationships and transitive links that are effective. The Transitivity Matrix shows the relationship between technical and organisational challenges and socio economic challenges in Table 5 and 6.

Table 5 Transitivity Matrix (T1) between the Technical and Organisational Challenges

	TO1	**TO2**	**TO3**	**TO4**	**TO5**	**TO6**	**TO7**	**TO8**	**TO9**	**TO10**	**TO11**
TO1	1	1	1	1	1*	1	1	1	0	0	0
TO2	0	1	1	1*	1	1	1	1	0	0	1
TO3	1*	1*	1	1*	1	1	1	1	0	0	1
TO4	1	1	1	1	1*	1	1*	1	0	0	1*
TO5	1*	1*	1*	1	1	1	1	1	0	0	0
TO6	0	0	0	0	0	1	0	0	0	0	0
TO7	1*	1*	1*	1	0	1	1	1	0	0	0
TO8	1	1	1*	1	1*	1	1	1	0	0	0
TO9	1*	1	1	1	1*	1	1	1	1	1	1
TO10	1*	1*	1	1	1*	1	1	1	0	1	1
TO11	1*	1*	0	1*	0	1	1	1	0	0	1

Table 6 Transitivity Matrix (T2) between the Innovation Challenges

	IO1	**IO2**	**IO3**	**IO4**	**IO5**	**IO6**	**IO7**
IO1	1	1	1	1	1	1	1
IO2	0	1	1	0	0	0	0

IO3	0	1	1	0	0	0	0
IO4	0	1	1	1	1*	1*	0
IO5	0	1	1	1*	1	1	0
IO6	0	1	1	1	1	1	0
IO7	0	1*	1*	1	1*	1*	1

Obtaining the Hierarchical Structure of Challenges

The reach ability matrix's purpose is to determine the reach ability set, antecedent set, and intersection set. By comparing each challenge at reach ability set and an intersection set, several hierarchical levels are created. Technical and organisational challenge TO6 (Creating change enabling work culture) is found at Level I, while Innovation challengeIO2 (Insufficient funds and grants), and IO3(Lack of IT Infrastructure) is found at the level I. Technical and organisational challenge TO7 (Link between various departments), and technical and organisational challenge 8(Widening skill gap)are found in Level II. Innovationchallenge4 (Problem of energy consumption), challenge 5 (Lack of Entrepreneurial policies), and challenge 6 are all found in Level II. (Digital Capabilities and Digital Orientation). Tables 7 and 8 show the remaining levels based on this method.

Table 7 Level Partitioning the Technical and Organisational challenges

Challenges	Reach ability	Antecedent sets	Intersection set	Level
TO1	1,2,3,4,5,6,7,8	1,3,4,5,7,8,9,10,11	1,3,4,5,7,8	III
TO2	1,2,3,4,5,6,7,8,11	1,2,3,4,5,7,8,9,10,11	1,2,3,4,5,7,8,11	II
TO3	1,2,3,4,5,6,7,8,11	1,2,3,4,5,7,8,9,10	1,2,3,4,5,7,8,9	V
TO4	1,2,3,4,5,6,7,8,11	1,2,3,4,5,7,8,9,10,11	1,2,3,4,5,7,8,11	II
TO5	1,2,3,4,5,6,7,8	1,2,3,4,5,6,7,9, 10	1,2,3,4,5,6,7	III
TO6	6	1,2,3,4,5,6,7,8,9, 10,11	6	I
TO7	1,2,3,4,6,7,8	1,2,3,4,5,7,8,9,10,11	1,2,3,4,7,8	II
TO8	1,2,3,4,5,6,7,8	1,2,3,4,5,7,8,9,10,11	1,2,3,4,5,7,8	II
TO9	1,2,3,4,5,6,7,8,9,10,11	9	9	VII
TO10	1,2,3,4,5,6,7,8,10,11	9,10	10	VI
TO11	1,2,4,6,7,8,11	2,3,4,9,10,11	2,4,11	IV

Table 8 Level Partitioning Innovation Challenges

Challenges	Reach ability	Antecedent sets	Intersection set	Level
IO1	1,2,3,4,5,6,7	1	1	IV
IO2	2,3,	1,2,3,4,5,6,7	2,3	I
IO3	2.3	1,2,3,4,5,6,7	2,3	I
IO4	2,3,4,5,6,	1,4,5,6,7	4,5,6	II
IO5	2,3,4,5,6,7	1,4,5,6,7	4,5,6	II
IO6	2,3,4,5,6	1,4,5,6,7	4,5,6	II

IO7	2,3,4,5,6,7,	1,7	7	III

Among the technical and organisational challenges, a six-level hierarchical structure based on the ISM technique is achieved. Figure 2 shows the model that was created. The ISM model organises the difficulties into a hierarchy and determines the impact of each challenge of Society 5.0 implementation.

