HYBRID DWLSTM AND GRU BASED NETWORK FOR LIP-BASED BIOMETRIC AUTHENTICATION FOR MOBILE DEVICES

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ABSTRACT

In today's society, mobile devices such as phones, tabs and laptops are considered essential for both personal and business purposes and the risks of passwords as a sole means of authentication is widely recognised. These devices can provide a gateway to gaining access to private and confidential data and online services such as social media, mail communication, financial services like G-pay, Phonepe, Paytm, Mobile-banking, and ecommerce services. Among these services, financial services play a major important role. Recently several classification methods were introduced to solve lip based biometric authentication systems. The results of previous investigations into lip prints are insufficient and produce lesser authentication results. This is mainly due to the difficulties that accompany any analysis of the lips: lips are very flexible and pliable, and successive lip print impressions even those obtained from the same person may significantly differ from one other. The existing machine learning methods, single classifier will not be able to give higher authentication and only a small number of works will be available based on deep learning methods for lip biometric authentication. The use of deep-learning-based lip biometrics authentication gives higher results than usual machine learning methods. Thus, the proposed system is performed based on the deep learning method. The proposed system, Lip-Based Biometric Authentication (LipBA) system is rigorously examined with real-world data and challenges with the purpose of could be expected on lip-based solution deployed on a mobile device. The major aim of the work is to introduce a hybrid system for password authentication by lip analysis. The proposed system is performed based on three major steps such as (1) database collection, (2) lip biometric authentication, (3) Performance evaluation. In the initial step, Annamalai University Deep Learning Lab includes 5000 Live Lip video frames in real time for 10 persons with image size of 81x48. Second step, efficient lip based biometric authentication is then used to authenticate lip with a known database. For real time LipBA, hybrid Divergence Weight Long Short Term Memory (DWLSTM) and Gated Recurrent Unit (GRU) based network for financial services. In the hybrid model, the first layer of the proposed model is the DWLSTM layer with 10 hidden neurons and the second layer is the GRU layer with 20 hidden neurons. The final layer is used for person authentication via Live Lip dataset. This work can authenticate the lips in a laboratory environment. The overall existing and proposed method is implemented via the Ananconda with Jupyter notebook. Finally the results of the hybrid model are compared against existing methods such as Support Vector Machine (SVM), and Probabilistic Neural Network (PNN) with respect to metrics like precision, recall, F1-score, and accuracy for real time dataset.

Key Words: *Mobile devices, biometric authentication, deep learning, lip authentication, Divergence Weight Long Short Term Memory (DWLSTM), Gated Recurrent Unit (GRU), and classifiers.*

Introduction

Wireless technologies have become increasingly popular in burgeoning military affairs and so is security, where the identity of an individual on the other side of the network has become challenging to determine [1]. Thus, authenticity of an individual to access the private resources is the foremost concern and strong authentication between two parties (end-to-end) needs to be implemented. With mobile devices constantly taking a bigger part in everyday life, the ease of accessing a bank account, paying for any services or even checking medical journals independently of current time and place is getting more and more feasible. Having in mind that these kinds of services require access to the personal information or user, the logical major requirement is high security and strong user authentication methods [1, 2, 3]. Secure authentication before gaining access to personal devices is essential. Biometric authentication is the process of verifying the claimed identification of a person based on an innate human characteristic or trait [4,5].

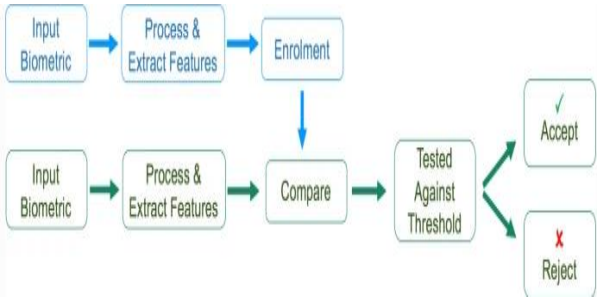


Fig.1: Biometric Authentication

Overview, Involving an Enrolment Stage in Blue and Authentication in Green

Figure 1 gives an overview of the two stages of biometric authentication which first includes an enrolment stage; users can then authenticate themselves against the enrolment data. However, identification differs from authentication in that it is the ability to identify an individual from a predefined group of users. Biometric traits can be physiological or behavioral. Physiological biometrics such as face or fingerprint have already been successfully rolled out in many state-of-the-art devices, both of these examples have been spoofed in high profile media cases. Behavioral biometrics captures a pattern or behavior such as signature or voice verification. Behavioral biometrics can be more difficult to spoof; however, they can also be more difficult to model and authenticate robustly. Within biometric authentication, liveness detection refers to being able to detect if a human is live and present during the authentication process. If liveness is successfully incorporated within a biometric system, it could prevent face recognition systems from being spoofed using photographs or artificial fingerprints being successful. Liveness detection is naturally easier to build into a behavioral biometric system as the behavior requested can be altered.

Lip-Based Biometric Authentication (LBBA) is the process of authenticating a person based on their visual lip movements while speaking [6, 7]. LBBA has great potential for mobile devices; it is a behavioral biometric in which liveness could be easily incorporated by randomizing the requested spoken content, and it can be captured using a device's front-facing camera. When speaking, people's lips are involved in motions. Studies show that such motions present unique lip movement patterns for different individuals. This triggers present research work that is used to extract behavioral patterns of lip image for user authentication on mobile devices such as smartphones and smart pads. Recently, lips recognition [8, 9, and 10] has been proposed as a new relevant emerging kind of biometrics, which is derived from criminal and forensic real-life applications.

Lip information has also been used in identification. In the recent work [11] generated lip features using information about the lip area, height and width of the lip contours, oral cavity pixels and visible teeth. In the recent work [11], they collected a private 20 person data set for all training and testing. Their best recorded result for identification was reported as 94.7% accuracy. In this paper, lip-based biometric authentication becomes one of the most relevant emerging tools, which comes from mobile devices. The main objective of this work is to authenticate a person from videos by using his/her facial component via lips. The main purpose of this work is to prove the benefit of lips as a biometric modality by using both Divergence Weight Long Short Term Memory (DWLSTM) and Gated Recurrent Unit (GRU). Finally, to strengthen the reliability of the authentication results, hybrid classifier for user authentication by examining the lip patterns. Authentication framework is performed based on Lips for protecting personal password confidentiality. The proposed authentication framework is able to be adapted for users and any camera based devices such as smartphones, tablets, and mobile applications. Extensive experiments demonstrate that the LipBA system is reliable and efficient for user authentication in real environments.

Literature Review

Wright and Stewart [6] developed to push the field forward through the application of deep learning. A deep Artificial Neural Network (ANN) using spatiotemporal convolutional and bidirectional gated recurrent unit layers is trained end-to-end. For the first time one-shot-learning is applied to lip-based biometric authentication by implementing a siamese network architecture, meaning the model only needs a single prior example in order to authenticate new users. This approach sets a new modern performance for lip-based biometric authentication on the XM2VTS dataset and Lausanne protocol with an equal error rate of 0.93% on the evaluation set and a False Acceptance Rate (FAR) of 1.07% at a 1.00% False Rejection Rate(FRR).

Wright and Stewart [7] proposed a lip-based authentication system that performs beyond a closed-set protocol, benchmarking a new open-set protocol with equal error rates of 1.65% on the XM2VTS dataset. New datasets, QFace and FAVLIPS, were collected for the work, which push the field forward by enabling systematic testing of the content and quantities of data needed for lip-based biometric authentication. The FAVLIPS dataset was designed to mimic some of the hardest challenges that could be expected in a deployment scenario and include varied spoken content, miming and a wide range of challenging lighting conditions. The datasets captured for this work are available to other university research groups on request.

Wrobel et al [12] proposed a lip-based biometric recognition approach with the Probabilistic Neural Network (PNN). In the first step, lip area is restricted to a Region of Interest (ROI) and in the second step; features extracted from ROI are specifically modeled by dedicated image processing algorithms. Extracted lip features are then an input data of PNN. All experiments were confirmed in the ten-fold cross validation fashion on three diverse datasets, Multi-PIE Face Dataset, PUT database and own faces dataset. Announced results were verified in the comparative studies and confirm the efficiency of the proposed lip based biometrics learned by Particle Swarm Optimization (PSO) technique. Results achieved by PNN were improved by the PSO technique.

Cruz et al [13] proposed a lip biometric system that focuses on the uniqueness of the parameters of the lips as a useful feature to distinguish similar-looking people. Data gathering includes five identical twins, ten similar faces, and ten dissimilar faces of still face-front images of subjects with neutral expressions were used to examine the efficiency and performance of the system. Different lighting conditions measured in flux under various distances have been characterized. The Viola-Jones algorithm is proposed for face detection and the Active Appearance Model (AAM) for lip extraction.

Lu et al [14] proposed a lip reading-based user authentication system, LipPass, which extracts unique behavioral characteristics of users' speaking lips leveraging built-in audio devices on smartphones for user authentication. First investigate Doppler profiles of acoustic signals caused by users' speaking lips, and find that there are unique lip movement patterns for different individuals. To characterize the lip movements, a deep learning-based method is proposed to extract efficient features from Doppler profiles, Support Vector Machine (SVM), and Support Vector Domain Description is introduced to construct binary classifiers and spoofer detectors for user identification and spoofer detection, respectively. Afterwards, a binary tree-based authentication approach is proposed to accurately identify each individual leveraging these binary classifiers and spoofer detectors with respect to registered users. Through extensive experiments, LipPass can achieve 90.21% accuracy in user identification and 93.1% accuracy in spoofer detection.

Wrobel et al [15] proposed a new method of personal identification that analyzes lip prints. In spite of its important role in forensic and biometric applications, the results of previous investigations into lip prints are scanty. This pattern contains only such furrows that occur on the greatest number of lip prints obtained from the same person, where these furrows' locations and inclinations remain similar across the lip prints obtained. It should be noted that in approach, instead of lip photos lip prints are employed which can be obtained at a crime scene. It is worth noticing also that a new method is introduced for personal identification were, instead of popular machine learning methods, the furrow-analysis of lip prints. According to the authors' convictions, based on reports in the literature, the proposed approach describes for the first time a strategy as to how lip print structures could be analyzed in biometric applications.

Porwik et al [16] proposed a classification method based on an ensemble of binary classifiers. This strategy consists of two phases: (1) the competence of the base

heterogeneous classifiers in a pool is determined, and (2) an ensemble is formed by combining those base classifiers with the greatest competences for the given input data. Results showed that the competence of the base classifiers can be successfully calculated even if the number of their learning examples was limited. Such a situation is particularly observed with biometric data. New biometric data structure is introduced in which the Sim coefficients, along with an efficient data processing technique involving a pool of competent classifiers chosen by dynamic selection. A public dataset retrieved from a biometric repository was used to test the quality of the proposed approach. All the results clearly showed the remarkable performance of ensembles generated by proposed dynamic base-classifier selection, an approach which outperformed all other methods. The proposed ensemble-based strategy demonstrates higher recognition accuracy.

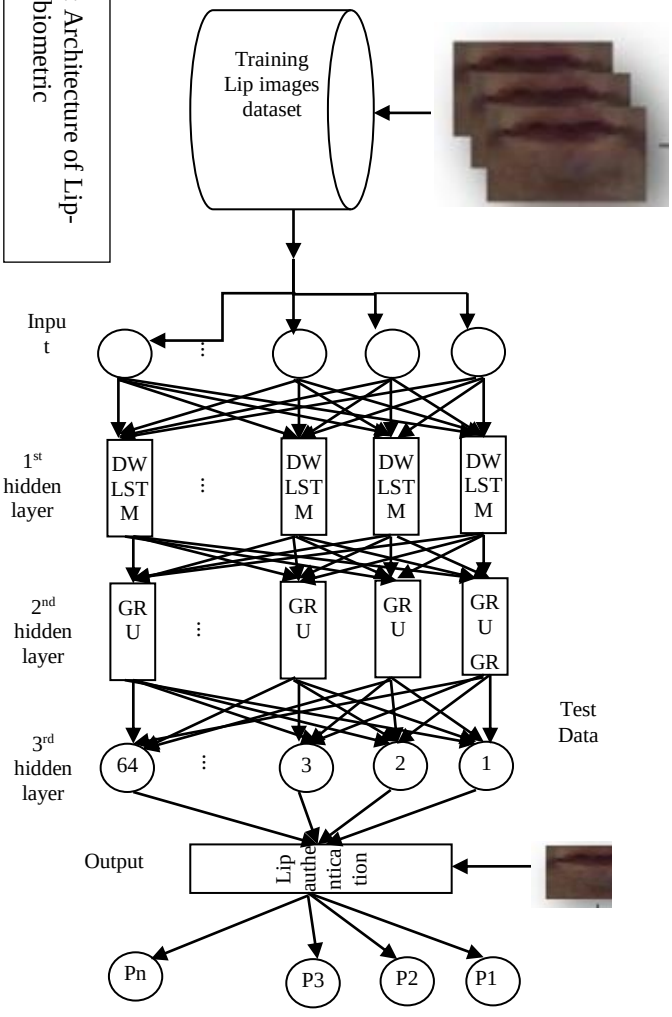
Wright et al [17] investigated using lip movements as a behavioural biometric for person authentication. The system was trained, evaluated and tested using the XM2VTS dataset, following the Lausanne Protocol configuration II. Features were selected from the Discrete Cosine Transform (DCT) coefficients of the greyscale lip image. DCT coefficients are selected, the selection process, and static and dynamic feature combinations. Using a Gaussian Mixture Model (GMM)- Universal Background Model framework an Equal Error Rate of 2.20% was achieved during evaluation and on an unseen test set a False Acceptance Rate of 1.7% and False Rejection Rate of 3.0% was achieved. This compares favourably with face authentication results on the same dataset whilst not being susceptible to spoofing attacks.

In the last decade researchers have focused on the use of hybrid intelligent systems for classification. For such systems, various computational-intelligence techniques have been proposed to solve realistically complex problems as seen in the fields of medical diagnosis and biomedical technology, image analysis, biometrics, banking, data analytics and many others. Hybridization techniques have mostly been inspired by the human behavioral system because it integrates information from different parts of the body before finally coordinating the activity of all of the body's parts. In the technical sciences, this approach can be analogously treated as a hybrid composition of many diverse computational units which together help to form an ultimate decision. The major aim of the work is to design hybrid classification systems for biometric authentication of users based on the lip. This system is developed based on the deep learning classifier and implemented for real-time data.

Proposed Methodology

In this paper, Lip-Based Biometric Authentication (LipBA) is introduced for used authentication and could be expected on lip-based solutions deployed on a mobile device. The proposed system is performed based on three major steps such as (1) database collection, (2) lip biometric authentication, (3) Performance evaluation. In the initial step, 5000 live lip video frames in real time for 10 persons are collected from video with image size of 81x48. Second step, efficient lip based biometric authentication is then used to authenticate lip with a known database. For real time LipBA, hybrid

Fig.2.: Architecture of Lip-based biometric



Divergence Weight Long Short Term Memory (DWLSTM) and Gated Recurrent Unit (GRU) based network for financial services. The input images are fed into the DWLSTM classifier and then the result of this classifier is fed into GRU algorithm for authenticating the particular person. Hybrid systems should validate the claim on real time data depending upon the person into yes and no. Results confirmed by a LipBA system using real time dataset are compared to existing systems via the metrics like precision, recall, f1-score, and accuracy. The overall architecture of the proposed system is shown in figure 2.

In this work, 5000 live lip video frames in real time for 10 persons are collected with image size of 81x48. The dataset consists of 5000 Live Lip Video frames of 10 Persons. Each Person's Live lip of 500Video frames extracted. Ten persons dataset consists of 500*10=5000 Video frames of Live Lip.

Lip-Based Biometric Authentication (LipBA)

At first, all the images of the dataset are used as the input of the LSTM layer. LSTM is the first hidden layer. Each DWLSTM neuron collects the data and along the path, a weighted value is generated. Image is then passed from the DWLSTM layer to the GRU layer which is the second hidden layer. Again, a weighted value is generated along the path from the DWLSTM layer to the GRU layer. Similarly, data is then passed to the dense layer which is the third hidden layer. A weighted value is generated from GRU to the Dense layer. The dense layer is a normal neural network layer that we have used to produce the output. From the third hidden layer, the image is then passed to the output neuron and weight is generated correspondingly. The output is then compared with the original value to find out the error function. The weighted values are then updated according to the difference of the actual value and predicted value until it reaches the minimum point of the cost function and weights are then saved for future predictions and the system's performance is measured.

Divergence Weight Long Short Term Memory (DWLSTM) classifier

In this work, Divergence Weight Long Short Term Memory (DWLSTM) classifier is introduced to solve the limitations of long-term dependencies in general classifier, a linear self loop memory cell that showed data values through the lip biometric based authentication [18, 19]. The memory cell is moderated through the amount of lip biometric flow in and out from the cell. Instead of a simple Recurrent Neural Network (RNN) unit, a DWLSTM unit has a memory cell that has state $c_t \in R^K$ at time t. Through the memory cell, the lip biometric image is flowed and controlled by three gates such as an input gate secondly a forget gate and finally an output gate. The input gate $x_t \in R^K$ controls the flow of lip biometric images into the cell. Forgetting memory cell is controlled by the $f_t \in R^K$ forget gate and the output gate $o_t \in R^K$ modifies the output flow from the memory cell. The element wise sigmoid function of a vector by σ and the element wise product of two vectors by the three gated are all the sigmoid units that sets each and every element gate value from 0 and 1 [20,21].

Each memory cell in the DWLSTM neuron stored other lip biometric image that maintains cell state of its own. Whereas, the neurons in normal RNNs merely consider their previous hidden state and the present output input state to a new hidden state. The DWLSTM neuron considers its old cell state and the outputs of its new cell state. The DWLSTM consists of cell state, input gate, hidden state, Forget gate, and output gate.

Forget gate: The forget gate decides when specific portions of the cell state are to be replaced with more recent information. Its outputs values, close to 1 of the cell state should be retained, and zero for values that should be neglected.

Input gate: Based on the input output o_{t-1}, input x_t , and previous cell state c_{t-1}, the network learns the conditions under any information that should be stored or updated in the cell state.

Hidden state (h_t): It is calculated by multiplying output gate vector by cell state vector

Output gate: Depending on the input and cell state, output gate decides which information is propagated forward where the output $o_t$and cell state c_t to the next node in the network. Thus, for exploring the variations in lip biometric image, an ideal DWLSTM affects the biometric authentication of other user's images over a long term of time. The dynamic fashion for long biometric about specific person lip image needs to retain property in order to authenticate images. The results obtained for the proposed DWLSTM model with a calculation of weight values via the entropy are evaluated and discussed in this section.

Cell state: 1D vector of fixed shape with random value initialization. It contains the information that was present in the memory after the previous time step. DWLSTM architecture consists of five main parts (Figure 3).