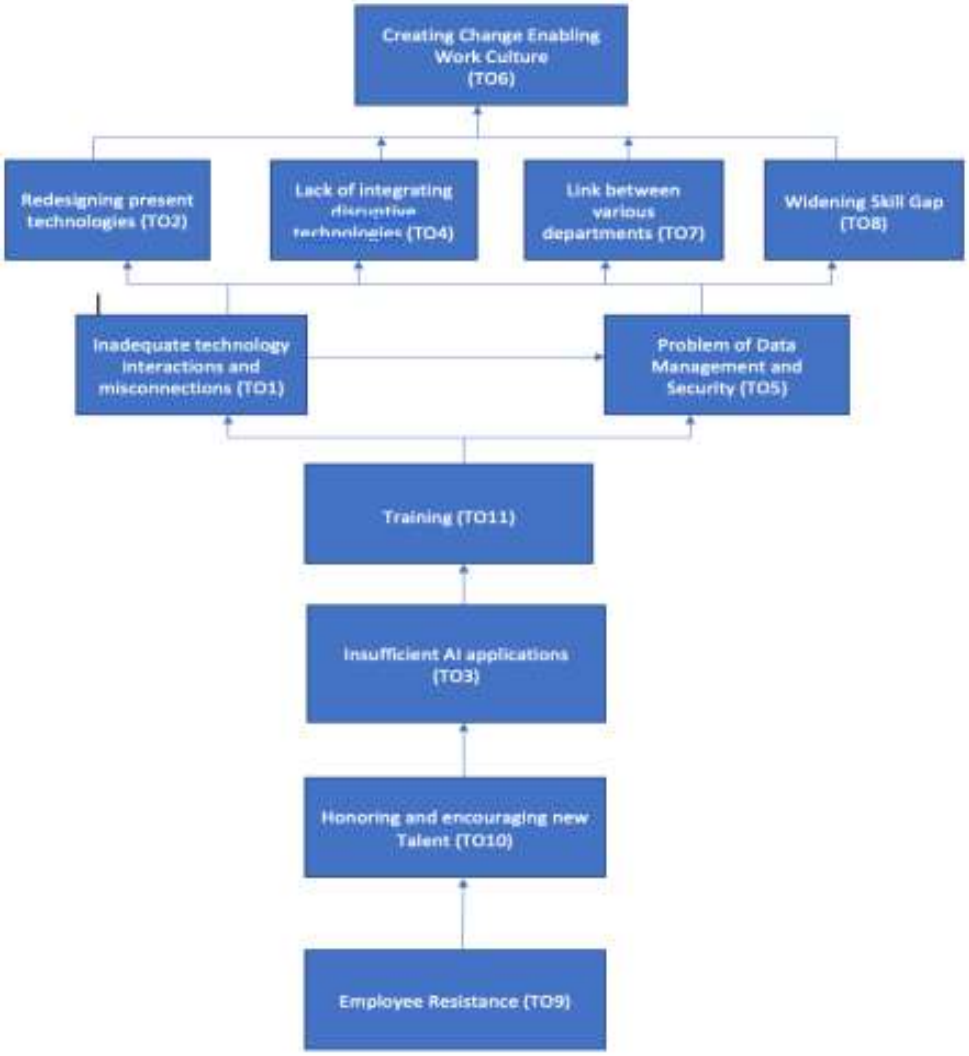

Figure 2 ISM based hierarchical model of Technical and Organisational Challenges

The analysis found that the most critical technological difficulty is 'building change enabling work culture (TO6),' as depicted in Figure 2. The second most critical concern is 'Link between multiple departments (T02),' 'Widening skill gap (TO3),' and 'Lack of integrating disruptive technology (TO4). 'The model also identifies issues at level 3 such as 'Inadequate technological interactions and misconnections (TO1),' 'Redesigning current technologies (TO2),' and 'Data Management and Security Problem (TO5).' The 'Training (TO11)' task is placed at level 4. The 'Insufficient AI application (TO3)' challenge is placed at level 5. These model-centred

difficulties serve as a link in the hierarchy structure, implying that they will influence issues at lower levels and may be affected by challenges at higher levels. Meanwhile, level 1 comprises one problem, 'Honouring and promoting fresh talent (TC10),' which places it at the top of the ISM model, implying that it has a lower influence on other society 5.0 implementation challenges and is more likely to be affected by them.

Among the socioeconomic problems, a five-level hierarchical structure based on the ISM approach has been achieved. Figure 3 depicts the model that was created. The ISM model organises the difficulties into a hierarchy, determining the impact of each challenge for the economy's implementation of Society 5.0.

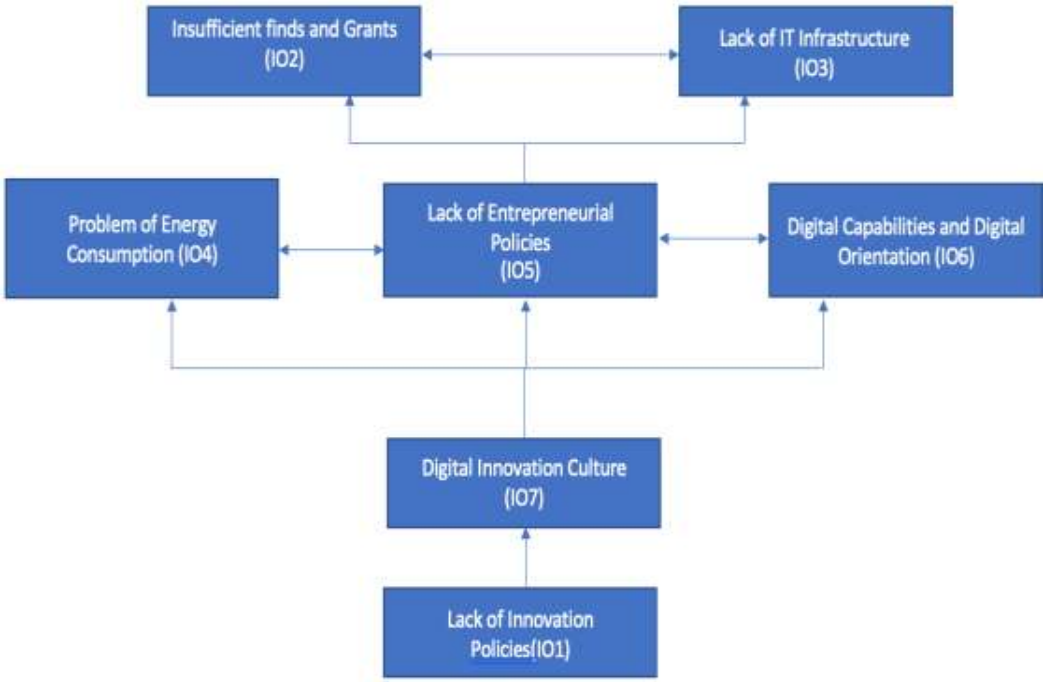

Figure 3 ISM based Hierarchical Model of Innovation Challenges

The most serious organisational issues were discovered to be "insufficient cash and grants (IO2)" and "lack of IT infrastructure (IO3)." For economies and organisations trying to implement society 5.0, resource availability is critical. While IT infrastructure is a must, it is also a luxury. The government's assistance is critical.

As shown in figure 3, the investigation revealed Insufficient funds and grants (IO2) and Lack of IT Infrastructure (IO3)' as the most crucial innovative challenges. The model further finds that at level 2 there are challenges like 'Problem of energy consumption (IO4)', 'Lack of Lack of Entrepreneurial policies (IO5), and 'Digital Capabilities and Digital Orientation (IO6)' are placed. AT level 3 'Digital Innovation Culture (IO7) is placed. All of the problems lead to the last challenge, which is the government's lack of innovation policy (IO1). These central issues in the model are the connecting links in the hierarchy structure, implying that they will affect

lower-level challenges and may be affected by higher-level challenges. It can be deduced that level 1 of the ISM model for innovation includes two challenges: insufficient funds and grants and lack of IT infrastructure, placing it at the top of the ISM model and indicating that it has little impact on other society 5.0challenges, though it is likely to be affected by other challenges.

Driving-Power and Dependence-Power of the Challenges of Society 5.0

Based on their dependence and driving power, independent challenges, linked challenges, autonomous challenges, and dependent challenges are categorised into four types. Dependent challenges are those that are primarily dependent on other challenges; linkage challenges are those that connect challenges and have a significant influence on other challenges and are unstable; and independent challenges are those that have little or no influence on other challenges but require the most attention from policymakers.

Figure 4 depicts four quadrants for organisational issues affecting society 5.0 implementation in context of emerging economies: independent challenge, dependent challenge, linking challenge, and autonomous challenge. For example, technical and organisational challenge 6 'Creating a change-enabling work culture' has a reliance power of 11 and a driving power of 1, and it is defined as a driving factor with a position of 11 on the x-axis and 1 on the y-axis. The bottom levels' issues are all driving challenges, while the highest levels' challenges are all dependant challenges, according to the findings. Figure 4 depicts 'Employee Resistance (TO9)' and 'Honouring and encouraging new talent (TO10),' which are major technical and organisational challenges of society 5.0 implementation because they have the greatest ability to influence other challenges and are less likely to be influenced by other challenges.

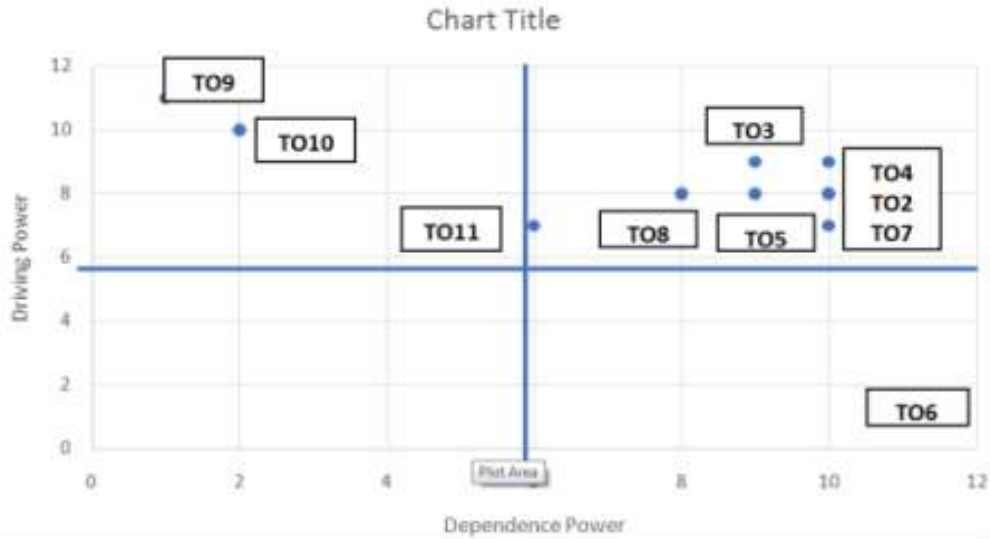

Figure 4 Driving- Power, and Dependence- Power of Each Technical and Organisational Challenge Affecting Implementation of Society 5.0

Figure 5 depicts four quadrants for innovation issues influencing Society 5.0 in emerging economies, representing linked challenge, dependent challenge, independent challenge, and autonomous challenge categories. For example, with a dependency power of 7 and a driving power of 2, innovation challenge 2 and 3 'Insufficient funding and grants and lack of IT infrastructure' are positioned at 7 on the x-axis and 2 on the y-axis. The bottom levels' issues are all driving challenges, while the highest levels' challenges are all dependant challenges, according to the findings. The lack of innovation policies (IO1) depicted in Figure 5 can be considered a key innovation problem of society 5.0 implementation in emerging economies since they have the greatest power to influence other challenges and are less likely to be influenced by other challenges.

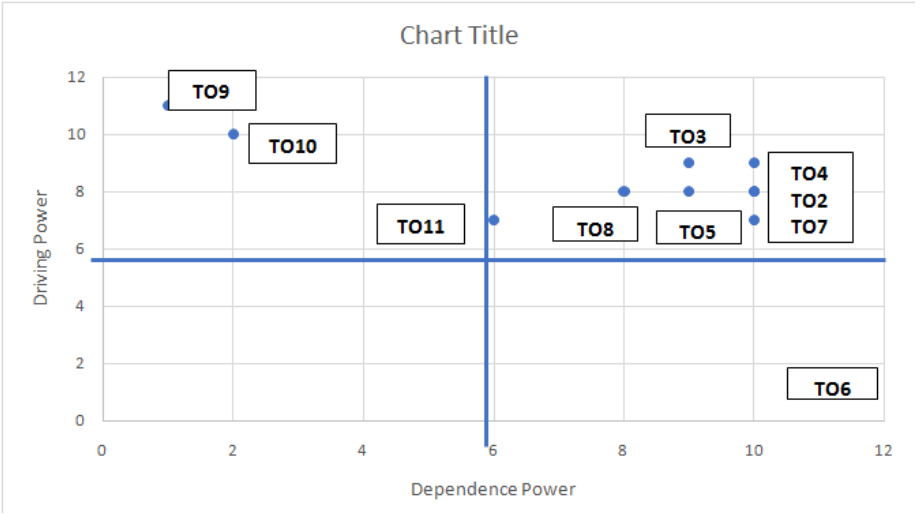

Figure 5 The Driving- Power, and Dependence- the Power of Each Socio Economic Challenge Affecting Implementation of Society 5.0

Result and Discussion

The current study offers an analytical methodology for evaluating the Society 5.0 application-related criteria. Society 5.0 has emerged as a result of the quick adoption of digital technology in areas including business, supply chains, organisations, social connections, and even the person. The research in Society 5.0 was prompted by a paucity of existing literature, however it does not address the discovery of implementation-related issues.

The study focused on identifying and evaluating 18challenges faced by emerging economies on their way forward to Society 5.0. These difficulties were divided into two groups: technological and organisational. These 18 difficulties (11 technical and organisational challenges and 7 innovation challenges) are organised into a hierarchy and separated into five stages using ISM analysis. The MICMAC analysis was then used to identify autonomous problems, linking challenges, independent challenges, and dependent challenges (Figures 4 and 5). The major issues that rising countries face are distinct, and they must be addressed promptly in order to hasten the adoption of Society 5.0. The factors which majorly obstruct IIOT implementation are independent and they need to be immediately addressed to expedite IIOT adoption.

The originality of this study is that it focuses on understanding the dynamic link between the problems. The problems of Society 5.0 have been identified by previous studies, but interaction relationships to build strategies have not been examined in the context of emerging economies. The effect of these obstacles on each other is depicted in the ISM-based hierarchy model. The difficulties are positioned in a two-dimensional form based on dependency and driving power. The findings also provide clarity and insight into how to formulate a strategy to solve the issues. For policymakers to execute Society 5.0 smoothly, they must first comprehend the importance of these difficulties.

Conclusion

The current study provides an analytical framework for assessing the challenges of putting Society 5.0 into practice. A shift to Society 5.0 is taking place as a result of the quick adoption of digital technology in societal elements like businesses, supply chains, organisations, social relationships, and individuals. Although there is little literature to draw upon, it served as inspiration for the research for Society 5.0. However, implementation issues are not mentioned. The goal of the study is to comprehend the difficulties that emergent economies face in implementing Society 5.0. Structured interviews were used in the research to collect data from experts in business, government, and academia.We were able to compile a comprehensive list of obstacles for the study with the aid of the interviews. ISM is used to rank the barriers and determine the key variables affecting the adoption of society 5.0 in developing nations. The report offers a hierarchical structure of obstacles that practitioners, decision-makers, and businesses can employ to ensure that society 5.0 is implemented successfully in emerging economies. In the future, the research can be assessed utilizing a variety of strategies and interactions with more decision-makers. Future research should broaden its scope, involve more interactions with decision-makers, and evaluate the study using other approaches.