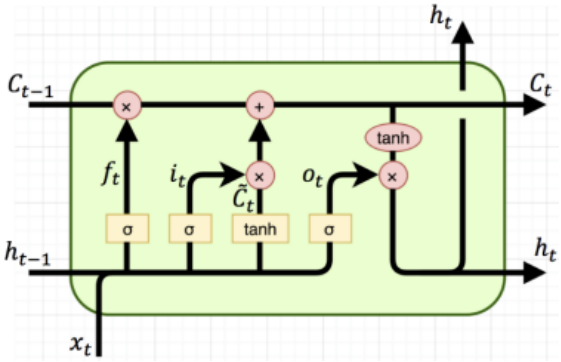


Fig. 3: A Single Cell EWLSTM Architecture

These three layers play an important role in activation function. The activation function decides whether the neuron should be activated or deactivated. The activation function does the non-linear transformation to the input making it capable to perform more complex tasks. The values of these vectors are calculated by the Equations (1)– (5)[22],

$$i_t = \sigma\left(W^{(i)}x_t + U^{(i)}h_{t-1} + b^{(i)}\right) \quad (1)$$

$$f_t = \sigma\left(W^{(f)}x_t + U^{(f)}h_{t-1} + b^{(f)}\right) \quad (2)$$

$$o_t = \sigma\left(W^{(o)}x_t + U^{(o)}h_{t-1} + b^{(o)}\right) \quad (3)$$

$$c_t = i_t \odot u_t \odot f_t \odot c_{t-1} \quad (4)$$

$$h_t = o_t \odot \tanh(c_t) \quad (5)$$

where x_t is input vector, c_{t-1} is previous cell state, h_{t-1} is previous hidden state, W and U are input-to-hidden and hidden-to-hidden weight matrices, σ is the logistic sigmoid function, and ⊙ denotes the element-wise multiplication. Weighting features plays a major important role in the biometric authentication that each image has the different importance with respect to the target concept. In order to calculate the weight value of each image in the authentication system, let us assume that when a certain feature value is observed, it gives a certain amount of information to the target class. The amount of information that a certain feature value contains is defined as the discrepancy between prior and posterior distributions of the target class. Kullback-Leibler (KL) is measure of divergence and the range of a feature value f_{ij} is calculated with the use of the KL measure by equation (6).

$$KL(C|f_{ij}) = \sum_{C} P(c|f_{ij}) \log\left(\frac{P(c|f_{ij})}{P(c)}\right) \quad (6)$$

where f_{ij} means the j value of the i^{th} feature in training biometric image dataset. The feature weight is able to be defined as the weighted average of the KL measures across the feature values. Therefore, the weight of feature i for images, denoted as $fw_{avg}(i)$ by equation (7),

$$fw_{avg}(i) = \sum_{j|i} P(f_{ij}) \cdot KL(C|f_{ij}) \quad (7)$$

In this equation (7), $P(fr_{ij})$ means the probability that the feature i has the value of f_{ij}. Above weight $fw_{avg}(i)$ is biased towards feature with many values. The final form of the weight of feature i, denoted as fw(i) is defined by equation (8),

$$fw(i) = \frac{\sum_{j|i} P(f_{ij}) \sum_{c} P(c|f_{ij}) \log\left(\frac{P(c|f_{ij})}{P(c)}\right)}{-Z. \sum_{j|i} P(f_{ij}) \log\left(P(f_{ij})\right)} \quad (8)$$

where Z is a normalization constant

which is computed by equation (9),

where n represents the number of images in training data. In this work, the normalized version of fw(i) (Equation (9)) is given so as to ensure that $\sum_i fw(i) = n$. Finally, this weight value is updated to each gate in the DWLSTM classifier.

Recurrent Neural Network (RNN)

Recurrent Neural Network (RNN) is a kind of artificial neural network which is suitable for analyzing and processing image based on the weight connection between the layers. Gated Recurrent Unit (GRU) is a variant of LSTM with a gated recurrent neural network structure, and comparing with LSTM, there are two gates (update gate and reset gate) in GRU and three gates (forgetting gate, input gate, and output gate) in LSTM; for the moment, GRU has fewer training parameters than LSTM, so GRU converges quicker than LSTM during training [23]. The GRU structure is shown in Figure 4, where σ and tanh are the activation functions, $c^{\langle t-1\rangle}$ is the input of the current unit, which is also the output of the previous unit, $c^{\langle t\rangle}$is the output of the current unit, which links to the input of the next unit . $x^{\langle t\rangle}$ are the inputs of training data, $\hat{y}^{\langle t\rangle}$is the outcome of this unit, generated by the activation function, and represent the reset gate and the update gate, respectively, and the candidate activation $\tilde{c}^{\langle t\rangle}$is computed similarly to that of the traditional recurrent unit. There are two gates in GRU, one is the update gate, which preserve previous information to the current state; The value of $\Gamma_u$ranges from 0 to 1, the closer Γ_u is to zero, the more previous information it retains; the other is the reset gate, which is used to determine whether the current status and previous information are to be combined. The value of Γ_r ranges from –1 to 1, the smaller the value of Γ_r , the more previous information it ignores [24].

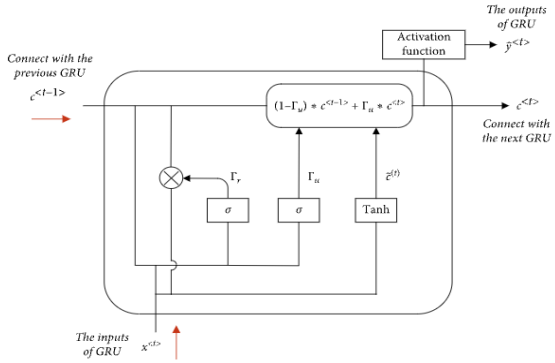


Figure 4. A General Architecture of a Single GRU Cell

According to Figure 4, the equations of GRU can be shown by equation (10,11,12, and 13),

$$\Gamma_u = \sigma(\omega_u[c^{\langle t-1\rangle}, x^{\langle t\rangle}] + b_u) \quad (10)$$

$$\Gamma_r = \sigma(\omega_r[c^{\langle t-1\rangle}, x^{\langle t\rangle}] + b_r) \quad (11)$$

$$\tilde{c}^{\langle t\rangle} = \tanh(\omega_c[\Gamma_r * c^{\langle t-1\rangle}, x^{\langle t\rangle}] + b_c) \quad (12)$$

$$c^{\langle t\rangle} = (1 - \Gamma_u) * c^{\langle t-1\rangle} + \Gamma_u * \tilde{c}^{\langle t\rangle} \quad (13)$$

where ω_u , ω_r, and ω_c represent the training weight matrix of the update gate, the reset gate, and the candidate activation$\tilde{c}^{\langle t\rangle}$, respectively and b_u, b_r, and b_c are the bias vectors.

Results and Discussion

This section makes the performance comparison of the proposed system and existing methods via the real time dataset collected from lip biometric images. For experimentation, the Live Lip Dataset is collected from Annamalai University Deep Learning Lab via the use of Webcam in laptop. The Webcam is opened using python executable code in Jupyter notebook code and the real time dataset is collected for ten different persons. In Live Lip Dataset, 5000 live lip video frames are collected from 10 persons with image size of 81x48. The dataset consists of 5000 live lip Video frames of 10 Persons. Each Persons Live lip of 500Video frames extracted. Ten persons dataset consists of 500*10=5000

Video frames of Live Lip. The authentication methods are implemented via the use of Ananconda with Jupyter notebook in windows. The system is performed based

on Intel Core I3 processor with 500 GB hard disk, 1 GB RAM. The results of the proposed system and the existing methods such as Support Vector Machine (SVM), and Probabilistic Neural Network (PNN) are measured via the metrics like macro precision, macro recall, macro f1-score, and accuracy. These metrics have been generated via a confusion matrix. A confusion matrix needs to be computed for each class $g_i \in G = \{1, \dots, K\}$, in such a way that the ith confusion matrix assumes class $g_i$as the positive class and the remaining classes g_j with $j \neq i$ as negative class. As each confusion matrix pools together the entire observations labelled with a separate class apart from $g_i$as the negative class, this method increases the number of true negatives. This gives us:

- "True Positive (TN)" for event values that are correctly analyzed.
- "False Positive (FP)" for event values that are incorrectly analyzed.
- "True Negative (TN)" for no-event values that are correctly analyzed.
- "False Negative (FN)" for no-event values that are incorrectly analyzed.

Let us TP_i, TN_i, FP_i and $FN_i$to indicate the true positives respectively, true negatives, false negatives and false positives, in the confusion matrix associated with the i[th]class. Let the recall here be indicated by R and precision by P.Micro average pools the performance over the least possible unit. It is computed by equation (14,15),

$$P_{micro} = \frac{\sum_{i=1}^{|G|} TP_i}{\sum_{i=1}^{|G|} TP_i + FP_i} \quad (14)$$

$$R_{micro} = \frac{\sum_{i=1}^{|G|} TP_i}{\sum_{i=1}^{|G|} TP_i + FN_i} \quad (15)$$

The micro-averaged precision, P_{micro}, and recall, R_{micro}, give rise to the micro F1-score. It is computed by equation (16),

$$F1_{micro} = 2.\frac{P_{micro}.R_{micro}}{P_{micro} + R_{micro}} \quad (16)$$

Given that a classifier gets a large$F1_{micro}$, it denotes that it performs exceedingly well. Here, micro-average may not be sensitive to the overall predictive performance. Due to this, the micro-average can be misleading when there is an imbalance in the class distribution.

Macro average averages over bigger groups and over the performance of individual classes than observations. It is computed by equation (17,18),

$$P_{macro} = \frac{1}{|G|}\sum_{i=1}^{|G|} TP_i / TP_i + FP_i \quad (17)$$

$$R_{macro} = \frac{1}{|G|}\sum_{i=1}^{|G|} TP_i / TP_i + FN_i \quad (18)$$

The recall and macro-averaged precision leads to the macro F1-score. It is computed by equation (19),

$$F1_{macro} = 2.\frac{P_{macro}.R_{macro}}{P_{macro} + R_{macro}} \quad (19)$$

If $F1_{macro}$ has a bigger value, it points out to the fact that a classifier is able to perform well for each of the individual class. Multi-class accuracy is termed as the average of the correct predictions. It is computed by equation (20),

$$accuracy = \frac{1}{N}\sum_{k=1}^{|G|}\sum_{x:g(x)=k} I(g(x) = \hat{g}(x)) \quad (20)$$

where I is defined as the indicator function, which returns 1 when there is a match between the classes and 0 otherwise. The proposed system is tested with real-time video for varying numbers of hidden layers. For authentication, 5000 images are extracted from the live webcam and it is used to evaluate the performance of the system for consecutive 'n' images (n= 1, 3, 7 and 10). Similarly, when the model is tested for every 3 frames and 7 frames gives 90.32% and 92.17% respectively. The proposed model with three dense layers achieves an accuracy of 94.15% for every 10

frames. Among the classifiers, the proposed algorithm gives the highest validation accuracy

and these models are tested in the real time video to evaluate the performance of the system.

Table 1. Performance of Lip Authentication for Real-Time Video

Methods	n=1(in %)	n=3(in %)	n=7(in %)	n=10(in %)
SVM	75.62	78.32	81.32	84.21
PNN	78.22	81.21	83.12	85.78
LSTM	82.12	85.63	87.41	90.14
GRU	84.52	86.93	90.36	92.75
DWLSTM AND GRU	88.36	90.32	92.17	94.15

Performance analysis

The performance of the classifier can be evaluated using measures like precision, recall, F1-score, and accuracy. The precision, recall, F1-score, and accuracy for real-time testing images are shown in Table 2 for every 10 consecutive person images.

Table 2. Performance Evaluation Metrics Under Authentication Methods

METHODS	RESULTS (%)			
	PRECISION	RECALL	F1-SCORE	ACCURACY
SVM	80.12	82.72	81.42	84.21
PNN	83.79	84.81	84.30	85.78
LSTM	87.51	89.17	88.34	90.14
GRU	89.23	91.28	90.255	92.75
DWLSTM AND	92.62	93.71	93.165	94.15

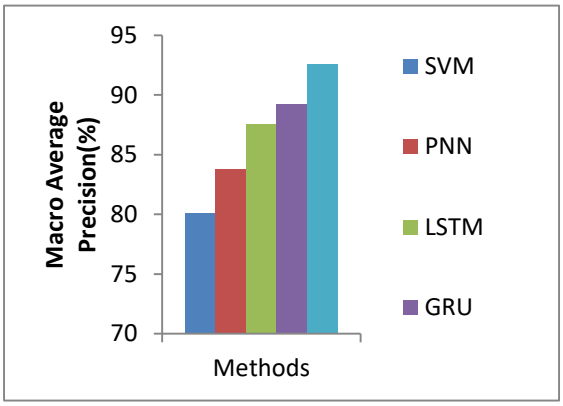
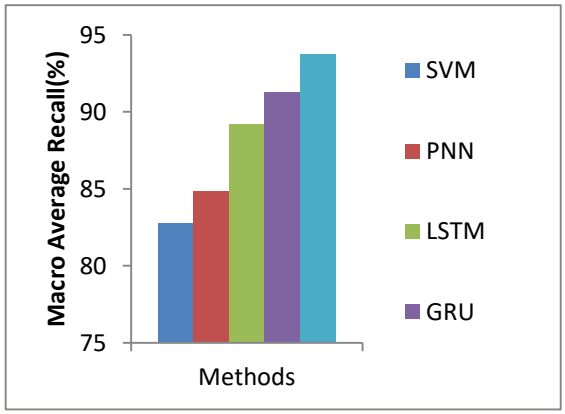


Fig. 5. : Macro Average Precision Comparison VS. Authentication Methods

The macro average precision results comparison of authentication methods such as SVM, PNN, LSTM, GRU and proposed hybrid system is illustrated in figure 5. From the results it shows that the proposed hybrid system gives higher macro average precision value of 92.62%, whereas other methods such as SVM, PNN, LSTM, and GRU gives reduced value of 80.12%, 83.79%, 87.51%, and 89.23% respectively. However, the proposed algorithm has higher results than the other methods, since the proposed algorithm hybrid classifier is introduced for



authentication.

Fig. 6. : Macro Average Recall Comparison VS. Authentication Methods

The classification methods like SVM, PNN, LSTM, GRU and proposed hybrid system with respect to macro average recall results are illustrated in figure 6. It shows that the proposed system gives higher

macro average recall value of 93.71%, whereas other methods such as SVM, PNN, LSTM, and GRU gives reduced recall value of 82.72%, 84.81%, 89.17%, and 91.28% respectively. However, the proposed algorithm has higher results than the other methods, since the proposed algorithm hybrid classifier is introduced for authentication

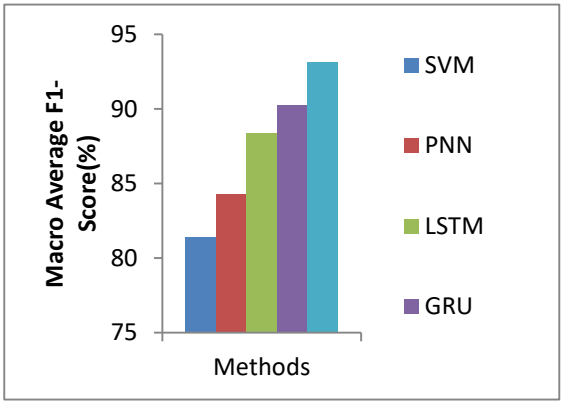


Fig. 7. : Macro Average F1-Score Comparison VS. Authentication Methods

SVM, PNN, LSTM, GRU and proposed hybrid system results evaluation via macro average f1-score are illustrated in figure 7. It shows that the proposed method gives increased f1-score value of 93.165%, whereas other methods such as SVM, PNN, LSTM, and GRU shows reduced value of 81.42%, 84.30%, 88.34%, and 90.255% respectively. However, the proposed algorithm has higher results than the other methods, since the LSTM classifier is enhanced via the use of divergence function. The proposed work gives higher importance to the features by introducing the weight value to the classifier. It makes more results than the other methods.

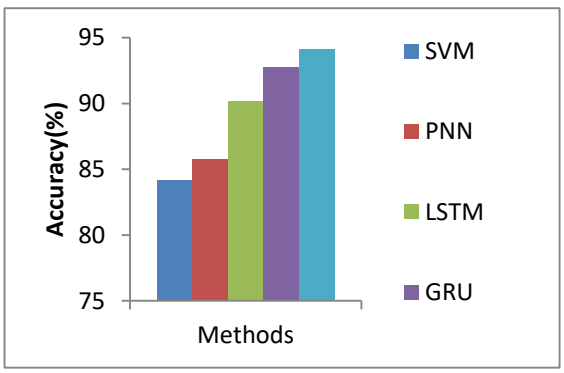


Fig. 8. : Accuracy Comparison VS. Authentication Methods

The accuracy results comparison with respect to accuracy is illustrated in figure 8. It shows that the proposed method gives increased value of 94.15%, whereas other methods such as SVM, PNN, LSTM, and GRU shows reduced value of 84.21%, 85.78%, 90.14%, and 92.75% respectively. The proposed work gives higher importance to the features by introducing the weight value and combining the GRU to the LSTM classifier.

Conclusion and Future Work

In this paper, a novel and effective lip-based biometric recognition approach introduced hybrid Divergence Weight Long Short Term Memory (DWLSTM) and Gated Recurrent Unit (GRU) namely DWLSTM-GRU. The Lip-Based Biometric Authentication (LipBA) system has been less developed than the recognition of other human physical attributes such as the fingerprint, voice patterns, blood vessel patterns, or the face. The LipBA system is unique and it can be used as a universal biometric where all individuals can use it. DWLSTM-GRU system is performed by extracting unique behavioral characteristics of users' mouths through videos on Smartphones and it is trained based on video frames for user authentication. DWLSTM-GRU authentication approach is introduced to accurately identify each individual based on the lip images. Finally, to strengthen the reliability of the authentication results of hybrid system, a divergence based weight function is used in the DWLSTM scheme for user authentication by examining the lip images with different persons. The proposed system, DWLSTM-GRU system gives better performance than the other classifiers for authenticating the lips in real-time video for mobile phones. Authentication results are measured via the metrics like precision, recall, f1-score, and accuracy. Experiments are conducted to Live Lip Dataset with 5000 live lip video frames of 10 Persons. The results show that the LipBA system can achieve 94.15% accuracy on average in user identification. In the future work, lip area is segmented via the use of Region of Interest

(ROI). The feature extraction is performed via image processing algorithms. These two steps play a major important role for increasing the results of biometric authentication; these will be left as scope of future work.