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Evaluation of Mutual Fund Selection of Customers in India Based on MEREC Model

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Abstract

Since its inception in 1963, mutual funds have gained a fair share of popularity among the customers in India. It is regarded as a comparatively simple and painless channel of investment. The customers can park their money under different funds like Equity Funds, Debt Funds, Hybrid Funds, etc. depending on their risk appetite, future goals, and tenure of their investment. The objective of this study is to evaluate the needs or consumer perception to select the right mutual funds to suit their risk and return appetite. For the purpose of the said objective, consumer needs, like Standard Deviation, Sharpe Ratio, Treynor's Measure, and Beta have been employed. The application of the MEREC model has been carried out so as to find out the objective weights of each of the above-mentioned parameters. It also evaluates the effect that each need plays in the selection of the said funds. The study gives an idea as to which need should be given due importance while selecting a mutual fund scheme from the viewpoint of the customers.

Keywords: *Mutual Fund, Customer, Bank, MEREC Model*

Introduction

Mutual funds (MFs) are investment platform that is comprising of funds from several investors to devote in assets, like stocks, bonds, money market instruments and other avenues. Professional fund supervisors handle a MF scheme through professionally allocating different asset class into it with an aim to produce wealth or income. The selection of different asset classes in a MF scheme is carried out in such a way that they meet the diverse financial goals of the investors. Further, MF provides a professionally managed platform to retail and small customers to invest in a plethora of asset class, like shares, bonds etc. which was otherwise not possible earlier in an easy manner. Moreover, MF have become a very common option for the Indian customers who are aware of financial investments due to the fact that their funds are managed by professionals. The fund managers have adequate experience in this field and are able to manage the risk appetite of the customers accordingly. Additionally, diversification is one of the major reasons for growth in MFs where the customers tend to diverse their financial portfolio and minimize risks. This also means that the customers are able to afford the MF plans at lower investment cost. The value of a MF organisation can be determined the performances of assets under its management. When a customer purchases a MF scheme, he/she is basically purchasing some units of that particular scheme, more accurately, a portion of the portfolio's value of the selected scheme.

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Hence, each investor of a MF scheme shares the gain and loss in proportion of the amount of money they have allocated to it. The net asset value (NAV) is determined by the MF investment policy, and is a way to monitor the gain or loss in a MF scheme. Investment in MF schemes differs from stock market investing in the sense that MF schemes do not offer their owners voting rights, unlike stock. The redemption methods are easier with payment of mere redemption fees. The geographical spread of MF is increasing, and the industry is maturing with broad base of customers.

MFs have helped equity and corporate bond markets in India to grow at a rapid pace in addition to facilitating an important function of imparting liquidity to the money market (RBI, 2018). Credit intermediation has shifted in recent years, with non-bank intermediaries, such as asset management firms, gaining ground and diminishing the banking sector's traditional dominance. Investment in MF market often provides investors operational autonomy along with potential superior returns in India, and are the main factors behind thriving Indian MF industry. The Indian economy is witnessing formalization recently owing to the fact that the household savings have shifted their asset from physical form to financial form. Most particularly, the transition from bank deposits such as Fixed and Recurring to securities such as MF and Equity has been possible to due financialization of the industry. MF is broadly classified into equity fund, debt fund, and hybrid funds as specified in Figure 1. The equity fund investments have more than half of their assets into equity instruments where the rest of corpus is invested in debt and money market. The debt fund consists of major investments in bonds, government securities, and money markets. The debt fund is fixed in nature in the sense that it incorporates major portion of investments in fixed income. The hybrid fund is a combination of equity, debt and gold bonds. The customer perception plays a vital role in determination of success of the MFs. This perception is shaped by the income to earnings ratio and risk appetite of the customers. The selection of the type of the MF is based mainly on the nature of income and awareness level.

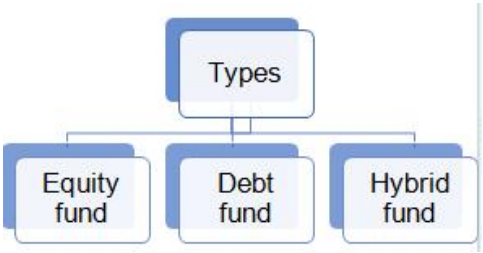

Figure 1 Different Types of Mutual Funds

Access to broad range of financial market is the key factor that attracts the new age customers in India. The diversification of funds lowers down the risk factor, hence, allows the customer to undertake wide types of funds. The customers are allowed to buy and sell MFs easily through various portals. The funds are managed professionally by the fund managers who

have experience in that field and so, the customers believe that their money is in safe hands. The returns of MFs as compared to deposits is exponential in nature which is the major benefit that the customers derive from MFs. An equity MF scheme is invested in an assorted range of stocks; therefore, the performance of the scheme is driven by the variation in the total market capitalization of those stocks. The aggressive development of MF industry has led to growth of number of mutual fund schemes that are on offering in the market. What are the contributing factors that decide the customers' choice of selection of a MF scheme? The extant literature in the area of finance provides information on the variety of factors that contribute towards selection of MF specifically in India. These factors include risk appetite, future goals, and tenure of the investment of the customers. The information available on MF industry is inconsistent and uncertain in nature. Hence, this can be easily solved through a Multi-Criteria Decision Making (MCDM) tool which is capable of evaluating numerous alternatives with respect to several criteria. Therefore, this paper attempts to answer the above question with the application of Method based on the Removal Effects of Criteria (MEREC) model.

Literature Review

The relevant literature on selection of MF portfolio using different methodologies is largely divided into two sections. The first component enlists application of different tools for evaluation of MF investments. Subsequent section ofthe literature review incorporates the implementation of MEREC model for estimating the significance of parameters while responding multi-criteria decision making (MCDM) problems. Woerheide (1982) proposed the parameters that were important to customers while they invested in mutual funds with a view to achieve financial goals. (Malavika & Suresh, 2022)stated that the public sector mutual funds have received better responses leading to improvised satisfaction. Budiono and Martens (2010) examined the impact of fund fees, data on past performance and turnover ratio of mutual fund scheme on its excess returns. Another aspect studied by Paule-Vianez et al., 2020 about the "herd effect" followed in mutual fund decision making process. Larger mutual funds actively avoid greater trading expenses by trading less regularly and retaining larger stocks (Busse, et al., 2020). Chang et al. (2010) implemented a multi-attribute decision analysis approach to rank different MF schemes. The information on maximizing and minimizing potential biases of equity funds was studied by Anarkulova et al., 2022. Elton et al. (2011) showed that employing alpha estimated from a fund's holdings and security betas in the selection of a MF scheme produced better results as compared to other methods. Kaur et al. (2013) studied the investors perception towards selection of MFs using factor analysis. Hanafizadeh et al. (2014) measured MFs efficiency using neural network back-propagation data envelopment analysis (DEA). Utz et al. (2015) implemented ecological, societal, and trade regulation criteria to evaluate the sustainability of MFs. Jakšić et al. (2015) examined the progress of MF schemes while incorporating various financial ratios as evaluation parameters. Puška et al. (2018) demonstrated the applicability and suitability of multi-criteria decision analysis in making a superior investment decision. (Zhou et al., 2018; Galagedera et al., 2018) developed a DEA frontier enhancement technique while incorporating mean-variance methodology for developing a superior portfolio. Biswas et al. (2019) adopted an integrated DEA-multi-attributive border approximation area comparison (MABAC) technique for ranking

equity large cap funds in India. Maheen (2021) evaluated the performance of funds that are actively managed during the market downturn to establish their superiority. Baydaş et al. (2022) compared ten MCDM techniques objectively to analyse the financial performance of stocks.

MEREC model is a new method for determining criteria weights. It works on the principle of removal effects of criteria while calculating objective weights for evaluation criteria (Keshavarz-Ghorabaee et al., 2021). Goswami et al. (2022) implemented a new MEREC-Proximity Index Value MCDM technique to select a renewable power plant in Indian subcontinent. Rani et al. (2022) selected best food waste treatment equipment while employing fuzzy logic, MEREC model and additive ratio assessment (ARAS) technique. Mishra et al. (2022) developed a modified MEREC model based on social, economic and environmental parameters of sustenance to solve a MCDM case. Hezam et al. (2022) solved an alternative fuel vehicle selection problem employing intuitionistic fuzzy-MEREC technique.

It can be understood from above literature review that assorted techniques have been proposed in the past to evaluate the parameters for the assessment of the MFs. MEREC model has been successfully applied in various domains of engineering and therefore, it is contemporary to management decision. The selection of appropriate MFs is crucial in determining the returns and it leads to building up of trust in customers. Moreover, it can also be interpreted from the MEREC framework that parameters that drive the efficiency of the alternative is allocated more priority. This feature of the model makes it suitable for prioritizing important needs of the customers while selecting a MF portfolio. Although, the extent and administration of the factors varies in MF, the selection of MFs from the implementation of MCDM model has been scarcely attempted. Hence, this paper for the first time proposes the implementation of MEREC model to evaluate the customer preferences with respect to different financial parameters like, Standard Deviation, Sharpe Ratio, Treynor's Measure, and Beta while selecting Large Cap and Small Cap MFs. The results derived from the study can help new as well as old investors to understand the significance of the said criteria while formulating their portfolio.

Methodology

Keshavarz-Ghorabaee et al. (2021) introduced MEREC technique for estimating the criteria' weights in a MCDM conundrum. In this model the criteria weights are obtained through unbiassed weighting methods. The technique considers the consequence of removal of criteria on alternative's performance while calculating the criteria weights. Parameters which are primarily driving the performance of an alternative are assigned a superior priority weightage. First the performance criteria of options are decided. Subsequently, a simple logarithmic measure is applied with same priority to determine the performances of alternatives.

The absolute deviation measure is employed with a view to recognize the impacts of eliminating each criterion. This portion signifies the modification between the overall alternative's performance and its performance in eliminating a criterion. The sub sequent stages are utilised to compute objective weights by MEREC:

Following are the steps of MEREC model

Step 1: Development of the decision matrix. A decision matrix showing the performance of alternatives with respect to each criterion is developed. All the elements in this matrix must be greater than zero. The negative values must be converted into positive ones using suitable approach. The decision matrix denoted by Equation 1 has 'm' criteria and 'n' alternatives.

$$X = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1j} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2j} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} & \cdots & x_{im} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nj} & \cdots & x_{nn} \end{bmatrix} \#(1)$$

Step 2: Normalization of the decision matrix. Linear normalization technique is followed to make the decision matrix dimensionless so that all the alternatives may be compared with respect to the considered criteria. Equation 2 shows normalized matrix where B represents the beneficial criteria, and H shows the non-beneficial ones.

$$n_{ij}^{x} = \begin{cases} \dfrac{\min\limits_{k} x_{kj}}{x_{ij}} & \text{if } j \in \mathcal{B} \\ \dfrac{x_{ij}}{\max\limits_{k} x_{kj}} & \text{if } j \in \mathcal{H} \end{cases} \#(2)$$

Step 3: Calculation of the performance score. Performance score for all the alternatives is calculated while utilizing a logarithmic measure with equal criteria weights. It is evident from the previous step, that smaller values in normalized matrix yield higher performance score obtained through Equation 3.

$$S_i = \ln\left(1 + \left(\frac{1}{m}\sum_{j} \left|\ln\left(n_{ij}^{x}\right)\right|\right)\right) \#(3)$$

Step 4: Calculation of the overall performance of alternatives after removal of criteria. This step is similar to the previous step. The difference is in calculation of performance score after removal of criteria. There are m sets of performances associated with m criteria. Equation 4 denotes the overall performance of i^{th} alternative concerning the removal of j^{th} criterion.

$$S'_{ij} = \ln\left(1 + \left(\frac{1}{m}\sum_{k,k\neq j} \left|\ln\left(n_{ik}^{x}\right)\right|\right)\right) \#(4)$$

Step 5: Computation of total of absolute deviations. In this step, the removal effect of the j^{th} criterion based on the values obtained from Step 3 and Step 4 is determined. Equation 5 is used for this purpose.

$$E_j = \sum_{i} \left|S'_{ij} - S_i\right| \#(5)$$

Step 6: Determination of final weights of the criteria. Equation 6 is used for calculating objective weight for each criterion.

$$w_j = \frac{E_j}{\sum_k E_k} \#(6)$$

Implementation of MEREC methodology

MEREC method usually exploits the variations in different alternatives' performances with respect each criterion while determining the weights. Unlike the other methods, the proposed method applies limination impact of all parameters on the overall scores of options for computing significance of each parameter. Besides, it is widely accepted that MF market always corrects itself to demand of customers. Hence, the disparities of performance of different MF (alternatives) in each category, say Large Cap MF captures the weightage of customers' preferences with respect to the said financial parameters while formulating their portfolio. Therefore, in this paper for the first time MEREC model is implemented for determining weights of customers' preferences for financial criteria, i.e., Standard Deviation (SD), Sharpe Ratio (SR), Treynor's Measure (TM) and Beta (β). in order to choose Large Cap and Small Cap MFs to match their risk return profile.

Illustrative Example 1

In order to understand relative significance customers' needs with respect to all selected financial criteria for selection of best Large Cap MF, initial decision matrix needs to be formulated. The alternatives in the initial decision matrix are the funds that fall in the category of Large Cap MF in India, whereas the criteria are identified as SD, SR, TM and β. The data for the calculation is derived from the website of the Association of MFs in India (AMFI) in the month of September 2021 for the time period of last five years. Table 1 shows the decision matrix for the Large Cap MF which encompasses the performance of the selected funds on the identified criteria as in the month September 2021 for last five years.