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WOMEN IN INDIAN CORPORATE BOARD - EMERGING CATALYST

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ABSTRACT

This Paper addresses the need for women representation in the corporate board and their influence on corporate Governance research that creates a credible business case for the existence of effective deployment of women corporate directors. What requires to be done to create the value of women at the corporate governance apex? Women directors contribute positively to organizations but remain significantly underrepresented in corporate board positions. The challenges women face is well-understood and less recognized. The success of women who, against considerable odds, rise above the glass ceiling and reach up to the board position in India.

Keywords: *Corporate Governance, Women on Board, challenges faced by women directors, Companies Act, 2013*

Introduction

Expanding the women participation on corporate boards stimulates heated debate around the world. In a few countries' legislation enforce their presence. Research has demonstrated that the presence of woman directors has a direct and positive effect on a company's risk administration and profits. Women director on board also broaden a company's profile. Increased gender diversity on board has been studied from many angles. This paper aims at identifying various factors which determines the influence of women on board with reference to the corporate Governance in India. It also aims at identifying the challenges women face in India to reach to the board position.

Thanks to the mandate by the Companies Act, 2013 that mandate of at least one woman on board by certain companies. As per the latest study in 2020 Women hold only 17 per cent of the board positions in India an increase of barely only 8.6 per cent (2012-13) since the law was passed. 96% of Large companies have only one-woman director representation as mandated by the Act.

As per the Global Board Diversity Tracker Egon Zehnder's report 2020 It is essential to make sure that women are being heard and they are given chances to make an impact within the company management. The need of the day is to move from counting women representation on Board to making women on Board count.

Companies should look at increasing the women on board by more than one as one woman alone cannot be a catalyst. Preferably there should be two or more as it takes time for a different voice to be heard. It is also identified that same women are represented in different companies. The research as found that woman director holds more than one board seat than 8 percent of male director in each sample. This reflects that globally and in India female directors are more likely to retain multiple board position than male counterpart. Companies need to think talent pipeline by expanding their definition of candidate ready to take up Board position by engaging with prospective women leaders and be open to hire first-time women as Board member. As per Egon Zehnder's report 2020 which surveyed 44 countries data shows that 23.30 per cent of board positions are taken by women, up only from 20.40 per cent in 2018. It was also surveyed that 89 per cent of major companies have only one woman on their board.

Gender equality is considered as most important issue by the United Nations' Sustainable Development Goals list. It is in the fifth priority list and is considered as one of the most important issue faced by 87% of companies in India according to the study conducted by Mckinsey in 2019.

Statutory Requirement in India

The Companies Act, 2013, made it mandatory for public company having paid up share capital of Rs. 100 crores or more or its turnover exceeds Rs. 300 crores as per the latest audited Balance sheet of the companies to appoint at least one-woman director from 1st April 2014. SEBI then amended the Listing Requirements and regulations On May 9, 2018, based on the recommendations of the Kotak Committee, to mandate the top 500 companies by market value to appoint at least one-woman independent director by 1st April 2019. The deadline for the next 500 was fixed as on 1stApril,2020.

Review of Literature.

Arfken, D.E., Bellar, S.L. & Helms, M.M. (2004) This study identifies whether increased gender diversity in the board reduces corporate irregularities and increases board autonomy. The result identifies various reasons which contribute to the scarcity of women who can take up board position. It further concluded that although women representation is critical, they are overlooked.

Toyah Miller and María del Carmen Triana (2009) studied that gender diverse board has positive relationship between firm performance and business innovation.

Kennedy B. Mwengei Ombaba Jackline Omuya (2016) This paper aims at identifying the impact of women director's contribution and effectiveness in Kenyan educational institution. The study identifies that gender diverse board has positive impact on the strategic control. It was also concluded that if women are appointed on the board there is increased activities and reduced conflict in the institution.

Daehyun Kim, Laura T. Starks (2016) This paper studies how the contribution of women on the board enhances the firm value. The study concludes that women on board contributes exceptional and functional expertise which is generally missing without gender diversity. This additional expertise the women bring in increases the value of the firm.

We see important and positive relationship in the current studies; some of studies suggest a positive but insignificant relationship, while other does not indicate a significant correlation between corporate governance and women representation. Most of the current research focuses on women on the board and their impact on firm performance. Almost all the current studies and literature provides incomplete and mixed findings. Hence, in this context, further empirical analysis is required to obtain definitive results regarding the influence of women on board and the challenges faced by the women to reach board position.

Objectives of the study

- To determine the influence of women director's representation on board and Corporate Governance in India.
- To Identify the challenges faced by Indian women to achieve Board of Director status.
- To give suggestions how to overcome challenges faced in India to increase the women representation on the corporate Board.

Research Methodology

Data collection:

The sample used in this study consist of careful collection of primary data from 100 individuals who are employed and have the capacity to invest in the stock market.

Limitations of the study:

The study is based on a limited sample collection from 100 individuals. Larger number of samples can be collected from wider coverage area and more variable can be used to get exhaustive result and interpretation.

Data Analysis and Interpretation

Variable	**Frequency (Yes) in %**	**Frequency (No) in %**	**Total in %**
Investment in Share market	93	7	100
Understanding the corporate Governance of a company	64	36	100
Women on Board for better corporate Governance	95	5	100
The Gender diverse board is an Innovative board	80	20	100
Women excel in soft skills that is required for the business	94	6	100
Women understands the insight of the customer and investor needs	83	17	100
Women work with empathy in workplace	92	8	100
More gender diverse board have better long-term performance	79	21	100
Do you agree that women should be given equal opportunity in the workplace to acquire skills, training, experience, and mentorship?	100	0	100
Commitment from the top to build women in key growth position and commitment of fair pay.	98	2	100
Supportive enactment of policy, procedure and by enforcement by way of Act to bring in certain percentage of women on board	91	9	100
Help women to work with flexibility and remote work option.	94	6	100
Reduce unconscious bias that hold back women in certain functional jobs	98	2	100
Leadership Skills women directors should possess to contribute for the business development and result in effective corporate Governance	90	10	100
Extreme level of confidence women directors should possess to contribute for the business development and result in effective corporate Governance	100	0	100
Networking skills women directors should possess to contribute for the business development and result in effective corporate Governance	91	9	100
Project Management skills women directors should possess to contribute for the business development and result in effective corporate Governance	89	11	100
Social interaction skills women directors should possess to contribute for the business development and result in effective corporate Governance	89	11	100
Negotiation skills women directors should possess to contribute for the business development and result in effective corporate Governance	84	16	100

People Management skills women directors should possess to contribute for the business development and result in effective corporate Governance	93	7	100
Decision making capacity women directors should possess to contribute for the business development and result in effective corporate Governance	100	0	100
women directors should share their point of view in critical situation for the business development and result resulting in effective corporate Governance	100	0	100
Team building capability women directors should possess to contribute for the business development and result in effective corporate Governance	95	5	100

- 93% of the respondent accepted that they invest in stocks and in share market and 7% denied investment in stock market.
- 64% of the respondent read and understand corporate governance parameters before investing in the share market and 36% of the respondent does not read corporate governance parameter before investing in the stock market.
- 95% of the respondent agree that women director on the board of company bring in better corporate governance in a company and 5% disagree the same.
- 80% of the respondent agree that gender diverse board is an innovative board and 20% of the respondent disagree that gender diverse board is an innovative board.
- 94% of the respondent agree that women generally excel in soft skill that is required for business development. 6% of the respondent disagree the same.
- 83% of the respondent agree that women understand the insight of the business and customers more effectively and 17% of the respondent disagree the same.
- 92% of the respondent agree that women work with empathy in workplace which enhances the business needs and 8% of the responded deny that empathy is need in the workplace.
- 79% agree that increased gender diverse board have better and improved long-term performance. 21% of the respondent disagree the same.
- 100% of the respondent agree that women should be given equal opportunity in the workplace to acquire required skills, training, experience, and mentorship to get elevated to board position.
- 98% of the respondent agree that commitment by the top management to build women in key position and ensure fair pay is required in comparison with the fellow gender and 2% of the respondent disagree this statement.
- 91% of the respondent agree that Supportive enactment policy, procedure and by enforcement by way of Act to bring in certain percentage of women on board will help in female representation in the board. 9% disagree that enactment can bring in change in women representation on board.
- 94% of the respondent agree that women should be given flexible and remote work option to grow in the company. 6% of the respondent disagree this option will help women grow in the corporate ladder.
- 98% of the respondent agree that unconscious bias in holding back women in certain functional job reduce their chance to grow up in the corporate leadership position. 2% of the respondent disagree the same.
- 90% of the respondent agree that leadership skills are must for the women director to possess to enhance the corporate governance of a company.

10% of the respondent disagree the same.

- 100% of the respondent agree that building confidence is the key skill women director should possess to enhance the effectiveness of the corporate governance.
- 91% of the respondent agree that Networking is the key skill that women director should possess to build and enable effective corporate governance and 9% of the respondent disagree the same.
- 89% of the respondent accept that project management skills are the key skill that women director should possess and 11% of the respondent reject this statement.
- 89% of the respondent concur that social interaction skill is important quality women director should have to ensure effective corporate governance. 11% of the respondent does not agree to the same.
- 84% of the participant accept that Negotiation skill women director should possess for effective corporate governance. 16% of the participant reject this as they consider this skill is not important to improve corporate governance.
- 93% of the respondent agree that people management expertise is important for women director on the board for effective corporate governance. 7% of the respondent disagree the same.
- 100% of the respondent agree that decision making skill is key for women director to function effective and to enhance corporate governance.
- 100% of the respondent agree that women director should share their unbiased point of view in important decision and situation for effective corporate governance.
- 95% of the respondent agree that team building capacity is important for women director for effective corporate governance and 5% of the respondent disagree that team building quality is not important for effective governance.

Variable	**Frequency (Women) in %**	**Frequency (Men) in %**	**Frequency (Both) in %**	**Total in %**
Speaking effectively in the leadership meeting	51	28	21	100
Maintaining work & life balance	76	13	11	100
Building effective relationship with colleagues	43	35	22	100
Bringing in transformative change in the business	51	30	19	100
Emotional Balance at workplace	64	27	9	100
Sound decision making capacity for commercial transaction	31	45	24	100
Handling high and extreme pressure situation	43	40	17	100
Logical decision-making capacity during rough and tough situation	57	26	17	100
Team building capability	56	23	21	100
Striking a work life balance, balance between family commitment and career advancement	76	10	14	100

- 51% of the respondent feel that women speak effectively in the leadership meeting. 28% of the respondent agree that men speak effectively in the leadership meeting and 21% of the respondent opine

that both men and women speak effectively in the leadership meeting.

- 76% of the respondent agree that women maintain better work life balance. 13% of the respondent believed that men better maintain work life balance and 11% of the respondent opine that both men and women maintain work life balance.
- 43% of the respondent opine that women build effective work relationship with their colleagues. 35% of the respondent were of the opinion that men build effective work relationship with their colleagues and 22% feel that both men and women build effective work relationship with their colleagues.
- 51% of the respondent believed that women bring in transformative changes in the business, 30% of the respondent agree that men bring in transformative changes in the business and 19% of the respondent feel that both men and women bring in transformative changes in the business.
- 64% of the respondent were of the opinion that women maintain emotional balance at work, 27% of the respondent opine that men maintain emotional balance at work and 9% of the respondent feel that both men and women can maintain emotional balance at work.
- 31% of respondent were of the opinion that women have the capacity to make sound commercial decision required for the business, 45% of the participant agree that men only have the capacity to make sound commercial decision and 24% of the respondent feel that both men and women can take sound commercial decision required for the business and company.
- 43% of the respondent agree that women can handle high and extreme pressure situation at work, 40% of the participant believe that men only can handle high and extreme pressure situation at work and 17% of the respondent agree that both men and women can handle high and extreme pressure situation at work.
- 57% of the participant opine that women can make logical decision during rough and tough times in the company, 26% of the respondent feel that only men can take logical decision during rough and tough times in the company and 17% agree that both men and women can take logical decisions during tough times for the company and business.
- 56% of the respondent feel that team building capacity is well done by the women, 23% of the respondent agree that men are better in team building capabilities and 21% feel that both men and women agree that both men and women are good at team building capabilities.
- 76% of the respondent were of the opinion that women strike better work life balance between family commitment and career advancement, 10% of the respondent believe that men can strike better work life balance between family commitment and career advancement and 14% of the respondent agree that both men and women strike balance between family commitment and career advancement.

Findings of the study

- The above data analysis clearly shows that gender diverse board brings in lots of positive changes to the development of the company.
- It brings different perspective in which each aspects of the company decision are taken.
- 95% of the respondent agrees that more women on board brings in better corporate Governance.
- The respondents agree that women need to overcome the challenges faced to increase the participation of women on the board.
- Various suggestion was identified to improve the women participation in India to increase the Gender diversity on board.

Suggestions

- Supportive enactment and policies by the Government by fixing certain percentage women participation on board will help in increasing the Gender diversity.
- Adequate training to women employees in various areas like soft skills, Team building, leadership quality, logical

reasoning, emotional balance, and Commercial sense will help in more women getting into leadership position and eligible for board position.

- Top management commitment to employ and recommend women in leadership position will help increasing eligible women employees in board position.

Conclusion

The mere presence of women that causes better performance or it is better performing companies that can afford to take on their board more women in order to look be better Governed. Any which ways it makes good sense of business to have more women on board and increased Gender diversity.

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A BAYESIAN MODEL ON COMPARING CALL RECOMMENDATIONS IN TRADING OUTCOMES – META ANALYTIC APPROACH

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ABSTRACT

Investment consulting plays a major role in any individual or corporate financial planning. Competent consultants research on technical analysis of different companies and stocks. This work has aimed to study plausible models for investment advisories recommended through a trading strategy. The data is extracted from a reputed stock consulting firm for the year 2020. This study incorporates the essential module of Bayesian approach, construction of priors, suitable inferences using posterior distribution of the parameters. It is observed that the recommendations made for sell call has higher odds for profit in the outcomes and a source of heterogeneity has been observed across the stratification variables.

Keywords: *Bayesian, heterogeneity, Investment consulting, stratification variables, trading.*

INTRODUCTION

The History of Stock exchange in India dates back to the mid-19th Century. In 1830's trading was permitted in the private shares in Bank and Cotton presses across Bombay. Initially there were only a few traders. In the year 1875 were the informal group of 250 share brokers organised themselves as an association named NSSA (Native Stocks and Share Association) which was later called the Bombay Stock Exchange (BSE).

Premchand Roy Chand was the founder of NSSA, made a fortune in the stockbroking business and came to be known as the Cotton King, the Bullion King or just the Big Bull. He assisted in setting out traditions, conventions, and procedures for the trading of stocks at Bombay Stock Exchange and they are still being followed. In 1957 August 31st, BSE became the first stock exchange to be recognized by the Indian Government under SCRA - The Securities Contracts Regulation Act. The National Stock Exchange (NSE) was established in the year 1992 as the first dematerialized electronic exchange in the country. Hence NSE became the first exchange in the country to provide a fully automated screen-based electronic trading system offering easy trading facilities throughout the nation, for more details refer https://www.nseindia.com/.

The primary function of a stock broker is to be a point of contact or middle person between client and stock exchange. The primary role is to assist clients in making informed investment choices. They extend every possible help to assist clients to invest in securities effectively and earn the best return on their investment. One of the most basic responsibilities of a stockbroker is to buy stocks on behalf of his client. A share broker will also help his clients by forwarding tips and market news on best deals to make their investment process easy. They understand the client's needs and financial goals and accordingly guide them with the best investment opportunities.

This study aims at proposing performance metric for a stock broker based on the recommendations. This work provides a vast scope to acquire better understanding from the data, when considering the association of appropriate variables. The prime goal of analysing the data lies in quantifying the associations by applying suitable statistical models. In some cases, the data needs to be treated suitably so that the statistical models could be applied to obtain information from the data. This study has made an attempt, using the dataset received from a stock trader for the year 2020. The analysis plans have been framed using Bayesian statistical modelling. It includes a selection procedure for the variables and to study the association and to quantify the association.

The study has largely concentrated on multiple 2 x 2 contigency tables. Measure of association between the variables of interest is attained through odds ratio and observing the

variability could be reached through measure of heterogeneity. It is observed that the recommendations for sell call have higher odds for profit in the outcomes across months and entry rate classification. A positive measure of heterogeneity could be observed across two stratification variables.

In the current times, a qualitative statistical analysis on a wide spread areas of interest emerging from multi centric studies is quite commonly seen in epidemiology, medical, social, clinical trials, sports etc., Sutton, A. J., & Higgins, J. P. (2008), Hardy, R. J., & Thompson, S. G. (1998), Costantini, D., & Møller, A. P. (2013), Sacks, H. S et al. (1996), Lunn, D., et al. (2013) are less but distinctly explanatory work. Random effect model has been used as a parameter estimation procedure. The output summaries derived from posterior distributions was done using MCMC (Markov Chain Monte Carlo) methods Lavielle & Lebarbier (2001). Stan language has been used to carry out the Bayesian analysis using R (Carpenter, B., et al. 2017).

Description of the data set has been presented in section 2; the models and the methodology which has been applied in this study is in detail presented in section3; data analysis and summary have been explained in detail in section4; conclusions are clearly given in section5 which is derived from the analysis.

DATASET DESCRIPTION

The data set considered in this analysis is received from a firm, involved in providing live trading calls using the NSE and BSE data. The CUE application which was introduced by the trader provides a better understanding about the share market so as to make more earnings, which is additionally, supported with analytics and visualization alerts. When there is a requirement in investigating the data, focus lies in understanding the variables and the association between the variables of interest. The initial process is to understand the nature of the dataset considered in the study. This is a one-year dataset from 1st Jan 2020 to 31st Dec 2020 which has 23 variables of which 13 are categorical in nature. Table 1 summarizes the basic information explaining the variable and its description.

Table1: Explanation of the variables in the dataset.

S.No.	Variable	Explanation
1	Product_Type	Segment Codes
2	Status_symbol	Call Sequence
3	Call_Status	Buy / Sell status when the call is initiated
4	Call_Result	Outcome status - P or L
5	Entry_Rate_C	Classification of Entry_Rate
6	Segment	Name of the segment
7	Quar	Quarter (Jan - Dec) of the transaction
8	Outcome	Classification of Outcome
9	Alerts	Whether the call has Alert
10	Direct_Tgt	Whether the call yields Tgt2 directly
11	Tgt1	Whether the call has Tgt1
12	Net_Result	Outcome status - P or L
13	Stocks	Name of the stock
14	Stk_OPN_Date	Date of a stock when opened
15	Stk_CLS_Date	Date of a stock when closed
16	Call_Amount	Outcome value - P/L in INR
17	Net_Return	Outcome value - P/L after deduction in INR
18	Entry_Rate	Rate when the call is initiated
19	Month_Num	Number 1 - 12 corresponding to a month
20	Year	Year of the transaction
21	St_date	Date of a stock open (Start)
22	Ed_date	Date of a stock closed (End)

23	Day_Diff	No of days a stock kept open

This dataset having 6111 observations of which 13 are factor variables. In this study typical outcomes of profit and loss are to be considered. While considering the loss outcomes, the response variables are stop loss and exit loss which comes under the category outcome. Stop loss is a rate which indicates a reverse in the market. Exit loss occurs when the current market price is less than the call rate. While considering the profit outcomes, the response variables are Alerts, target1, trailing stop loss and exit profit. The variable alerts, which is a factor variable having two levels 1 and 0. If the call had an alert it is 1 otherwise it is 0. The variable Target1 is the rate, which the system would indicate and safe traders may decide to exit the stock. Total number of Target1 calls achieved is about 45%. Exit profit occurs when the current market price is more than the call rate. Trailing stop loss indicates an inverted U turn in a bullish market. Safe traders may decide to exit the stock and the system would close the call.

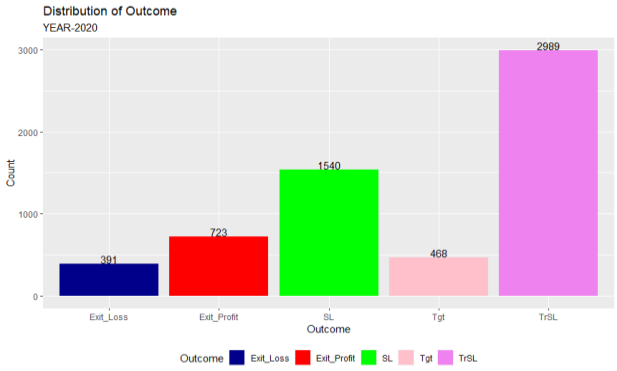


Fig. 1 The variable outcome has five levels of which two are loss outcomes and the other three are profit outcomes.

Fig. 1 explains the outcome variable, which is a factor variable having 5 levels (Target, Trailing stop loss, Exit loss, Exit profit, Stop loss). The levels Exit loss and Stop loss are loss outcomes whereas the other three outcomes are profit outcomes.

The first variable is product type which is represented as 1- cash, 2- futures, 4-options, 8-index listed under the variable segment. Status symbol is another variable which represents the call sequence having 12 levels and is then followed by call status.

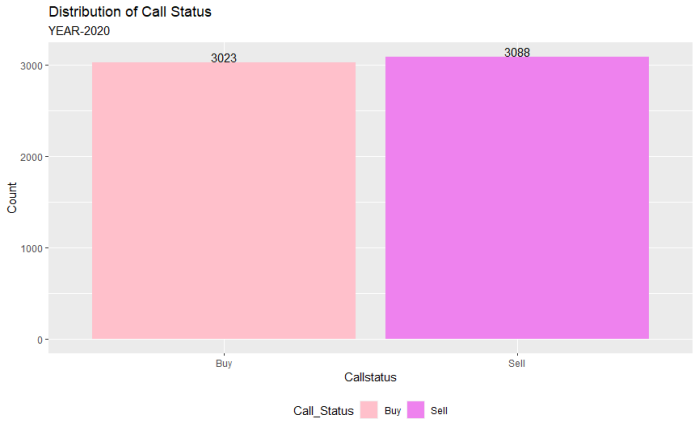


Fig. 2 Call status is the recommendations which are given for buy call and sell call.

Fig. 2 represents the call status, whether the call is buy call or sell call (two levels), which could be visualized in the above figure whereas buy call has 3023 and sell call has 3088 entries.

The next variable is the call result in which the outcome values are profit and loss. A total of 4180 outcomes ended up in profit and 1931 ended up in loss, which indicates that 68% of the outcomes resulted in profit. Entry rate is the rate when the call is initiated, which is metric in nature and is treated as categorical variable using appropriate rules. The levels after treatment are <=500, 501-1500, 1501-2500, 2501-3500, 3501-4500, 4501-5500, >5500.

Then follows the variable Quarter, representing four quarters in a year, and is then followed by the variable Direct target indicates that whether the call yields target2 directly which is a factor variable, having 2 levels (0 and 1). Only 9 calls for the direct target have been achieved. The next variable is the net result which has two outcomes profit and loss, and is calculated after deductions. It could be seen that 67% of the total number of calls made were profit, which numbers to 4107 calls.

The next variable is the name of the stock which is listed in the Indian stock market which is then followed by the date when the stock is opened and closed. Then next variable is the call amount which is the

outcome value in Indian rupee. Then followed by the variable net return indicating the outcome value, after deductions which could be profit or loss. Then follows the variable month number ranging from 1 to 12 representing twelve months, and then followed by the year which is 2020 throughout. Then follows the day difference, between the stock opened date and the closed date.

METHODS AND MODELS

This study aims in understanding the benefits of Bayesian modelling in statistical inference on categorical data analysis, which could provide a model to assess the performance metrics of an investment advisor. One of the three association measures of a typical 2x2 cross classified dataset is the Odds ratio, which is applied here to find the association between the variables of interest. Odds ratio is considered to be one of the most important effective measure in comparing binomial proportions. It occurs as a parameter in most of the models for a categorical data.

In a 2x2 contigency tables, within row 1 the odds of success is,

odds1= $\frac{\alpha_1}{1-\alpha_1}$ and within row 2 the odds of success is, odds2 = $\frac{\alpha_2}{1-\alpha_2}$

The ratio of the odds from the two rows, $\theta = \frac{odds1}{odds2} = \frac{\alpha_1/1-\alpha_1}{\alpha_2/1-\alpha_2}$ is the odds ratio. When the odds ratio is greater than 1, the odds of success are higher in row1 than in row2. When the odds ratio is less than 1, the odds of success is less likely in row1 than in row2.

In recent days, odds ratios have been widely applied in many areas which have majorly three reasons to explain the importance of it. The first important thing is, it gives an estimate (together with confidence interval) which explains the association between the two binary predictor variables. It helps in examining the effects of other variables in that relationship which uses logistic regression. It also has a very special and convenient interpretation in case-control studies.

The Bayesian method follows certain procedures which are explained as follows:

- To create a statistical model which could link data to parameters.
- To formulate prior information about parameters.
- Combining the above two sources (i.e., data and prior) using the Baye's theorem.

Finally, the result is the combination of prior information and the data to generate posterior distributions.

In the random effect model, where X_i be an estimate effect size to a corresponding true effect size θ_i and the within study variance be σ_i^2, then the modelling assumptions are,

$$X_i \sim N(\theta_i , \sigma_i^2)$$
$$\theta_i \sim N(\mu_0 , \tau^2)$$

where μ_0 is the average effect size in the population and τ^2 is the amount of heterogeneity in the effect sizes i.e., between-study variance. Here the interest lies in understanding the between variability of odds ratio estimates according to the grouping variables.

This study aims in providing the following summaries in order to have a better understanding of association between the variables of interest in the case of individual and in overall levels together with the measure of heterogeneity.

i. Point estimate and confidence interval for the true effect size θ_i.
ii. Point and interval estimates of μ_0.
iii. Amount of heterogeneity which serves as an estimate of variability measures between the strata.

DATA EXPLORATION AND ANALYSIS

This work has aimed to study plausible analytical models for investment advisories. This work has identified ample scope for Bayesian modelling to provide suitable analytical tools that could incorporate historical information through appropriate prior considerations. The first step involved in collecting dataset for the year 2020 (Jan to Dec) representing the broker's investment recommendations. Secondly, the major part is to arrive at selecting the right response variables and an appropriate procedure to treat the variables. The next task lies in finding the suitable associated variables which are

grouping and predictor variables. Finally, the dataset is represented in the form of K x 2 x 2.

The aim lies in converting the rectangular dataset received from the broker in to a 2 x 2 dataset with k levels. Ten various models have been identified. Typical outcomes for profit and loss are considered in this study. For the loss outcomes, the format is a two-fold contingency table which has levels Y_1 representing buy/sell (call_status) and Y_2 representing stop loss (SL) and exit loss (outcomes) whereas SL indicating the stop loss rate which is the limit for a bearish market. Exit is another status symbol which means the rate at which the system will close the call at current market price (CMP). It will end up in loss if the current market price is less than the call rate. Both SL and Exit loss comes under the loss outcome category.

Table 2: Data format explaining the Loss Outcomes

Y_1/Y_2	SL	Exit Loss
Buy	n_{11}	n_{12}
Sell	n_{21}	n_{22}

For the profit outcomes, the format is a twofold contingency table which has levels Y_1 representing buy/sell (call status) and Y_2 representing profit outcomes Alerts, target 1, trailing stop loss and exit profit. Target1 is the rate which the system would indicate and safe traders may decide to exit the stock. When the current market price is greater than the call rate then it results in Exit profit. The rate at which system indicates a bullish market before reaching target1 results in Alert. Trailing stop loss indicates an inverted U turn in a bullish market. Safe traders may decide to exit the stock and the system would close a call. Two models for the loss outcomes and eight models for the profit-based outcomes are achieved and the details of variables considered are presented in the table.

Table 3: Details of the variables considered in this study

Model	Grouping variable	Predictor variable	Response variable
M1	Month	Call Status	Loss outcomes
M2	Entry rate	Call Status	Loss outcomes
M3	Month	Call Status	Alerts
M4	Entry rate	Call Status	Alerts
M5	Month	Call Status	Target1
M6	Entry rate	Call Status	Target1
M7	Month	Call Status	Trailing stop loss
M8	Entry rate	Call Status	Trailing stop loss
M9	Month	Call Status	Exit Profit
M10	Entry rate	Call Status	Exit Profit

One of the major interests in statistical research is the association between variables. This would be further interesting because of confounding of a variable with others or reversibility of results. This work involves in exploring suitable Bayesian modelling with an effort to comprehend prior constructions and to prepare essential computing framework in state of art platforms for application of the modelling. Bayesian analysis for such complex models can be made quite simple using MCMC to generate posterior distributions. There are quite few essential needs for MCMC in identifying the number of chains, number of simulations, number of burn-ins and the thin period for saving the samples and finally the numbers of samples are calculated.

This study follows a normal model for a log transformed Binomial parameter. All the hyper parameters are chosen appropriately and the entire exercise has been carried out in R and R Stan. The final summary outputs are presented in the Table 4.

Table 4: Combined Odds Ratio and heterogeneity measure (τ^2) for various data sets considered in this study, together with the lower and upper limits of 97.5% confidence interval.

Model	Overall OR point estimate	Overall OR interval estimate	Heterogeneity (τ^2) point estimate	Heterogeneity (τ^2) interval estimate
M1	0.960	(0.640,1.420)	0.250	(0.110,0.550)
M2	0.870	(0.510,1.460)	0.290	(0.110,0.710)
M3	0.870	(0.670,1.120)	0.170	(0.080,0.350)
M4	0.860	(0.580,1.270)	0.230	(0.090,0.530)
M5	0.860	(0.650,1.130)	0.190	(0.090,0.390)
M6	0.810	(0.550,1.190)	0.220	(0.090,0.500)
M7	0.930	(0.680,1.270)	0.220	(0.100,0.450)
M8	0.820	(0.520,1.260)	0.300	(0.120,0.710)
M9	1.090	(0.770,1.570)	0.260	(0.110,0.560)
M10	1.180	(0.720,1.940)	0.320	(0.120,0.770)

From the table 4, it could be seen that the overall odds ratio with point estimate and interval estimate together with the variance point and interval estimate for ten various models. The overall odds ratio is less than 1 for the first eight models and the overall odds ratio is greater than 1 in model 9 and 10. Also the estimates are not statistically significant in all the models.

In model1, the overall odds ratio is less than 1 which is 0.960 indicates that the outcome of a call is loss and it is most likely to happen when the recommendations for sell call is initiated than the recommendations are made for a buy call when the analysis is carried out month wise. When the analysis is carried out entry rate wise in model 2, the sell call has higher odds for loss outcome than buy call with an estimate of 0.870 and the estimates are not statistically significant.

From model 3 onwards the outcomes are based on profit which are measured in variables such as alerts, target1, trailing stop loss and exit profit. In model 3 and 4, the outcome is profit and whether the call had an alert message. The overall odds ratio is less than 1 with an estimate of 0.870 for month wise and 0.860 for entry rate wise indicating that the sell call has higher odds for profit compared to buy call when the call received an alert message. It could be concluded that the profit outcomes had an alert message when the recommendations are made in sell call and the estimates are not statistically significant.

In model 5 and 6, the profit outcomes are analysed based on target1 which indicates that whether the call had hit target1. The overall odds ratio is less than 1 which is 0.860 for month wise and 0.810 for entry rate wise analysis, indicating that the call had hit target1 when the recommendations are made for sell call and has higher odds for profit than buy call. In the model 7 and 8, the outcomes are based on trailing stop loss indicator. The overall odds ratio for month wise analysis is 0.930 and entry rate wise analysis is 0.820 indicates that the odds are higher for profit for sell call than when the recommendation are made for buy call. The estimates are not statistically significant in both the models.

For the models 9 and 10, the profit outcomes are based on exit profit. The overall odds ratio is greater than 1 indicating that the odds are higher for profit when the recommendations for the call status resulting in buy rather than sell. This shows that the outcome results in profit when the recommendations are made for buy call which has a greater impact on the investment recommendations. When the call recommendations are initiated to buy, the outcome results in profit and also has higher odds for profit than when the recommendations are initiated to sell. This gives a clear picture to understand the recommendations of the broker. Further individual measure such as model specific overall odds ratio (θ_i) together with the confidence interval is presented in forest plot for clear visual representation. Forest plot which is a graphical display of the estimated

results from the studies could be referred more in Larry and Ingram (1985).

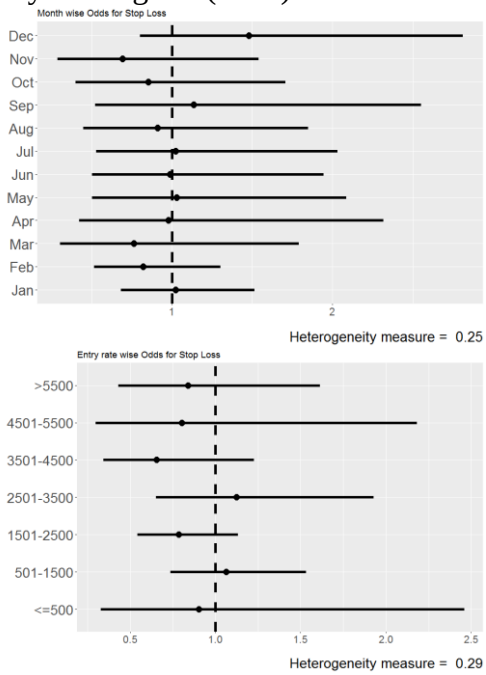
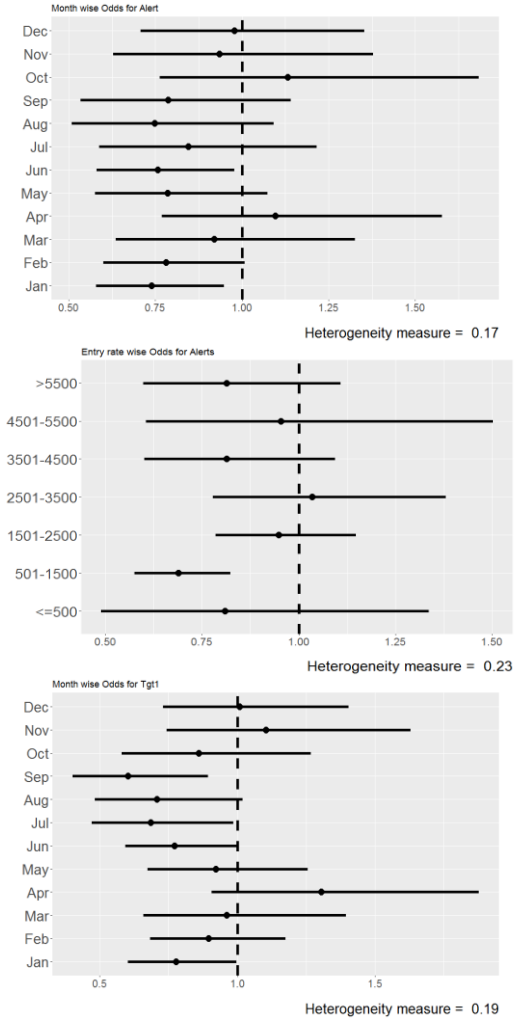


Fig. 3 Forest plot of the point and interval estimates of individual odds ratio for loss outcomes in the month wise and entry rate wise analysis.



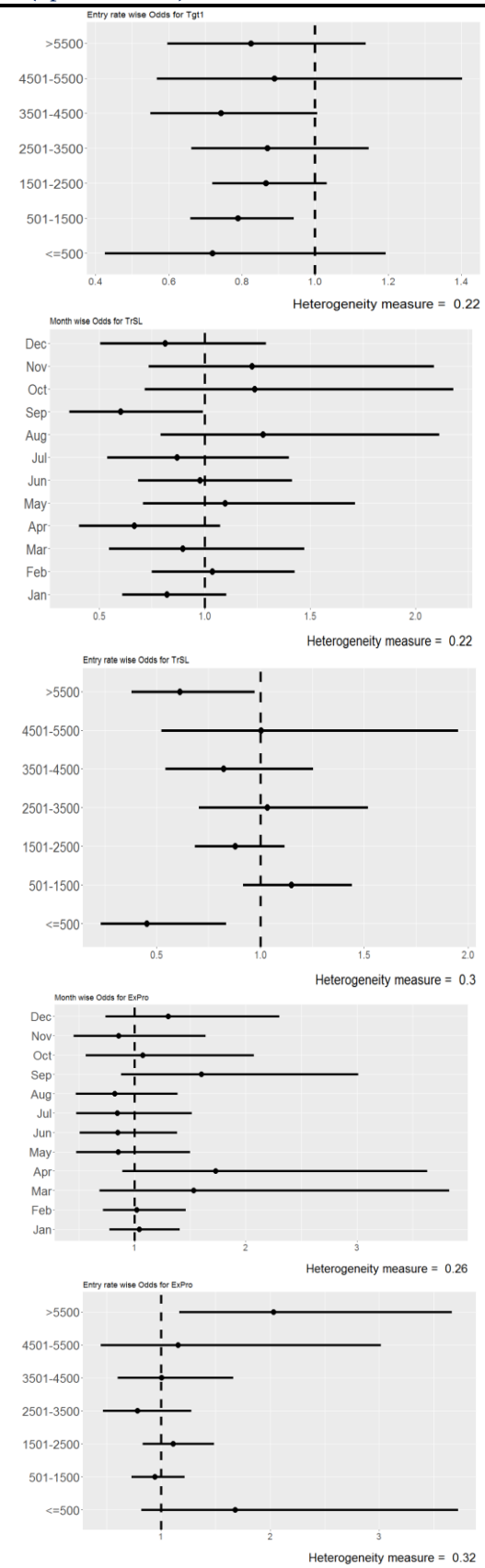


Fig. 4 Forest plot of the point and interval estimates of individual odds ratio for profit outcomes in the month wise and entry rate wise analysis.