Using the Equation 2 the decision matrix is normalized to bring all values on the same platform. Next, the overall performance of all the Large Cap MFs is estimated using Equation 3. Table 2 shows normalised decision matrix of Large Cap MFs, whereas performance score of alternatives is given in Table 3. Subsequent step in implementation of MEREC Model is to estimate the performance of each Large Cap fund by removing each criterion using Equation 4 and is represented by S'_{ij}. Table 4 shows the calculated values of S'_{ij} for Large Cap MFs.

Table 1 The decision matrix for Large Cap MF

Camb	SD	SR	TM	β
Aditya Birla Sun Life Frontline Equity Fund (F1)	25.53222	1.19333	0.30483	1.00386
Axis Blue chip Fund (F2)	20.24242	1.56865	0.31926	1.04619
Baroda Large Cap (F3)	23.14743	1.25055	0.28772	0.95708
BNP Paribas Large Cap Fund (F4)	20.12317	1.44621	0.28935	0.95885
Canara Robeco Blue chip Equity Fund (F5)	20.59734	1.54599	0.32020	1.04748
DSP Top 100 Equity Fund (F6)	21.93044	1.19097	0.25479	0.85917

Edelweiss Large Cap Fund (F7)	21.87830	1.34605	0.29330	0.97028
Franklin India Blue chip Fund (F8)	30.72519	1.07567	0.33381	1.09274
HDFC Top 100 Fund (F9)	26.30447	1.10335	0.28859	0.95959
HSBC Large Cap Equity Fund (F10)	21.81675	1.28519	0.27717	0.92380
ICICI Prudential Blue chip Fund (F11)	24.08127	1.24098	0.29837	0.98807
IDBI India Top 100 Equity (F12)	24.80503	1.31462	0.32892	1.07816
IDFC Large Cap Fund (F13)	19.51265	1.37340	0.26275	0.88154
India bulls Blue chip (F14)	19.28899	1.24749	0.23043	0.79281
Invesco India Large cap Fund (F15)	21.87316	1.36102	0.29694	0.98084
JM Large Cap Fund (F16)	15.57341	1.38057	0.19886	0.70730
Kotak Blue chip Fund (F17)	22.98080	1.35395	0.31211	1.02516
LIC MF Large Cap Fund (F18)	23.34669	1.30502	0.30496	1.00737
L&T India Large Cap Fund (F19)	21.14258	1.29606	0.26975	0.90139
Mirae Asset Large Cap Fund (F20)	21.77012	1.36361	0.29613	0.98151
Navi Large Cap Equity Fund (F21)	23.76899	1.25695	0.29815	0.98435
Nippon India Large Cap Fund (F22)	28.61612	1.16442	0.33663	1.09610
PGIM India Large Cap Fund (F23)	21.39558	1.31683	0.27873	0.92827
SBI Blue chip Fund (F24)	25.54476	1.21193	0.31029	1.01838
Tata Large Cap Fund (F25)	26.00534	1.21286	0.31682	1.03761
Taurus Large cap Equity Fund (F26)	18.60722	1.26109	0.22313	0.77190
Union Large cap Fund (F27)	24.56182	1.60770	0.39495	1.00178
UTI Master share Fund (F28)	24.82696	1.25585	0.31276	1.02563

Table 2 The normalized decision matrix of Large Cap MFs

Fund	SD	SR	TM	B
F1	0.83099	0.90139	0.65236	0.91585
F2	0.65882	0.68573	0.62289	0.95447
F3	0.75337	0.86016	0.69116	0.87317
F4	0.65494	0.74378	0.68727	0.87478
F5	0.67037	0.69578	0.62106	0.95564
F6	0.71376	0.90318	0.78049	0.78384
F7	0.71206	0.79913	0.67802	0.88521
F8	1.00000	1.00000	0.59573	0.99693
F9	0.85612	0.97491	0.68909	0.87546
F10	0.71006	0.83697	0.71748	0.84281
F11	0.78376	0.86679	0.66649	0.90144
F12	0.80732	0.81823	0.60459	0.98364
F13	0.63507	0.78321	0.75686	0.80425
F14	0.62779	0.86227	0.86299	0.72330

F15	0.71190	0.79034	0.66971	0.89485
F16	0.50686	0.77915	1.00000	0.64528
F17	0.74795	0.79446	0.63716	0.93528
F18	0.75985	0.82425	0.65208	0.91904
F19	0.68812	0.82995	0.73720	0.82236
F20	0.70854	0.78884	0.67155	0.89546
F21	0.77360	0.85577	0.66700	0.89805
F22	0.93136	0.92378	0.59074	1.00000
F23	0.69635	0.81686	0.71346	0.84689
F24	0.83139	0.88757	0.64090	0.92909
F25	0.84638	0.88688	0.62768	0.94663
F26	0.60560	0.85296	0.89124	0.70422
F27	0.79940	0.66907	0.50351	0.91395
F28	0.80803	0.85653	0.63582	0.93571

Table 3 The Performance score of Large Cap MFs

Fund	Performance Score
F1	0.18316
F2	0.28416
F3	0.21084
F4	0.26774
F5	0.27845
F6	0.20913
F7	0.23790
F8	0.12245
F9	0.15832
F10	0.22781
F11	0.20214
F12	0.20993
F13	0.26136
F14	0.24001
F15	0.24042
F16	0.29400
F17	0.23075
F18	0.21912
F19	0.23520
F20	0.24105
F21	0.20802
F22	0.15631

F23	0.23665
F24	0.18697
F25	0.18386
F26	0.24811
F27	0.30045
F28	0.20035

Table 4 The overall performance of Large Cap MFs

Fund	SD	SR	TM	β
F1	0.14386	0.16131	0.09004	0.16469
F2	0.20238	0.21052	0.19086	0.27535
F3	0.15179	0.17986	0.13310	0.18299
F4	0.18332	0.20945	0.19330	0.24182
F5	0.19976	0.20734	0.18399	0.26983
F6	0.13829	0.18826	0.15756	0.15847
F7	0.16863	0.19270	0.15823	0.21358
F8	0.12245	0.12245	0.00077	0.12177
F9	0.12461	0.15288	0.07552	0.12952
F10	0.15722	0.19174	0.15943	0.19318
F11	0.15110	0.17251	0.11564	0.18072
F12	0.16558	0.16842	0.10236	0.20658
F13	0.16990	0.21318	0.20624	0.21852
F14	0.14399	0.21043	0.21060	0.17418
F15	0.17128	0.19306	0.15833	0.21834
F16	0.15863	0.24639	0.29400	0.20886
F17	0.17137	0.18400	0.13702	0.21738
F18	0.16239	0.17953	0.12934	0.20202
F19	0.15847	0.19768	0.17306	0.19579
F20	0.17096	0.19333	0.15960	0.21912
F21	0.15449	0.17588	0.12221	0.18594
F22	0.14099	0.13922	0.03691	0.15631
F23	0.16257	0.19592	0.16771	0.20331
F24	0.14793	0.16192	0.09018	0.17160
F25	0.14855	0.15857	0.08196	0.17239
F26	0.14515	0.21659	0.22539	0.17725
F27	0.25812	0.22315	0.16461	0.28366
F28	0.15575	0.16815	0.10312	0.18666

Equation 5 is employed to compute absolute deviations, which is the removal effect of the j^{th} criterion. The last step in implementation of MEREC model for estimation of weights of the financial criteria and is calculated using Equation 6. Table 5 shows absolute deviation and weights of financial criteria for Large Cap MFs.