Fig. 1 of the forest plot representing the loss outcomes in two models (month wise and

entry rate wise) has an overall estimate which is less than 1. Except for five months in the year the odds ratio is less than one, indicating that for the five months odds are higher for stop loss and the recommendations made for the buy call rather than sell call. Except for the five months the odds are higher for stop loss for sell call rather than buy call. When considering entry rate wise analysis, out of the seven categories odds ratio are more than 1 in two cases which clearly tells that the recommendations are higher for buy call than sell call. Other remaining cases it is the vice versa. A positive measure of heterogeneity could be seen in both the models which has 25% and 29% clearly indicating that variations could be seen in the relationship between call status and loss outcomes in both month wise and entry rate wise analysis.

In Fig. 2 of the forest plot which represents the profit in four different outcomes which are alerts, target1, trailing stop loss and exit profit. The plot gives a better understanding that the outcome is profit, when the call recommendations are given for buy or sell. A positive measure of heterogeneity could be observed among the variables, in which model 10 has a higher measure of heterogeneity which is 32% and, also has a wider intervals. When considering model 3 and 4 which explains for month wise and entry rate wise overall odds ratio is less than 1. Individual odds ratios are less than 1 for all the months except for April and October which explains that in these two months the odds are higher for profit in buy call recommendations. When considering the entry rate wise analysis except for one category the overall odds ratio is less than one.

In model 5 and 6 which explains the profit outcomes for target1, the overall odds ratio is less than one except in the month of April, November and December. Considering the entry rate wise for all the seven categories the odds ratio is less than one clearly indicating that the odds are higher for profit in sell call. In the model 7 and 8, which explains about trailing stop loss has an overall odds ratio less than 1. When considering the individual odds ratio, except for the months February, May, August, October and November odds ratios are less than 1. It clearly indicates that for the five months the odds are higher for profit in buy call recommendations whereas for the rest seven months the odds are higher for profit in the sell call recommendations. It also shows a positive measure of heterogeneity of about 22%. In the entry rate wise analysis except for three categories the odds ratio is less than 1, which shows that odds are higher for profit in buy call for three categories and the odds are higher for profit in sell call for the other four categories.

In model 9 and 10, which explains about the exit profit has the individual odds ratio greater than 1 except for the months May, June, July, August and November clearly indicating that for these five months odds are higher for profit in sell call recommendations. But the overall odds ratio is greater than 1 which indicating odds are higher for profit in buy call recommendations. When considering the entry rate wise the overall odds is greater than one, but the individual odds ratio except for two categories is greater than 1 which shows a positive sign of having higher odds for profit in buy call recommendations. Specifically, to note that the odds ratio is quite high in the entry rate category (>5500) which is about 2.032 and leads the table. In the last two models, it is very clear from the visual and the numerical summary that the odds are higher for profit in buy call recommendations.

CONCLUSION

Investment consulting plays an essential part in individual and/or corporate financial planning. Bodies that involved with such consulting, work with different strategies for variety of financial products. This is carried out in a highly volatile and uncertain global financial market and environments. Performances of companies or industries are reported in highly sophisticated analytical tools by many organizations including regulatory bodies. An investment consultant advises his clients about which stocks they should buy to add to their financial portfolio and looks for profitable companies' stocks. Competent stock brokers research accounting, economic and technical analysis of different companies and stocks. They understand the

client's needs and financial goals and accordingly guide them with the best investment opportunities.

In this study, two stratification variables are considered to determine the odds for the profit and loss outcomes and the heterogeneous behaviour. It could be observed that sell call recommendations has higher odds for profit than buy call recommendations in the outcomes across all the months. Especially in the month of June, sell call recommendations has higher odds for profit in the profit outcomes and sell call recommendations has higher odds for stop loss in the loss outcomes category. Majority of the profit outcomes has higher odds for profit in the sell call recommendations. The notable part is under the outcome Exit profit, the buy call recommendations have higher odds for profit in the profit outcomes which seems quite interesting.

While considering entry level classification, buy call recommendations has higher odds for profit under the outcomes exit profit which is a quite interesting feature to note. Overall impact in entry level is, sell call recommendations has higher odds for profit in the profit outcomes and higher odds for stop loss in the loss outcomes. The extreme values in the entry level have higher odds for profit in the sell call recommendations. The mid value in the entry level has higher odds for profit in buy call recommendations in the profit outcomes of Alert and trailing stop loss. A positive measure of heterogeneity could be noted with a wider range of intervals. Model 10 has the highest measure of heterogeneity of about 32% with a wider credible interval which shows the association between call status and exit profit across various entry level. Model 3 has the least measure of heterogeneity comparing with other models which has 17% which shows the association between the call status and Alerts under profit outcomes.

However, there are very few works, to understand the performance metrics of investment advisories from historical data based on their investment recommendations. This study aimed at understanding the pattern of profit and loss outcomes recommended through a trading strategy. Ten various models could be achieved through possible combination of variables, incorporating the major association metric odds ratio. Adopting the Bayesian modelling as a statistical principle and the random effect model as a parameter estimating procedure, could be able to make alternative ways to assert the relationship between call status and profit/loss outcomes.

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ESTIMATION OF INDIVIDUAL AND COMBINED ODDS RATIO USING FULLY BAYESIAN AND SUMMARY STATISTICS– A COMPARATIVE STUDY

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ABSTRACT

Meta-analysis is the process of merging summary data from related but independent studies. The main aim of meta-analysis is to assess the level of heterogeneity between studies. The degree of heterogeneity in a meta-analysis influences the difficulty of making inferences. This may be obtained by calculating the between-study variance, but the interpretation is then bound to a certain treatment effect metric. The objectives of this paper is to calculate the odds ratio in clinical trials between treatment and control groups. In addition, this work focuses on the sample size of each study and the number of zeros that appear in the study arms, which are regarded dataset characteristics and contribute to the significance of this analysis. The emphasis is on analytical approaches for estimating the parameters of interest. MCMC has been used to conduct a comparative study on individual, overall odds ratio and heterogeneity for Eighteen datasets using the Binomial-Normal and Normal-Normal models through Bayesian. All of the datasets point estimates and interval estimates have been computed, and a comparative study between the balanced and imbalanced groups has been performed.

Keywords: *Bayesian inference, Binomial-Normal, Heterogeneity, imbalanced, MCMC, Normal-Normal, Sample Size, Odds Ratio.*

INTRODUCTION

Clinical trials (Friedman, et al 2015) are used to gather information on the safety and efficacy of novel drugs and medical devices. Before a medication or equipment can be offered to the common people, it must go through multiple phases of approval in the clinical trials process. Drug and device (Hobbs et al 2007) testing begin with years of laboratory study in animals and human cells. Researchers submit the findings to the Food and Drug Administration (FDA) (Johnson et al 2003) for authorisation to continue research and testing in humans if the initial laboratory study is successful. Human testing of experimental medications and equipment can begin once they have been approved, and is usually done in four stages. Each step is treated as a distinct study, and after completing one, investigators must submit their findings to the FDA for permission.

The data has been analysed in cohort, medical, and intervention studies to assess the treatment's safety and efficacy (Piantadosi 2017). Clinical trial results are mostly presented in the form of a 2X2 table, often known as a contingency table (Green et al 2004). The treatment group is represented by row one of this 2X2 table, while the control group is represented by row two (Agresti 2013). Each table is referred to as a study, and datasets are collections of studies that comprise k number of studies (k > 0).

Meta-analysis (Card 2012) **is a statistical method that integrates the results of numerous separate studies that address the same set of research-related hypotheses.** When evidence on a treatment's efficacy is available from a number of clinical studies with identical treatment protocols, such analyses are becoming increasingly common in medical research. When taken individually, each study may be either too small or too limited in scope to draw unambiguous or generalizable conclusions regarding the treatment impact. Combining the data (Carlin 1992) from many studies to increase the evidence for treatment effectiveness is an appealing prospect.

The primary goal of meta-analysis (Bowden et al 2011) is to increase the power of investigators to detect an overall treatment effect, quantify the degree of benefit associated with a particular study treatment, measure the amount of heterogeneity (Engels et al 2000) between studies, and uncover study characteristics related to particularly effective treatments. It gives a more precise assessment

of the effect size and makes the conclusions more generalizable.

When endeavouring to estimate a combined effect from a group of similar studies via meta-analysis, the effects identified in the individual studies must be fairly similar enough that a combined estimate can be assured of being a meaningful description of the set of studies. Individual estimates of treatment effect, on the other hand, will differ by chance, some variation is to be expected owing to observational error. Differences in the studies themselves, the populations studied, treatment regimens, endpoint definitions, and other situations are frequently the causes of the increased variability. As a consequence, any excess variation implies heterogeneity.

Heterogeneity (Higgins et al 2002) may be more or less sensitive to different types of effect measurement. As a consequence, it may be possible to resolve conflicts across studies and generate conclusive results when individual studies are inconclusive. The Odds ratio may be used to identify the measure of heterogeneity (Langan et al 2016), which is an important metric in this investigation.

If the study has one or more zeros in its arms, estimating the odds ratio may be difficult. Continuity correction is required in such studies, which may have an influence on the outcomes. Over the last few decades, Bayesian inference has been found to have a significant performance in clinical trials. In Bayesian inference, continuity correction (Tian et al 2007) is accomplished by assigning a prior to the likelihood of the data, i.e., applying a specific type of prior information about the parameters.

The posterior distribution is generated using MCMC, which is essentially a method of leveraging markov chains to solve a variety of problems using a standard operating system. R (Viechtbauer 2010), a statistical software application, is used to carry out the calculations. Estimates for points and intervals (Viechtbauer 2007) are assessed using various parametric value combinations. In this work, a hierarchical Bayesian (Chu et al 2018) model was used to depict individual and overall odds ratios for sparse (Subbiah et al 2008) and imbalanced datasets (Khalilia et al 2011). The main goal is to assess how well imbalanced studies perform across models. Eighteen datasets were used to validate the created model. It has been found that the Bayesian technique produces a greater interpretation of sparse data.

MEASURES AND METHODS

The odds ratio, (Yin et al 2006) a descriptive measure for comparing groups on binary outcomes, i.e., between the two groups 1 and 2 of the variable X, is the principal association metric applied in this study. One of its most prominent advantages is that it is consistent throughout case control, follow-up, and cross-sectional studies, allowing it to be used to directly compare the results of various study designs. OR offers a wide range of statistical applications, including case-control studies, multi-centre research, meta-analysis, and precision in diagnosis.

A two-fold contingency table that categorises two dichotomous variables is required for the proposed study. Treatment and control are two levels of X1, whereas success and failure are two levels of X2. The number of individuals who account for each combination of X1 and X2 is represented by the cell count.

Table 1: Data format for treatment / control counts of a study

X1/X2	SUCCESS	FAILURE
TREATMENT	p_{11}	p_{12}
CONTROL	p_{21}	p_{22}

The odds are defined as θ = p/1- p, for a likelihood of success. The ratio of the odds θ_1 and θ_2 in the two rows,

$$\theta = \frac{\theta_1}{\theta_2} = \left(\frac{p_{11}}{p_{12}}\right)/\left(\frac{p_{21}}{p_{22}}\right)$$

this is known as the Odds Ratio. The cross-product ratio is an alternate term for OR, and a sample form of OR is $\frac{p_{11} * p_{22}}{p_{12} * p_{21}}$ that ranges from 0 to infinity. An odds ratio of exactly 1 means that exposure towards treatment does not affect the odds towards control. An odds ratio of more than 1 means that there is a higher odd towards treatment happening with exposure towards control. An odds ratio of less than 1 means that there is a higher odd towards control happening with exposure

towards treatment. In addition, for simplicity, the natural logarithm of Odds Ratio is commonly employed.

Prior distributions (Wu et al., 2007) are important in Bayesian modelling, especially when the observational issue is focused on parameter space constraints. The choice of priors, however, is essential in Bayesian methods. In recent years, research in practical and theoretical statistics has focused more on the Bayesian approach to statistical inference. This work intends to make use of the Bayesian approach's inherent benefits in statistical inference on ordinal attributes with binary outcomes.

Using Monte Carlo methods to simulate posterior distributions, Bayesian assessments for sophisticated models may be performed on a fixed data set in a very simple manner. Through a unifying framework within which numerous complicated issues may be investigated using software, MCMC (Sorensen et al 2002) gives considerable potential for accurate statistical modelling. Individual and overall odds ratios for all eighteen datasets were compared between Binomial-Normal (Pezeshk et al 2002) and Normal-Normal models (Frison et al 1992) in R (R Core Team 2016) to analyse the behaviour of the balanced and imbalanced studies.

The Random effect Model or REM (Riley et al 2011) is a statistical approach for combining the results of several studies to improve the accuracy of study effect estimates and determine if study effects are close enough to be pooled (Efron 1996). It has been demonstrated that taking a simple average of research impacts may not be the best way to summarise the outcomes. When drawing conclusions about the population, it's essential to understand the causes of variability, both within and across studies. These models are of great scientific interest, and they closely imitate meta-analysis statistical concepts. There are several researches and/or meta-analyses available that detail the theoretical, analytical, computational, and observational components of REM. Despite the fact that medical, epidemiological, and wellness studies dominate this discipline, many other disciplines use REM for prospective, retrospective, or cross-sectional investigation.

The two models discussed in this paper are

(i) M1: BINOMIAL -NORMAL MODEL

Consider the Binomial distribution as the success factor's likelihood. Specifically for each table's two rows,

$$r_t \sim \text{Binomial}\ (n_1, \theta_1)$$

$$r_c \sim \text{Binomial}\ (n_2, \theta_2)$$

The number of persons in the treatment group in row 1 is denoted by r_t, which is obtained from n_1 cases, each with a probability of θ_1. The number of persons in the control group in row 2 is denoted by r_c, which is obtained from n_2 cases, each with a probability of θ_2. Then we define $\delta=\text{logit}(\theta_1) - \text{logit}(\theta_2) = \log(\frac{\theta1/(1-\theta1)}{\theta2/(1-\theta2)})$. For each of the k tables, this is the log-odds ratio, or the quantity of interest in log scale. We also establish, for k tables $\mu=\frac{\text{logit}(\theta1)+\text{logit}\ (\theta2)}{2}$.

This parameterization is the same as $\theta_1 = \text{logit}^{-1}(\mu+ \delta/2) = \frac{\exp(\mu+ \delta/2)}{1+\exp(\mu+ \delta/2)}$ and $\theta_2 = \text{logit}^{-1}(\mu- \delta/2) = \frac{\exp(\mu- \delta/2)}{1+\exp(\mu- \delta/2)}$

As a result, the model's second stage involves generating priors for μ and δ.

$$\mu \sim N\ (\mu_0, \sigma_0^2)$$

$$\delta \sim N\ (d, \tau^2)$$

Further to that, appropriate priors for the scalar parameters μ_0, σ_0^2, d and τ^2 can be defined.

As a result, numerical and visual summaries (Lewis et al 2001) of point and interval estimates for values of interest can be provided. We will accordingly exponentiate study-wise OR estimates, Overall OR estimate, and Heterogeneity measure since the model uses log scale for impact measure.

(ii) M2 - NORMAL-NORMAL MODEL

Let,

$$Y \sim N\ (\mu, \sigma^2)$$

As a consequence, the second stage of the model includes establishing priors for μ and σ^2.

$$\mu \sim N\ (\delta, \sigma)$$

$$\delta \sim N\ (\delta_1, \delta_2)$$

σ^2 ~ inverse gamma (σ_1, σ_2). As a consequence, it is capable to achieve numerical and visual summaries of point and interval estimates for values of interest. It is

possible to obtain study-specific OR estimates, an overall OR estimate, and a measure of heterogeneity.

DATA DESCRIPTION

The entire dataset was extracted from various existing literature clinical studies since 1990 to 2021. The collected datasets are in the form of 2 X 2 table called a Contingency table (Green et al 2004), which categorises two dichotomous variables, X and Y. Where X denotes the treatment and control groups in a research trial, and Y denotes the study's success or failure. Eighteen datasets with k number (k >0) of 2x2 tables each have been extracted. These studies have been collected in such a way that the cells in the study has no zero, one zero, two zeros and more than two zeros. When it comes to quantifying the measurements of significance, sample size is essential. So extracted datasets have been categorised based on sample size. As a result, datasets have been classified as balanced and imbalanced according to sample size.

Table 2: Information of extracted datasets from clinical studies

Clinical Studies	TITLE	Total No of Studies	No of Balanced studies	No of Imbalanced studies	Number of Zeros in the study			
					No zero	One zero	Two Zeros	Four Zeros
Agresti-Book	D1	5	4	1	-	3	2	-
Agresti-Paper 1992	D2	3	-	3	-	3	-	-
Azza Sarfraz 2021	D3	4	-	4	4	-	-	-
Carlin 1992	D4	22	-	22	22	-	-	-
Cochran	D5	4	-	4	-	4	-	-
Efron 1996	D6	41	7	34	31	6	3	1
Friedlin	D7	3	-	3	1	2	-	-
Hardy	D8	9	-	9	9	-	-	-
Kishore 1	D9	7	3	4	6	1	-	-
Kishore 2	D10	7	3	4	4	1	2	-
Normand 1999	D11	6	1	5	6	-	-	-
Skene 1990	D12	8	1	7	6	2	-	-
Smith 1995	D13	22	1	21	20	2	-	-
sweeting 2004	D14	23	2	21	2	5	16	-
sweeting 2004	D15	7	-	7	5	2	-	-
Tian 2007	D16	48	-	48	11	26	11	-
Tian 2007	D17	48	-	48	6	17	25	-
Warn 2002	D18	46	7	39	29	17	-	-

Table 2 describes the datasets in detail. The datasets have been renamed as D1, D2,., D18. The first column shows the datasets initial names and the datasets new names are listed in the second column. The total number of studies in each dataset is listed in the following column. The study's characteristics are defined in the following two columns. The number of zeros is shown in the last four columns.

D1 is a data set from Agresti's book that contains four balanced studies labelled 1 to 4 and one unbalanced study labelled 5. In D1, studies 2, 3, and 4 have one zero in one of their cells, while studies 1 and 5 have two zeros. D2 is a data set from Agresti's 1992 publication that comprises three unbalanced studies numbered 1 through 3. In D2, each of the three has a single zero in one of its cells. Azza Sarfraz 2021, a dataset on the Remdesivir drug that was recently published is termed as D3, includes four unbalanced studies, none of which include a zero. Carlin 1992, also referred as D4, is a compilation of twenty-two imbalanced studies, none of which contain a zero.

D5, a Cochran dataset, includes four studies, all of which are in an unbalanced group with no zero. There are forty-one

studies in Efron's 1996 dataset. This dataset is known as D6, and it contains seven balanced studies (5, 8, 17, 20, 25, 37 and 40) and thirty-four unbalanced studies (1,2,3,4,6,7,9,10,11,12,13,14,15,16,18,19,21,22,23,24,26-36,38,39,41). This dataset comprises thirty-one studies (1,2,3,7,8,9,10,12,13,14,15,16,17,18,19,20,21, 22,23,24,26,27,30,31,32,33,35,36,37,38,39) with no zero, six studies (5, 6,11,28,29,34) with one zero, three studies (25,40,41) with two zeros, and study 4 is special case where all the arms in this study contains zero.

D7 refers to three studies in the Friedlin dataset. All three studies are in an imbalanced group, with no zero in study 1 and one zero in studies 2 and 3. Hardy, otherwise defined as D8, has a total of nine studies, all of which are in the imbalanced group and has no zeros. The Kishore 1 dataset D9 contains seven studies, three of which (1,3,4) are classified as balanced and the other four studies (2,5,6,7) are classified as imbalanced. There are no zeros in studies 1 through 6, while there is one zero in study 7. The Kishore 2 dataset D10 comprises seven studies, three of which (1,3,4) are categorized as balanced and the other four (2,5,6,7) as imbalanced. In studies 1, 3, 4, and 6, there are no zeros, one zero in study 7, and two zeros in studies 2 and 5. D11, the dataset's new name in Normand 1999, contains a total of six studies, with study 2 belonging to the balanced group and the other five studies 1,3,4,5,6 to the imbalanced group. There is no zero in any of the six studies.

D12, the dataset's new label in Skene 1990, contains eight studies, one balanced study 3 and seven imbalanced studies (1,2,4,5,6,7,8). Six of the dataset's studies (1,2,3,4,7,8) have no zeros, whereas two studies (5 and 6) have one. Smith 1995, referred to as D13, compiles twenty-two studies, one of which, study 17, is classified as a balanced group, and the remaining twenty-one studies (1-16, 18-22) are classified as an imbalanced group. In D13, twenty-one studies (1-20, 22) have no zeros and two studies (15 and 21) have precisely one zero. D14, a dataset from Sweeting 2004, incorporates twenty-three studies. Two studies (14, 21) are balanced, while the remaining twenty-one studies (1-13, 15-20, 22, 23) are unbalanced. The balanced studies (14 and 21) contain no zeros, five studies (2,6,12,19,23) contain exactly one zero, and the other sixteen studies (1,3,4,5,7-11,13,15-18,20,22) contain two zeros.

Sweeting 1, renamed as D15, comprises seven imbalanced studies in total. Five studies (1,3,4,5,7) contain no zeros, while two studies (2 and 6) contain only one zero. Tian 2007, also known as D16, has a record of forty-eight studies. All of the studies fall under the imbalanced category. There are eleven studies (2,3,8,13,15,16,17,19,26,41,42) with no zeros, twenty-six studies (1,4,5,6,7,9,10,11,12,14,18,21-25,27-30,32-35,40), with one zero and eleven studies (20,31,36,37,38,43-48) with two zeros. Tian 1, also defined as D17, has a maximum of forty-eight imbalanced studies. Six studies (8,11,16,26,41,42) do not have a zero, seventeen studies (1,5,13,15,18,19,20,25,27,28,30,32,33,34,35,39,40) have one zero, and twenty-five studies (2,3,4,6,7,9,10,12,14,17,21-24,29,31,36-38,43-48) have two zeros.

D18, or Warn 2002, is a set of forty-six studies. The balanced group includes seven studies (6,7,15,19,22,26,41), while the imbalanced group includes thirty-nine studies (1-5,8-14,16,17,18,20,21,23-25,27-40,42-46). Twenty-nine studies (4,8,10,11,12,14,15-19,21,24,25,26,28,30,32,34-43,45) in this dataset have no zeros, while seventeen studies (1,2,3,5-9, 13,20,22,23,27,29,31,33,44,46) have one zero.

IV. DATA ANALYSIS

(i) INDIVIDUAL ODDS RATIO ANALYSIS

Table 3 describes the individual odds ratio for three datasets D1, D2 and D3 model wise. The two models discussed here are fully Bayesian otherwise known as Binomial-Normal model (M1) and summary statistics namely Normal-Normal model (M2). These two models are designed to explore the behaviour of balanced and imbalanced groups.

Table 3: Individual Odds Ratio for D1, D2 and D3 with 95% confidence interval study wise

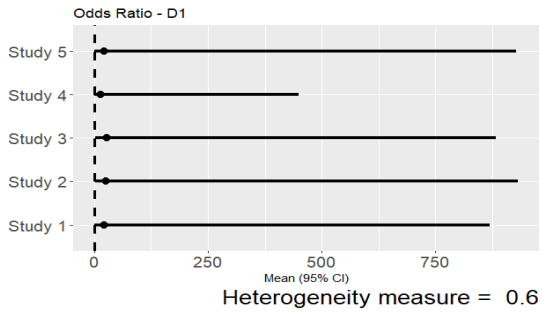
and model wise.

		FULLY BAYESIAN (M1)			SUMMARY STATISTICS (M2)		
Datasets	**Title**	**OR Estimate**	**95% CrI_LL**	**95% CrI_UL**	**OR Estimate**	**95% CrI_LL**	**95% CrI_UL**
D1	Study 1	22.31	1.12	868.76	4.04	0.12	128.57
	Study 2	26.56	1.86	931.26	4.84	0.16	152.08
	Study 3	28.54	2.10	882.99	4.88	0.16	156.42
	Study 4	13.76	0.73	449.71	3.58	0.11	115.13
	Study 5	22.22	1.11	927.52	4.02	0.12	133.61
D2	Study1	0.00	0.00	0.01	0.06	0.00	2.64
	Study2	0.00	0.00	0.01	0.06	0.00	2.75
	Study3	0.00	0.00	0.01	0.06	0.00	2.57
D3	Study1	0.56	0.37	0.87	0.57	0.37	0.87
	Study2	0.59	0.38	0.91	0.60	0.39	0.93
	Study3	0.66	0.25	1.67	0.66	0.26	1.66
	Study4	0.89	0.42	1.99	0.88	0.42	1.96

From the table, it is observed that the individual odds ratio for all five studies in D1 for M1 is greater than 1 indicates that the odds for treatment group is more likely than the control group. Study 4, a balanced data with one zero in one of its cells has the least OR 13.76 with interval estimates (0.73, 449.71). Study 3 has the highest OR 28.54 with interval estimates (2.10, 882.99). Likewise, the individual odds ratio for all five studies of D1 in summary statistics is greater than 1, indicating that the treatment group has a higher chance of success than the control group. The least OR 3.58 with interval estimates (0.11, 115.13) is found in Study 4, a balanced data. As a result, there is a variation in the OR estimate and interval estimate values between the two models. In M1, the interval estimates for studies 1,2,3, and 5 broaden, while in M2, they narrow. In M1, the interval estimates for study 4 narrow, while in M2, they expand. Hence both balanced and imbalanced dataset are not statistically significant in both models.

The three studies in D2 are imbalanced and have one zero. M1 has an OR of zero with a 95% confidence interval in all three studies. In M2, the OR obtained with a 95 percent confidence interval is greater than one for all three studies. By comparing these two models, we can infer that there is a significant variation in this dataset. All of the studies in D1 are statistically significant for M1, while for M2 all of the studies are not statistically significant.

D3, a recently published dataset regarding a Remdesivir drug. This dataset includes four studies, all of which are imbalanced. Study 1 is statistically important, with an OR of 0.56 and interval estimates of (0.37,0.87). The OR for Study 2 is 0.59, and the interval estimates (0.38, 0.91) suggest that this study is statistically important as well. Regardless of the fact that Study 3 and 4 have ORs less than 1 (0.66 and 0.89), the interval estimates in both studies broaden (0.25, 1.67) and (0.42, 1.99) respectively. As a result, the studies are treated as insignificant. As a result, there is no noticeable variation between M1 and M2.



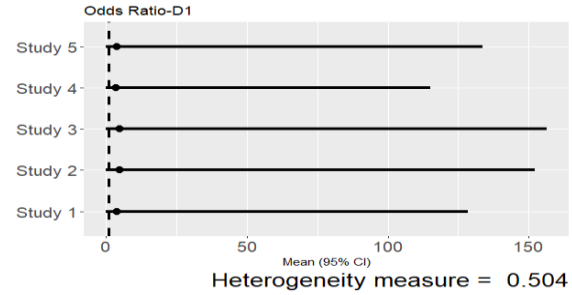


Fig. 1 and 2 are the forest plots of the dataset D1 for the Models M1 and M2.

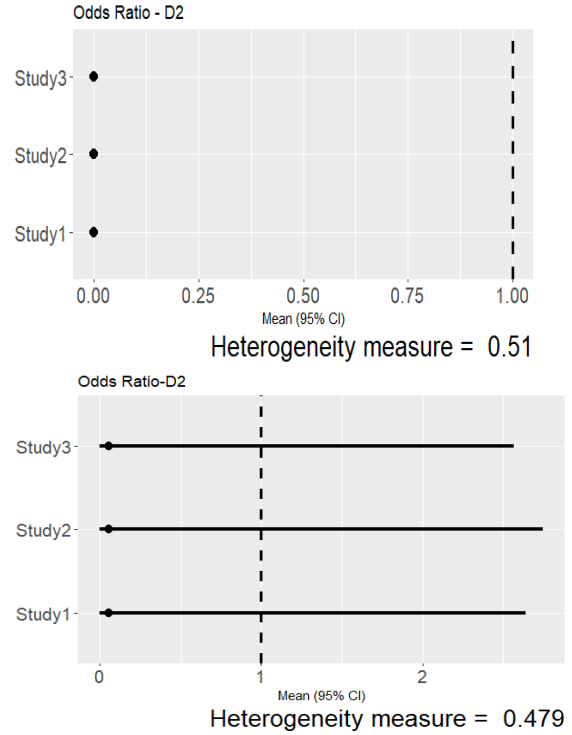
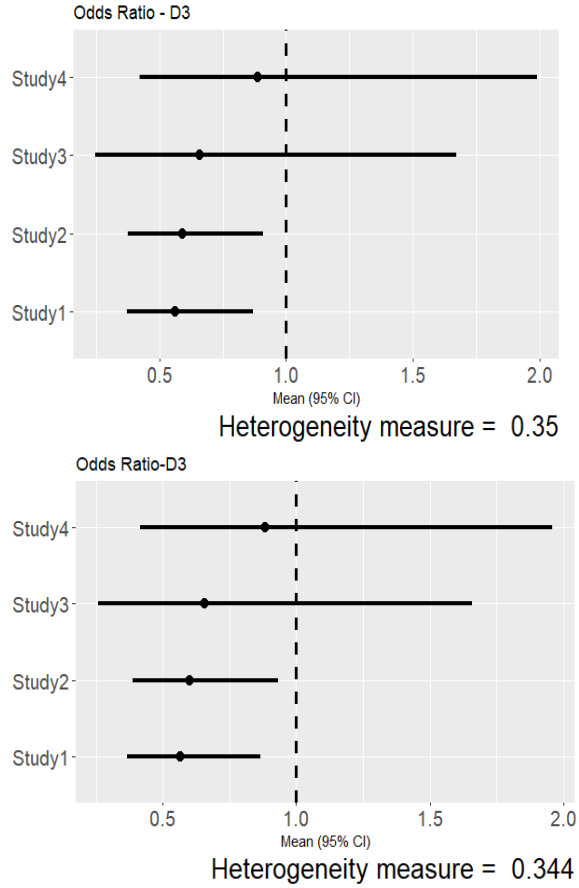


Fig. 3 and 4 exhibit forest plots for Models M1 and M2 from the dataset D1.

From the figure 3 and 4, We may observe that there is a substantial amount of variety in this dataset. For M1, all of the studies in D1 are statistically significant, but for M2, none of the research are statistically significant.



Figures 5 and 6 show forest plots from the dataset D1 for Models M1 and M2.

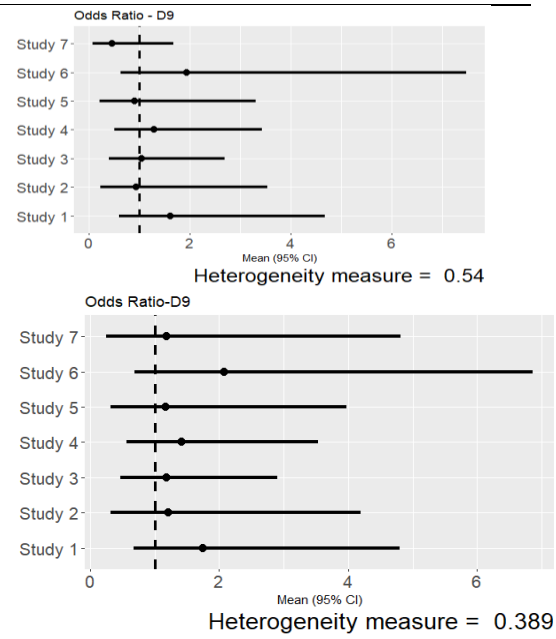
Table 4 : Individual Odds Ratio for D9 and D10 with 95% confidence interval study wise and model wise.

		FULLY BAYESIAN			SUMMARY STATISTICS		
Datasets	**Title**	**OR Estimate**	**95% CrI_LL**	**95% CrI_UL**	**OR Estimate**	**95% CrI_LL**	**95% CrI_UL**
D 9	Study1	1.61	0.60	4.67	1.75	0.68	4.80
	Study2	0.93	0.23	3.53	1.21	0.32	4.20
	Study3	1.04	0.40	2.68	1.18	0.48	2.91
	Study4	1.29	0.50	3.43	1.42	0.57	3.54
	Study5	0.90	0.21	3.30	1.16	0.32	3.97
	Study6	1.94	0.63	7.48	2.08	0.68	6.86
	Study7	0.46	0.07	1.68	1.19	0.25	4.81
D10	Study1	2.05	0.71	6.69	2.19	0.78	6.22
	Study2	1.48	0.20	10.03	1.94	0.40	9.60

Study3	1.18	0.45	3.02	1.39	0.53	3.47
Study4	1.94	0.74	5.43	2.11	0.83	5.37
Study5	1.48	0.20	10.92	1.95	0.40	9.43
Study6	3.38	0.88	17.98	2.97	0.81	12.67
Study7	0.48	0.06	1.98	1.60	0.32	7.19

According to table 4, the OR for most of the studies in dataset D9 for M1 is more than 1. Study 6 has the greatest OR of 1.94 with a broader 95 percent confidence interval (0.63, 7.48), whereas Study 7 has the lowest OR of 0.46 with the interval estimations (0.07, 1.68). As a result, none of the research are statistically significant. For M2, study 6 has the greatest OR 2.08 with interval estimates (0.68, 6.86), while study 5 has the lowest OR 1.16 with interval estimates (0.32, 3.97). When comparing these two models, it is determined that study 7, an imbalanced dataset with one zero, has a broader CI for M2 than M1. In addition, in studies 2, 3, 5, and 7, the OR for M1 is less than one while the OR for M2 is larger than one. Study 6 has the greatest OR 2.08 with interval estimates (0.68, 6.86) while study 5 has the smallest OR 1.16 with interval estimates (0.32, 3.97) for M2. As a consequence, we may conclude that the interval estimates of the studies in both models vary considerably.

For M1, the D10 dataset contains all studies with an OR greater than 1. With broader interval estimates (0.88, 17.9), study 6 has the greatest OR 3.38, while study 7 has the lowest OR 0.47 with interval estimates (0.05, 1.98). In addition, for M2, all of the studies exhibit an OR of greater than 1. Study 6 has the greatest OR of 2.97 with interval estimates (0.81,12.67), while study 1 has the lowest OR of 1.39 with interval estimates (0.53, 3.47). A comparison of these models has been made, and we can conclude that study 7's point estimate is less than 1 in M1 and larger than 1 in M2 with wider CI.



The forest plots of dataset D9 are shown in Fig. 7 and 8 for the two models.

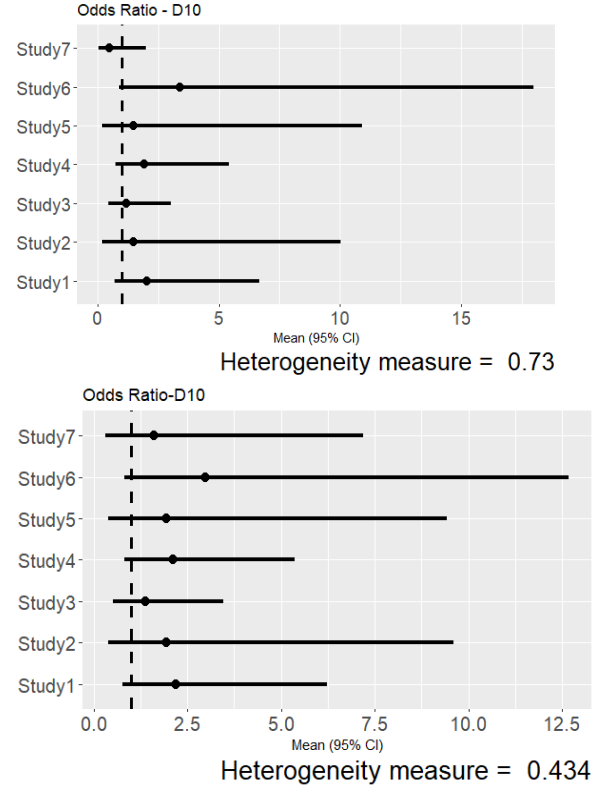


Fig. 9 and 10 illustrate the forest plots from dataset D10 for the two models.

(ii) OVERALL ODDS RATIO AND HETROGENEITY (τ^2):

Table 5: Overall Odds Ratio and Heterogeneity for Eighteen datasets with 95% confidence interval model wise.