It can be seen from the results that customers prefer TR the most while selecting the Large Cap MFs followed by SD criterion. Therefore, while making a portfolio of the said fund category customers provide highest priority to risk-adjusted return based on systematic risk. Moreover, customers provide least significance to β value while choosing the Large Cap MFs to suit their risk return appetite. This implies the volatility of the Large Cap MF scheme relative to its market benchmark has least significance in the eyes of customers.

Table 5 Absolute deviation and weights for Large Cap MFs

Criteria	Absolute Deviation	Weights
SD	1.74512	0.301
SR	1.06019	0.183
TR	2.25354	0.388
β	0.74483	0.128

Illustrative Example 2

The alternatives in this case comprises of Small Cap MF schemes in India, whereas the criteria remain the same as in Large Cap MFs. The data for the calculation is derived from the website of the Association of MFs in India (AMFI) in the month of September 2021 for the time period of last five years. Same methodology as discussed in above section is applied here to compute the significance of customers' preferences with respect to financial criteria while choosing Small Cap MF. Table 6 shows the decision matrix for the Small Cap MF, which includes the performance of the selected funds on the identified criteria as in the month September 2021 for last five years.

Table 6 Decision matrix for Small Cap MF

Fund	SD	SR	TM	β
Aditya Birla Sun Life Small Cap Fund (S1)	34.84955	1.10381	0.72699	0.52913
Axis Small Cap Fund (S2)	30.28422	1.41102	0.80759	0.52913
DSP Small Cap Fund (S3)	29.33797	1.40131	0.69452	0.59194
Franklin India Smaller Companies Fund (S4)	36.15149	1.15468	0.75260	0.55466
HDFC Small Cap Fund (S5)	39.80377	1.10557	0.83167	0.52913
HSBC Small Cap Equity Fund (S6)	36.66790	1.17330	0.77252	0.55691
ICICI Prudential Small cap Fund (S7)	37.43013	1.26979	0.85689	0.55466

IDBI Small Cap Fund (S8)	33.73246	1.21049	0.62934	0.64882
Kotak Small Cap Fund (S9)	41.07789	1.23010	0.95497	0.52913
L&T Emerging Businesses Fund (S10)	39.69837	1.16786	0.78322	0.59194
Nippon India Small Cap (S11)	37.87672	1.22312	0.83525	0.55466
Quant Small Cap Fund (S12)	47.56730	1.22271	1.04859	0.55466
SBI Small Cap Fund (S13)	25.09138	1.52774	0.64758	0.59194
Sundaram Small Cap Fund (S14)	37.31888	1.15584	0.81520	0.52913
Union Small Cap Fund (S15)	30.90090	1.31235	0.76641	0.52913

Table 7 shows normalised decision matrix of Small Cap MFs, whereas overall performance of alternatives is given in Table 8.

Table 7 Normalized decision matrix for Small Cap MFs

Cam	SD	SR	TM	B
S1	0.73264	1.00000	0.86567	0.81552
S2	0.63666	0.78227	0.77928	0.81552
S3	0.61677	0.78770	0.90614	0.91233
S4	0.76001	0.95594	0.83622	0.85487
S5	0.83679	0.99841	0.75672	0.81552
S6	0.77086	0.94077	0.81465	0.85833
S7	0.78689	0.86928	0.73444	0.85487
S8	0.70915	0.91187	1.00000	1.00000
S9	0.86357	0.89733	0.65901	0.81552
S10	0.83457	0.94516	0.80352	0.91233
S11	0.79628	0.90245	0.75347	0.85487
S12	1.00000	0.90276	0.60017	0.85487
S13	0.52749	0.72251	0.97182	0.91233
S14	0.78455	0.95498	0.77200	0.81552
S15	0.64962	0.84109	0.82115	0.81552

Table 8 The performance score of Small Cap MFs

Fund	Overall Performance
S1	0.15257
S2	0.25278
S3	0.20543
S4	0.15168
S5	0.15325
S6	0.15680
S7	0.19170

S8	0.10345
S9	0.19802
S10	0.12834
S11	0.17612
S12	0.17598
S13	0.24000
S14	0.17215
S15	0.22422

Table 9 shows the overall performance of Small Cap MFs.

Table 9 The overall performance of Small Cap MFs

Fund	SD	SR	TM	B
S1	0.08346	0.15257	0.12112	0.10781
S2	0.16103	0.20393	0.20314	0.21238
S3	0.10187	0.15563	0.18516	0.18657
S4	0.09092	0.14196	0.11250	0.11742
S5	0.11429	0.15291	0.09160	0.10853
S6	0.09958	0.14367	0.11200	0.12361
S7	0.14097	0.16236	0.12588	0.15880
S8	0.02280	0.08243	0.10345	0.10345
S9	0.16748	0.17555	0.10862	0.15530
S10	0.08776	0.11586	0.07904	0.10796
S11	0.12719	0.15437	0.11495	0.14270
S12	0.17598	0.15430	0.06277	0.14255
S13	0.10557	0.17394	0.23436	0.22179
S14	0.11973	0.16241	0.11615	0.12828
S15	0.13410	0.18904	0.18406	0.18263

The absolute deviation and weights of financial criteria for Small Cap MFs is given in Table 10.

Table 10 Absolute deviation and weights for Small Cap MFs

Criteria	Value	Weights
SD	0.949764	0.377
SR	0.361571	0.143
TR	0.727691	0.289
B	0.482724	0.191

From the results derived, it can be interpreted that customer prefer SD the most and SR the least while selecting Small Cap MF schemes. It implies that investors of Small Cap MFs are most interested to understand the distribution of the actual return from the MF scheme's

expected annual return. On the other hand, while making portfolio of Small Cap MF schemes, customers are least interested to evaluate the risk-adjusted performance of a MF.