DATASETS	MODEL	Over all OR			Over all Heterogeneity(τ^2)		
		Point Estimate	lower limit	Upper limit	Point Estimate	lower limit	Upper limit
D1	M1	22.00	1.73	624.04	0.60	0.14	2.15
	M2	4.25	0.16	117.64	0.50	0.14	1.68
D2	M1	0.00	0.00	0.01	0.51	0.14	1.60
	M2	0.06	0.00	2.45	0.48	0.14	1.51
D3	M1	0.66	0.33	1.34	0.35	0.12	0.92
	M2	0.66	0.33	1.34	0.34	0.12	0.90
D4	M1	0.79	0.63	0.97	0.16	0.08	0.28
	M2	0.79	0.64	0.98	0.16	0.08	0.29
D5	M1	3.51617E+25	129.19	1.04873E+70	0.51	0.14	1.69
	M2	17.40	0.68	477.06	0.48	0.14	1.52
D6	M1	0.19	0.10	0.35	2.68	1.24	5.36
	M2	0.36	0.24	0.52	0.52	0.19	1.12
D7	M1	8.34	0.76	247.48	0.52	0.14	1.73
	M2	2.22	0.16	30.27	0.50	0.14	1.58
D8	M1	0.59	0.36	0.97	0.40	0.15	0.92
	M2	0.60	0.37	0.96	0.39	0.15	0.93
D9	M1	1.07	0.45	2.46	0.54	0.15	1.71
	M2	1.39	0.62	3.09	0.39	0.13	1.03
D10	M1	1.49	0.53	4.09	0.73	0.16	2.70
	M2	1.97	0.77	4.97	0.43	0.13	1.25
D11	M1	1.84	0.87	3.97	0.35	0.12	0.89
	M2	1.75	0.83	3.65	0.35	0.12	0.91
D12	M1	1.95	0.83	4.82	0.40	0.13	1.02
	M2	1.79	0.75	4.23	0.40	0.13	1.07
D13	M1	0.24	0.15	0.35	0.59	0.24	1.25
	M2	0.29	0.19	0.41	0.43	0.18	0.93
D14	M1	2.09	0.58	8.68	0.58	0.15	1.90
	M2	0.89	0.24	3.31	0.41	0.13	1.15
D15	M1	0.24	0.10	0.56	0.40	0.13	1.07
	M2	0.29	0.12	0.68	0.38	0.13	1.01
D16	M1	1.16	0.67	2.14	0.68	0.20	1.91
	M2	0.98	0.54	1.78	0.41	0.14	1.01
D17	M1	2.07	1.01	4.39	0.38	0.12	1.05
	M2	1.39	0.70	2.74	0.31	0.12	0.74
D18	M1	14.74	9.58	24.72	1.38	0.61	2.64
	M2	7.02	5.13	9.86	0.40	0.16	0.82

Table 5 provides a clear specification of the numerical summary of the overall odds ratio with interval estimates and the measure of heterogeneity ($\boldsymbol{\tau^2}$) with interval estimates. For all models M1 and M2, the overall or combined odds ratio for the datasets D1, D3, D5, D7, D9, D10, D11, D12, D14, D16, D17, and D18 is greater than 1. As a result, these datasets lack statistical significance. The dataset D2, for model M2, is not statistically significant since its 95% interval estimates range from 0 to 2.45 with an OR of 0.06.

D4 has an overall OR of 0.79 with a 95

% confidence interval of (0.63, 0.97) for M1 and 0.79 with a confidence interval (0.64, 0.98) for M2. Despite the fact that all of the imbalanced studies under D4 have one zero in their arms, it is still considered statistically significant. D6 has an overall OR of 0.19 with a 95 % confidence interval of 0.10 to 0.35 for M1 and 0.36 with a confidence interval of 0.24 to 0.52 for M2. The majority of the studies in this dataset are regarded to be imbalanced, with just a few studies having no zero, one zero, or two zeros; yet, it is statistically significant.

D8 an imbalanced dataset with no zero has an overall OR of 0.59 with interval estimates (0.36, 0.97) for M1 and 0.60 with interval estimates (0.36, 0.96) for M2. D13 has twenty-one studies that are imbalanced. With the interval estimates (0.15, 0.35), the overall OR of D13 for M1 is 0.24 with a 95 % confidence CI and 0.29 for M2 with the interval estimates (0.19, 0.41). As a matter of fact, D8 and D13 are found to be statistically significant. Regardless of the fact that five of the seven imbalanced studies have no zeros and two include one zero, the OR of D15 for M1 is 0.24 (95 % CI: 0.10, 0.56) and for M2 is 0.29 (interval estimates: 0.12, 0.68). As a result, this dataset is regarded statistically significant with a significance level of 5%.

D6 has the highest τ^2 = 2.8 with 95% CI (1.24, 5.36) for M1, followed by D18 that has τ^2= 1.38 with the interval estimates of (0.61, 2.64) for M1. D4 has the least τ^2= 0.16 for both the models M1 and M2 with the interval estimates (0.08, 0.28) and (0.08, 0.29). Moreover, a positive measure of heterogeneity across all data sets indicates a heterogeneous impact size across all data sets analyzed in this study, with a substantially wider 95 percent credible interval. Individual odds ratio tables and forest plots for all datasets have been created, however individual odds ratio tables and forest plots for the remaining datasets have not been created owing to space constraints.

CONCLUSION

The primary goal of this study is to apply Bayesian inference to analyse the association measure of a 2 x 2 categorical data set, which has gained a lot of attention in recent years. Eighteen datasets, each in the form of a 2 x 2 with k studies (k>0), were analysed from published clinical studies. The focus is mostly on examining the variability between studies (i.e., combined odds ratio and heterogeneity).

The extent of sensitivity in estimating point and confidence interval of association measure such as odds ratio is hard to evaluate in general, especially for sparse data. The number of zeros in the studies and the sample size might have an influence on the dataset. So, based on the number of zeros, the extracted clinical trials were further categorized as balanced or imbalanced and analysed. A comparison study has been done using two models fully Bayesian (M1) and summary statistics (M2) to analyse point estimate OR and interval estimate of clinical studies using Bayesian inference. In order to establish a framework for sparse datasets and imbalanced studies, the point estimate and confidence interval were determined.

In order to provide a better understanding, the Random Effect model was used as the underlying model and Bayesian approaches as a statistical approach. The study's results adopting the Random Effect Model (REM) approach gave a better understanding of variability quantification. The odds ratio in datasets D2, D4, D6, D8, and D15 is more than one. Given the fact that these datasets are imbalanced with one or more zeros, the studies are statistically significant. As a consequence, we may conclude that prior specification has an influence on imbalanced research. This study presents a practical way for developing and implementing systematic Bayesian strategies for association measures.

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THE ACCELERATED PARADIGM SHIFT IN E-TAILING AMIDST COVID-19 PANDEMIC IN INDIA

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ABSTRACT

The COVID-19 pandemic has disrupted the way the world has been functioning, impacting all the sectors of the economy. Almost all sectors have been affected due to the sudden regulations regarding crowds and lockdown following the pandemic. Though COVID-19 has made businesses undergo major changes, it has also opened numerous opportunities once unexplored or not needed. Internet has deep penetrated our lives which has helped, the shift from Retailing to E-tailing picking up actual pace during the COVID-19 pandemic where consumers want products/services at door step without the need of them stepping out and taking risk. Though E-tailing started way before the pandemic, but the shift became more prominent considering the external factors in the environment. Today, world seems to be a much smaller place with many international brands making its way to our home via Internet. With the changing preferences of customers, Companies too have been mindful of the changes and have been updating their Online services to match the competitors in the industry, eventually retaining their customers. Pandemic though has caused distress to the almost all industry, technology has opened a plethora of opportunities to develop the businesses for long term sustainability. This article analyses how the COVID-19 emergency is hastening the growth of online business toward new companies, customers, and types of goods, perhaps including a long-term shift in internet business exchanges (e-commerce) from luxury items and products to everyday necessities. It also discusses how politicians might exploit the ability of computerized change in retail and similar industries to aid economic transformation and enhance social distance while ensuring that no one is left behind.

Keywords- *Digital Transformation, E-Tailing, Information Technology, Pandemic, Retailing*

INTRODUCTION TO E-COMMERCE

E-commerce has been gradually gaining traction across the globe and in India, long before COVID-19 (Dionysiou et al., 2021; Mukhopadhyay, 2021). In general, the pandemic's start and subsequent lockdown have thrown the development of online buying off-balance owing to limits on qualifying goods to necessities and physical mobility restrictions directly affecting delivery. Nonetheless, living experiences during the lockdown may influence views about using e-commerce after things have returned to normal. Before a pandemic, there were significant disparities where those who purchased items for the sake of comfort, whether it's for grocery shopping, essentials, or leisure activities, and those who felt it was necessary to purchase from marketplaces and brick - and - mortar as it was a more enjoyable activity. The pandemic had caused a change in consumer behavior and activity, which has had a direct impact on the e-commerce sector (Sayyida et al., 2021). The fact that just the bare requirements, particularly medical supplies, are being made accessible, as well as the fact that individuals are not willing to spend money beyond their immediate needs, presents both difficulties and possibilities. The COVID-19 problem has hastened the development of e-commerce to include new companies, consumers, and kinds of goods, as well as new markets.

CONSUMER BEHAVIOR DURING LOCKDOWN

Although most of the information readily available pertains to how consumer behavior has altered due to the lockdown, there seems to be a significant shift in the way businesses have reacted, both in the business-to-consumer and business-to-business sectors (Mehta et al., 2020; Pathak & Warpade, 2020). Because of the lockdown, businesses had to adjust fast in March, and they not only had to change their communication methods among their audiences, and thereby their methods of servicing and satisfying the customers, many of whom were functioning from distant locations. And besides, marketing strategy doesn't end with the sale. Satisfying customers earlier, during, then after the purchase seems to be the ultimate goal with all retailers these days; and besides, satisfied customers return, yet pleased customers share it with their friends regarding their services

and products.

This is indeed a complicated issue for companies that sell to other businesses. It seems, companies that sell to consumers always have had a kind of accessibility to their clients at home; but, firms that sell to enterprises face a whole other set of challenges. Businesses targeting the B2B (business to business) market will still have to concentrate their efforts online in the near future since their target audience will no longer be at the workplace in the traditional sense, as many would have made the transition to permanent home working.

TRANSFORMATION IN RETAIL INDUSTRY: E-STORES

Retail Industry is one in all the fast-growing segments with a plethora of opportunities to explore with numerous reasons like increase in double income families, Lifestyle changes thanks to increased social class combined with high consumer expectations (Dionysiou et al., 2021). The present change that Retail sector has been undergoing is that the combining Technology with the business operation thereby creating online shopping experience within the variety of E-Stores, which offers a large range of products and services with discounts hence attracting consumers (Trupti & Raut, 2018). In step with Investopedia, "Electronic retailing (E-tailing) is that the sale of products and services through the web. E-tailing can include business-to-business (B2B) and business-to-consumer (B2C) sales of products and services" (Hargrave, 2021). The Indian E-commerce segment still appears to be within the nascent stage with companies exploring different customer preferences and segments (Ruby, 2016). In step with EcommerceGuide.com, future statistics for E-commerce shows that by 2040, 95% of purchases could happen online and one amongst the most reasons attributed for this prediction is that shopping can have 24/7 from E-Stores with the below mentioned fig. 1 giving more insights (Pathak & Warpade, 2020).

Fig. 1 Advantages and Disadvantages of E-Stores

AMAZON –E-STORE THAT REVOLUTIONIZED ONLINE SHOPPING

Amazon was founded in the year 1995, by Jeff Bezos as an US internet-based company that allows third parties to sell everything ranging from books, apparel to all products via Internet (Lapaas, 2020). Today Amazon has become one of the largest E-Stores in the world with 89% of buyers favouring amazon than any other E-Store (Mohsin, 2021). This fact is mainly attributed to the company's success in building trust over the years through features like reviews and customized feed based on their previous purchases.

A. SWOT Analysis of Amazon

Strengths • Customer Loyalty and Satisfaction • Brand Value • Superior Distribution system • Discounts	*Weaknesses* • Thin Profit margins • Better Inventory management
Opportunities • Increase customer privacy and reduce security concerns • Amazon can still increase its product portfolio.	*Threats* • Competition from local E-Commerce websites • Aggressive pricing strategy might cause losses in the long run

E-SHOPPING AMIDST COVID-19

E-Shopping is the purchase of goods and services over Internet from any E-Stores instead of a traditional Brick and Mortar retail outlets. The main reason behind increased online shopping is attributed to numerous reasons such as Convenience of shopping, more time saving, easier to explore a variety of goods in a single place, saves money. Few other factors regarding E-Shopping shows that the age group between 30-45 are more interested in online shopping options than other age groups, people with high income range have high frequency of online purchase, Technology is also found to have high frequency of online purchase etc (Karal, 2016).

Statistics regarding Online shopping shows that in 2014 the average E-Commerce Sales/User was approximately around $ 247, which has increased to $ 424 in 2020. And the reason for such a drastic increase in Online shopping is attributed to advantages like Best discounts obtained during various festive season, Information about the product and reviews to check the performance of the product with other consumers, Wide range of products from various categories provides more options for selection, Convenience to choose products at any hour or day of the week which makes it convenient etc, these advantages make it attractive even though there might be few downsides to it such as Shipping rates for every single product irrespective of the product price, Return policy might sometime take too long or create disputes, Security concerns over data shared is one of the top concern regarding E-Shopping (Kothari & Maindargi, 2016).

Today, Online shopping is not only limited to Search engine, but Apps have been developed by the retailers to keep track of the customers taste and preferences and to cater their needs as per their expectations. The use of various Influencers sharing the product information seems to be a new trend used as promotional measure to drive traffic to the E-Store (Kothari & Maindargi, 2016) (Manjunatha & Road, 2018).

Online Shopping hit new high during 2020 during Covid-19 as people feared the spread of corona virus and chose to stay indoors to avoid contracting the virus. It is estimated to have increased by 32% approx. than the previous year 2019 and in the current year, already a 39% increase has been registered in the first quarter of 2021.

CHALLENGES FACED IN ONLINE SHOPPING

Although online shopping is becoming more predominant, there are few challenges faced by both the shoppers making the process more efficient. From consumers point of view, the main concern remains to be getting a wrong product in place of the product ordered and the following return policy complications, the information shared regarding the money transfer like Credit card info, Debit Card info and other payment options need utmost security and that is a concern considering data breach and hacking happening around the world, and also the prevalence many fraudulent websites on internet.

From the retailer's point of view, due to the covid-19 concern, the logistics and supply chain in reaching the consumer became a concern due to the restrictions in COVID-19 hit regions and the staffing issues, maintaining Standard operating procedures in warehouses, taking care of Sick employees etc. Also, to remind customers that website was still operational and taking orders was also needed. Few Websites had to prioritise essentials goods in place of any other products to help customers have access to basic needs. E-Stores like Amazon were one such platform that prioritized grocery staples and health-hygiene products.

NEW GOVERNMENT POLICIES REGARDING E-COMMERCE AMIDST COVID-19

The Government of India has always been protective of consumers and their rights with reference to E-Commerce and has established various laws and policies concerning online shopping. Consumer Protection Act of 1986, Act concerning Sales, Shipping, Refunds and Returns, Payment and Settlement Act of 2007, General Data Protection Regulations etc to supply support to shoppers online. Due to COVID-19 and various concerns regarding online shopping, the govt. of India has started drafting new regulations like limiting the

Flash Sales that happens few times a year, appointing Compliance officers etc for E-Commerce to counteract the unfair practices prevalent. These new regulations are expected to make a higher Online shopping experience.

CONCLUSION

Technological Revolution has been driving the last decades with major changes disrupting the business models, systems and customers. When it comes to people, online shopping allows them to distance themselves from a retail store even while gaining access to the whole product selection. Even when e-commerce has traditionally been associated with high-tech products, paperbacks, and toys, to several consumer groups, it is now predominantly intertwined with goods where the accessibility is important toward a significant number of people, such as grocery items, pharmaceutics, as well as other essential items, among several other things. Sustained accessibility to some sectors of the social sphere, whether digital or in-person, has been made possible by e-commerce, notably by effectively distributing time-stamped ticketing to prevent congestion at occasions like weddings, libraries, theatres, swimming pools, and public parks, among other things. E-commerce, in the same way, has emerged as a critical option or additional business plan for several businesses, enabling them to expand production regardless of contact limitations as well as other restrictive procedures.

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THE RISE OF ONLINE MARKETING IN INDIA

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ABSTRACT

We are living in 21st century where everything is online and the people are addicted with the use of internet. Today the business is beyond the boundary that is because of online marketing. Online marketing was not that popular in India before 2016 as it is today. In 2016 demonetization took place in India which created a panic situation because people were short of cash and the whole country was standing in the queue of banks and atm's to withdrawal and exchange their old currencies. From that time the mindset of Indian people changed and most of them trended towards digitalization. Which led into the massive growth of online marketing in recent years. Post demonetization the era online marketing rises and the craze of digital payments and cashless transaction increases in India.
This paper attempts to study the impact of demonetization in the massive growth of online marketing in India.

KEYWORDS: *Online Marketing, Demonetization, Digital Payment, Cashless Transaction.*

INTRODUCTION

The whole world is going digital now and social media has become the part of our daily routine. Now a day's majority of the People are preferring online marketing rather than traditional marketing. Post demonetization people don't have much cash in their hand which impacted the cash on delivery mode of payment. People started using plastic money and e wallets for making payments. Demonetization gave boost to digital payments and encouraged people to shop online more. It provided opportunity to ecommerce players to push customers in adopting cashless transactions [1].

Post demonetization the era of online marketing arises in India and the Use of credit cards, debit cards and digital wallet had been increased for financial transaction and online marketing got a positive push and it comes into the spotlight [2].

As per India spend analysis of R.B.I the transaction of mobile banking has been increased by 175% and transacted amount increased by 369% in last one year. The card transaction increased by 133% post demonetization where 15 lakh Indian started using cards (mostly debit cards) and the user of debit cards just doubled [2].

Online marketing is like any time anywhere that is why it is called 24*7 marketing. Paytm which is now India's largest mobile wallet company has witnessed a huge increase of 700% in overall traffic and 1000% growth in paytm account. The average transaction of paytm was increased by 200% and paytm mobile app download was increased by 300%. Other mobile wallet companies like oxygen, mobiwik, freecharge etc got huge push in increasing their business. The merchant transaction of freecharge mobile wallet witnessed by 9-fold jump whereas transaction volume of mobiwik witnessed increase of 18-fold. The wallet transaction of oxygen wallet was RS 450 crore till September 2016 but in the month of November it increased from Rs 450 crore to Rs 600 crore [3]. Immediate payment service (IMPS) e Payment system increases over 5-fold jump since November 2016 witnessed 20.10 crore transaction august 2019. The use of debit card grew 83% post demonetization. According to RBI data in November 2016 the debit card transaction was 23.47 crore but in August 2019 it reached 42.87 crore [a].

OBJECTIVES OF THE STUDY

- To study the demographic influencing factors in the rise of Indian online marketing.
- To study the effect of demonetization in the growth of digital payments and cashless transaction in India.

HYPOTHESES OF THE STUDY

- There is no significant association of demographic influencing factor in the

enlargement of Indian online marketing.

- There is no significant effect of demonetization in the growth of digital payments and cashless transaction in India.

REVIEW OF LITERATURE

Patil.S (2019) found that demonetization has changed the buying behavior of the Indian customers and it also increased the trend of electronic customer relationship management (ECRM). As per the data of Reserve Bank of India there has been huge growth in digital transaction in volume and value post demonetization. Debit card transaction increased more than 1 billion in January 2017 as it was 817 million in 2018. Demonetization has forced the people to being online and it has increased the number of online users in India. There were 370 million internet users in 2017 but it has increased by 24% and crossed 460 million in 2018.