Comparative Analysis

A comparative analysis is carried out to understand the reliability and usability of the adopted method. The authors chose criteria importance through intercriteria correlation (CRITIC) and Entropy methods to compute the criteria weights and to perform the analysis. Table 11 and Table 12 show the criteria weights determined by each method and the related Pearson correlation coefficients (r) for Large Cap MF Schemes and Small Cap MF Schemes respectively. Figure 2 and Figure 3 depict the trend in varying criteria weights in MEREC is alike to the other techniques considered in the comparative analysis for Large Cap MF Schemes and Small Cap MF Schemes respectively. Figure 4 and Figure 5 shows similar trend in the form of radar chart. It can be interpreted from the Table 12 and Table 13 that MEREC method has high positive correlation with respect to Entropy technique, whereas, CRITIC and MEREC models are also having positive correlation. Thus, it can be concluded that MEREC method generates results that can be considered credible and reliable weights for the MF schemes' performance assessment.

Table 11 The weights and correlation coefficients of the comparative analysis for Large Cap MF Schemes

	Weights obtained by MEREC method	Weights obtained by Entropy method	Weights obtained by CRITIC method
SD	0.300692	0.342735	0.188318
SR	0.182675	0.166787	0.201579
TR	0.388296	0.312012	0.324736
β	0.128338	0.178466	0.285366
R		0.870188	0.267136

Table 12 The weights and correlation coefficients of the comparative analysis for Small Cap MF Schemes

	Weights obtained by MEREC method	Weights obtained by Entropy method	Weights obtained by CRITIC method
SD	0.376629	0.432537	0.243121
SR	0.143381	0.168192	0.236909
TR	0.288566	0.331066	0.269444
β	0.191424	0.068205	0.250525
R		0.899059	0.283154

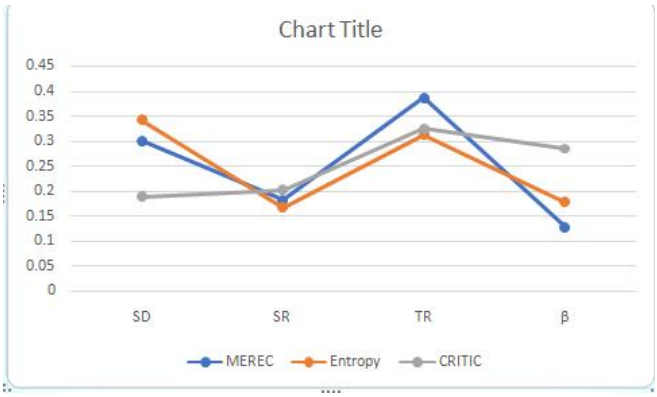

Fig 2 Trend chart for comparative analysis of weights estimated by different methods for Large Cap MF Schemes

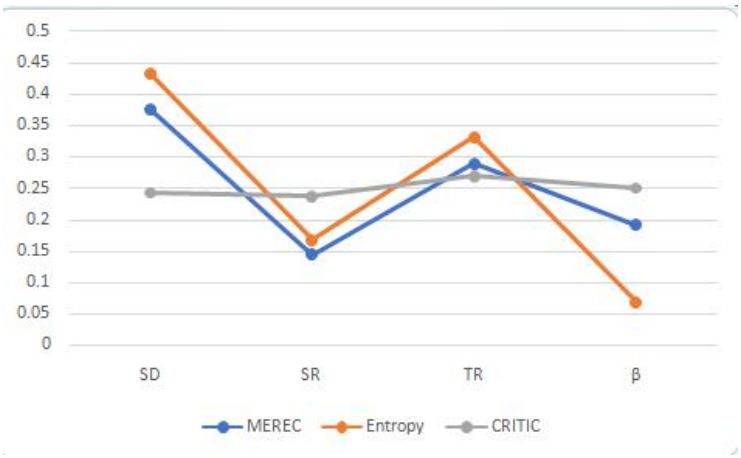

Fig 3 Trend chart for comparative analysis of weights estimated by different methods for Small Cap MF Schemes

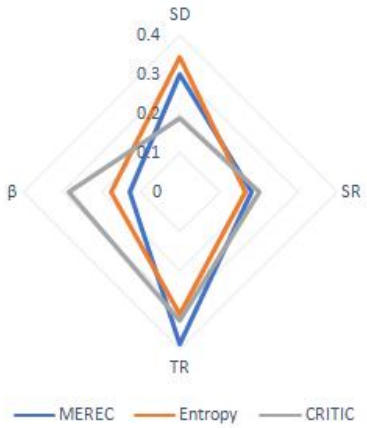

Fig 4 Radar chart for comparative analysis of weights estimated by different methods for Large Cap MF Schemes

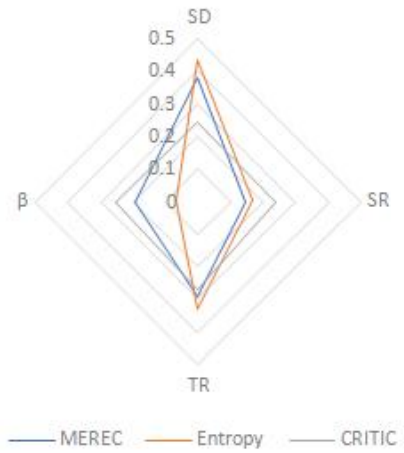

Fig 5 Radar chart for comparative analysis of weights estimated by different methods for Small Cap MF Schemes

Conclusions

In today's highly competitive and unpredictable environment, it is important that the investors make the right decisions to park their money in order to earn higher returns keeping their goals, risk appetite and tenure of investment in mind. MFs are one of the simplest and most viable vehicles of investment. The Indian MF industry has Assets Under Management of 38,03,683 crores as of April 30, 2022, as per the data provided by the AMFI, and research shows that this figure is only going to get higher in the coming years. However, choosing the right MF or the right scheme is very important for earning higher returns at the given level of risk. For this purpose, various parameters like SD, SR, TR, β etc., must be taken into consideration. The purpose of this is to find the objective weight of each criterion and find their individual impact on the said fund scheme so as to make it easier for investors to judge which parameter asserts more influence on the funds' performance. It is the very first paper which proposes and applies the MEREC model in the field of mutual fund industry in India.From the results derived from the implementation of MEREC model, it has been observed that customers prefer TR as most important criteria for selecting large-cap mutual funds.TR is preferred by the customer as it shows excess returns per unit of systematic risk. On the other hand, SD affects the investors of Small Cap MFs to the maximum extent. This is owing to the fact that investors of small cap MF have high risk appetite and SD is most equipped to measure that. It can be inferred that results derived from application of MEREC model can help investors understand the significance of different parameters with respect to their contribution in deriving the desired outcome.The results derived from the MEREC model is also reliable as it is having high correlation with the results obtained by already established techniques, like Entropy methodology. Investors can use theproposed technique to determine which factor to evaluate before investing in diverse categories of mutual funds. It will enable investors to construct a portfolio to match their risk return profile. Besides, regulators can also use the derived results to further strengthen their customer awareness programs. The future

scope of this research work can be to implement MERECmodel in different other segments of MFs, like Mid Cap and Multi Cap MFs.

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