Sheetal, et al (2019) remarked that people are showing confidence and interest in internet banking post demonetization. According to a report of Hindustan Business Line the transaction value of NEFT has gone up numerously. In September 2016 it was 988,000 crore (before 2 month of demonetization) and in September 2017 it increases to 14,182,000 crore and in September 2018 it increases to 18,015,000 crores.

Gupta, et al (2018) explained in the very first month after demonetization digital payment has witnessed a huge increase of 271% and mobile wallet transaction surpassed to 63 lakhs from 17 lakhs. Paytm which is India's biggest mobile wallet redounded 45 million people within 3 weeks post demonetization. In tier 2 cities digital transaction saw a growth of 150% and 157% in tier 3 cities post demonetization.

Banarjee & P sayeed (2017) conducted a survey and, they found only 27% of people preferred online shopping before demonetization but post demonetization the frequency of online shopping got a great push and it increases from 27% to 53%. Earlier only 14% of people preferred debit card to make payment for buying online products but post demonetization 43% of people started using debit card as payment method for buying online products.

K.C Balajee & K. Balajee (2017) explained immediate payment system and mobile banking increased tremendously in India post demonetization. The era of mobile wallet and digital payment has begun since demonetization. Paytm download has been increased by 200% and its traffic has increased numerously by 435%.

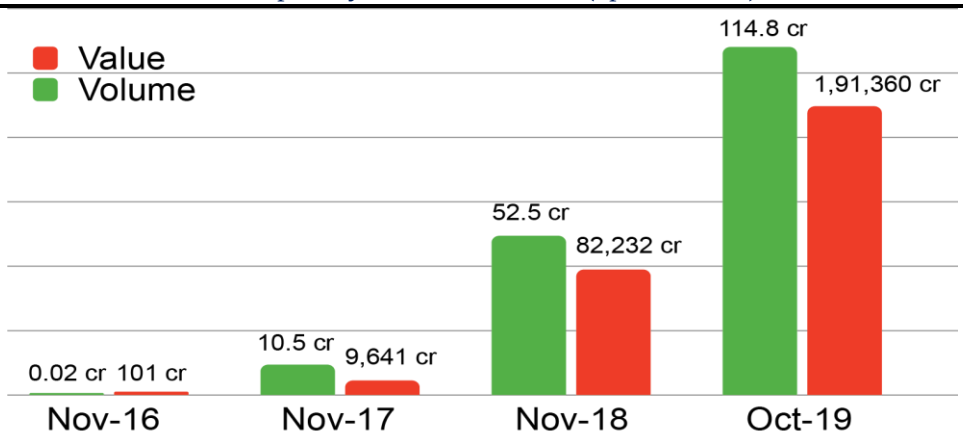
Prairna Gupta (2017) found that digital payments witnessed a tremendous growth of 271% in the first month after demonetization. Mobile wallet transaction increased to 63 lacks from 17 lacks and paytm one of the biggest players in mobile wallet demonstrated that within three month of demonetization they served 45 million people.

Pachare, S. M. (2016) explained digital wallet and digital payment has seen a numerous growth in their business post demonetization. Mobiwik claims over 2000% increase in their traction value and 18 times increase in overall transaction.
Ola money witnessed an increase of over 1500% in recharges and Razor pay witnessed increase of 150%.

GROWTH IN DIGITAL PAYMENTS

Digital payments have picked up and seen a solid growth in the value and volume transaction post demonetization. Mobile payment applications such as google pay, paytm, phone pay, Bharat interface for money (BHIM) and unified payment interface (UPI) have become popular among the customers.

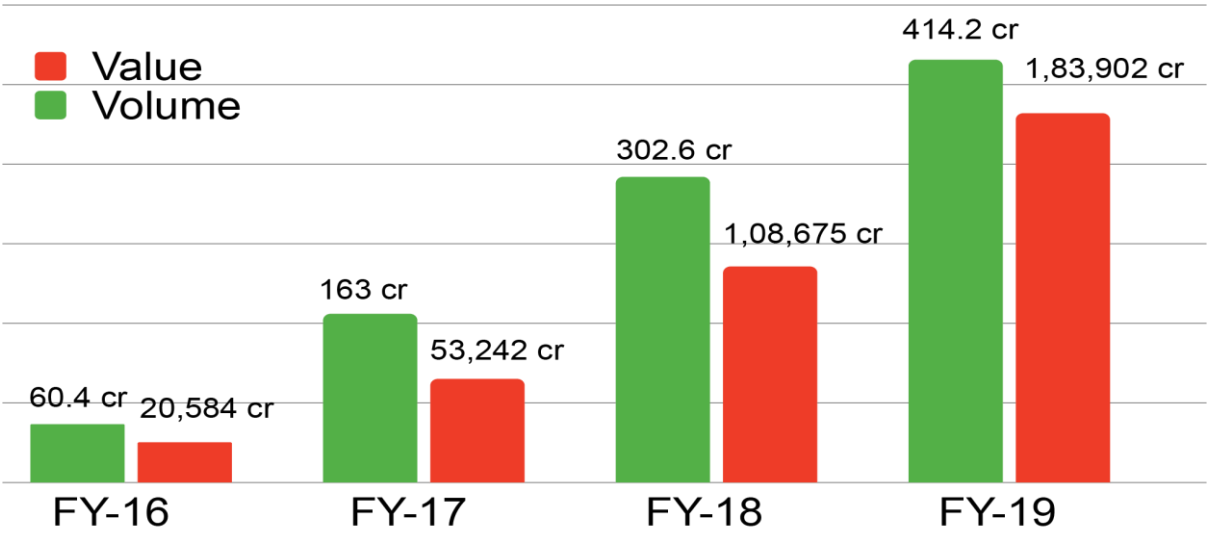
UPI TRANSACTION



Source: RBI [b]

We have witnessed a massive growth in volume and value of UPI Transaction in the last three year. According to RBI the figure of UPI Transactionin FY2016 was 0.02 crores (in volume term) but it got a huge uptick in FY2019 and stood at 114.8 crores. The value of UPI transaction in FY2016 was 101 crores but in 2019 it reached 1.91 lakh crores which was all time high in the history of value term of UPI transaction as it crossed 1 billion mark in October 2019.

MOBILE WALLET TRANSACTION



Source: RBI [b]

We have seen a numerous growth in volume and value of Mobile Wallet Transaction in the last three years. Mobile Wallet Transaction in FY2016 was 60.4 crores (in volume term) which has increased around six times and reached at 412.2 crores. The FY2016 was 20.5 thousand crore (in value term) which has increased 9 nine times and reached at 1.83 lakh crore.

RESEARCH METHODOLOGY

To make finding of the research practical and purposeful both primary and secondary method of collecting the data have been applied.

Sources of Data:

Primary Data has been collected through structured questionnaire and face to face interaction.

Secondary data has been collected from the articles published in various newspapers, management journals and magazines, report of various online marketing organizations and agencies etc.

Sample size:

The information was collected through structured questionnaire from 170 people from different tier of Indian cities by random sampling method. For analysis purpose statical tools were used.

- Chi square
- Regression

DATA ANALYSIS AND INTERPRETATION

Table 1: Demographic profile of the respondents

Factors	No of Respondent (N=170)	Percentage
Tier of cities		
Tier – 1	83	48.82
Tier – 2	46	27.06
Tier – 3	41	24.12
Gender		
Male	117	68.82
Female	53	31.18
Age (Years)		
Under 20	09	5.29
21 to 35	124	72.94
36 to 50	19	11.18
51 to 65	18	10.59
Marital Status		
Married	50	29.41
Unmarried	120	70.59
Educational Qualification		
Intermediate or Diploma	16	9.41
Graduates	39	22.94
Post graduates	71	41.77
MPhil or Ph.D.	44	25.88
Annual Income		
0 to 2.5 lacks	86	50.58
2.5 lacks to 5 lacks	31	18.24
5 lacks to 10 lacks	24	14.12
10 lacks and above	29	17.06

Source: Primary Data (Questionnaire)

Data has been collected through structured questionnaire from 170 people who comes under different tier of Indian cities. Among which 48.82% people were from tier 1 city, 27.06% from tier 2 and 24.12% were from tier 3 city. Where male were 68.82% and 31.18% were female among which 5.29% were under 20 years, 72.94% were in between 21 to 35, 11.18% were in between 36 to 50 years and 10.59% were in between 51 to 65 years. 29.41% were married and 70.59% were unmarried. 9.41% were up to school level, 22.94% were graduates, 41.77% were post graduates and 25.88% were doctorates. 50.58% of respondent's income was up to 2.5 lacks, 18.24% income was 2.5 to 5 lacks, 14.12% income was 5 lacks to 10 lacks and 17.06% respondent's income was 10 lacks and above.

Table: 2 Demographic influencing factors in the rise of Indian online marketing

Variables	**Influencing factors**					**Total**	**χ2 Value**	**Table Value**	**Hypotheses**
	S.A	**A**	**D**	**S.D**	**N**				**Null**
Tier of the city									
Tier 1	38	38	0	1	6	83	.056	.299	Accepted
Tier 2	23	24	2	0	1	50			
Tier 3	10	18	2	0	7	37			
Gender									
Male	52	58	2	0	5	117	0.25	.256	Rejected
Female	19	22	2	1	9	53			
Age									
Under 20	3	5	0	0	1	9	.001	.443	Rejected
21 to 35	56	60	0	0	8	124			
36 to 50	6	8	3	1	1	19			
51 to 65	6	7	1	0	4	18			
Marital Status									

Married	21	21	2	0	6	50	.585	.129	Accepted
Unmarried	50	59	2	1	8	120			
Annual Income									
0 to 2.5 lacks	36	41	0	0	9	86	.123	.323	Accepted
2.5 lacks to 5 lacks	14	14	1	0	2	31			
5 lacks to 10 lacks	12	7	2	1	2	24			
10 lacks and above	9	18	1	0	1	29			

Source: Primary Data (Questionnaire) significant at 5% level

Interpretation of demographic influencing factor: The table 2 above shows that the calculated chi square value is less than the table value at 5% level, there exist significant relationship between Gender and age and will be demographic influencing factor.

The calculated chi square value of Tier of the cities, marital status and annual income is more than 5% level so there does not exist significant relationship and it will not be demographic influencing factor in the rise of Indian online marketing.

Table 3: SUMMARY OF REGRESSION ANALYSIS

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.755[a]	.570	.557	.680

Dependent variable: Online marketing has made our life easy.

Predictors: (Constant), demonetization has pushed India towards digitalization,

Demonetization has begun the revolution of online marketing in India, demonetization has encouraged cashless transaction, demonetization is the major reason of increase in online marketing in India and demonetization has destroyed the traditional marketer.

- **Interpretation of impact** of demonetization: The table 3 above shows the impact of the independent variable on the dependent variable square value which explains that the independent variable in this model account for 57% variance in the dependent variable.

Table 4: Regression Summary of Hypotheses

Model	**Unstandardized Coefficients**		**Standardized Coefficients**	**T**	**Sig.**	**Hypotheses**
	B	**Std. Error**	**Beta**			**NULL**
Constant	.316	.154		2.058	.041	
demonetization has pushed India towards digitalization	.230	.089	.279	2.578	.011	Rejected
demonetization has encouraged cashless	.124	.058	.127	2.164	.032	Rejected

transaction						
demonetization is the major reason of increase in online marketing in India	.298	.097	.332	3.057	.003	Rejected
demonetization has destroyed the traditional marketer	-.017	.057	-.017	-.298	.766	Accepted

Interpretation of impact of demonetization in the growth of digital payments and cashless transaction in India: From the table 4 above it is seen that the null hypotheses is rejected for the variable like, demonetization is the major reason of increase in online marketing in India, demonetization has encouraged cashless transaction, demonetization has pushed India towards digitalization, demonetization has begun the revolution of online marketing in India, whereas variable like demonetization has destroyed the traditional market will have no significant impact in the contribution of demonetization in the extensive growth of digital payments and cashless transaction in India.

FINDINGS OF THE STUDY

Digital Payment: Witnessed massive growth in UPI transaction and Mobile Wallet transaction post demonetization. Just after 3 years of demonetization the volume of UPI transaction increased more than 100% and the value reached all-time high and created history as it crossed 1 billion mark in 2019. The volume of mobile wallet transaction increased around six times and the value increased around 9 times post demonetization.

Demographic Influencing Factor: Gender and age have more impact whereas tier of cities, marital status and annual income don't have much impact in the rise of Indian online marketing.

Impact of Demonetization: It has totally changed the mind-set of Indian customers. It not increased the online user but also but also pushed the customer to adopt digitalization.

SCOPE FOR FUTURE RESEARCH

Online marketing is a vast thing where each day something new introduced into the market and some fade away so, in this field there is scope for the further research.

CONCLUSION

Demonetization aims to push India towards digitalization and it begun the revolution of online marketing in India. Now the people are addicted with the technology and become comfortable with the digital world. The growth of digital wallets and cashless transactions has reached new heights and the use of plastic money and NEFT have increased numerously post demonetization which pushed India towards digitalization. Before demonetization cash on delivery was the basic mode of payment but now people prefer to pay digitally. Earlier cashless system was the requirement but now it has become the need of the Indian customers. From the above study it is very clear that demonetization has totally changed the Indian market scenario. Post demonetization the era of online marketing arises in India and the craze of digital payments and cashless transaction increased in India. Hence demonetization is found the major reason of increase in online marketing in India.

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THE IMPACT OF VARIOUS DIMENSIONS OF EMOTIONAL INTELLIGENCE ON ORGANIZATIONAL CITIZENSHIP BEHAVIOR– A STUDY WITH SPECIAL REFERENCE TO EDUCATION SECTOR

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ABSTRACT

Emotional intelligence is a dilated domain of psychology in which humongous studies are being conducted by focusing on its application in management studies. Emotional intelligence is such a strong quality of an individual which decides his behavior at work place and his level of commitment to his organization. The purpose of this study is to scrutinize the various dimensions of emotional intelligence and its impact on organizational citizenship behavior of employees in service sector. 284 teachers working in various arts and science colleges in Kancheepuram district have been chosen as respondents. A structured questionnaire has been issued to respondents to self-assess their emotional intelligence level and to determine their level of organizational citizenship behavior. The primacy role of emotional intelligence which spurs on extra role behavior among the faculty members has been observed. Each dimension of emotional intelligence has been evaluated to predict its influencing capability on the level of organizational citizenship behavior among the college teachers.

Key Words *- Emotional intelligence, mixed model of emotional intelligence, organizational citizenship behavior*

INTRODUCTION

The work behavior and culture are unique in each service sector especially in education sector. Type of the educational institution dictates the work culture and norms like working hours per day, work load per employee, the teaching strategies and flexibility in working pattern etc., which in turn determines the loyalty of employees to their institutions. The more the work culture is flexible, the way an employee conducts himself will be better. The loyalty that he shows towards his institution can be ascertained by his discretionary behavior with his colleagues at work place. The way he handles the students and extending warm assistance to their peers are found to be positive. The concept of such voluntary behavior is known as organizational citizenship behavior.

ORGANIZATIONAL CITIZENSHIP BEHAVIOUR

The evolution and development of the concept organizational citizenship behavior (OCB) relate back from the early 20th century onward with various constructs discussed by scholars, such as Weber, Barnard, Roethlisberger and Dickson, and Katz and Kahn, in management and organization theory (Organ, 2016).

Katz had laid foundation for this concept in the year 1964 and identified three types of behavior of workers for efficient running of an organization. One among them is of an innovative and spontaneous activity of employees in order to achieve organizational objectives which go beyond the role specifications (Katz, 1964). Dennis Organ who is known as father of organizational citizenship behavior, coined the term organizational citizenship behaviour in 1980s. Based on Katz thought, Organ developed the concept of Organizational Citizenship behaviour.

A formative definition for this term was given by Organ in the year 1988. Organ conceptualised the term organizational citizenship behaviour as an individual behaviour that is discretionary, that neither is explicitly recognized nor receives any monetary benefit, but which in the aggregate enhances the effective functioning of the organization (1988, p. 4.)

OCB is about the types of discretionary behavior and contributions that are not explicitly associated with the specific job requirement (Organ, 2016). Organizational

citizenship behavior is something more than that of an attitude or willingness to cooperate with other employees. It is more confessed with helping the peers, accepting additional workload in their absence, extending a warm assistance to them and being more loyal to the organization and its growth. But for this enriched quality he neither expects any pecuniary benefit nor any recognition. This discretionary behavior of an academician will do wonders in any institution by enriching the quality of education and teaching learning experiences among teachers and students. There are many factors which decides the level of such discretionary behavior and one among them is emotional intelligence level of the teachers.

The present scenario in education sector is such that teachers have to assume increasing work load because of diminishing resources which results in stress and job insecurity. But even then, most of them never compromise with their professional commitment and extra role play in their institutions. It's purely because of their social abilities which is one of the dimensions of emotional intelligence. This study focuses on emotional intelligence as an influencer of organizational citizenship behavior among the college teachers.

EMOTIONAL INTELLIGENCE

Apart from cognitive intelligence there is another intelligence which decides the success of an individual at his work place and that is identified as emotional intelligence. In the year 1990 John D. Mayer and Peter Salovey had identified the existence of a new form of intelligence called as emotional intelligence and they identified this emotional intelligence as a social intelligence which is considered as an ability to understand and control the emotions by an individual.

Emotional intelligence was initially conceptualized as an ability to monitor one's own feelings and that of others and emotion to differentiate among them and using this information to guide one's own thinking and also of his action (Peter Salovey and John D. Mayer, 1990).

The hierarchical model of emotional intelligence was constructed which was comprised of expression of emotion, regulation of emotion and utilization of emotion and how it is being used for solving the problems (Peter Salovey and John D. Mayer, 1990).

Based on the above definition they formulated a four-branch model of emotional intelligence in the year 1997. An individual's ability to perceive, understand, use and manage emotions helps him to achieve his goals (John D. Mayer and Peter Salovey, 1997).

In the year 1995 Daniel Goleman published a book titled, "Emotional Intelligence: Why It Can Matter More Than IQ" and it was on New York Times Best sellers list. In that book Daniel Goleman has propounded emotional intelligence as amassing of competencies and skills which are not innates rather learned capabilities that can be developed by individuals. This is because Goleman predicated that everyone is born with emotional intelligence which determines the capability of learning emotional competencies. Daniel Goleman (1995) has identified, Self-awareness, self-regulation, social skill, empathy and motivation as the five competencies of emotional intelligence.

K.V. Petrides, a Professor of Psychology and Psychometrics has conceptualized emotional intelligence as a personality trait. Emotion expression, emotion management, emotion perception and emotion regulation are considered as the dimensions of emotional intelligence (Petrides, 2010).

Reuven Bar On (2006) has constructed a model called Emotional - Social Intelligence [ESI]. He conceptualized emotional intelligence as a cross section of emotional and social competencies and skill that decides the behaviour of an individual (Bar-on, 2006).

People with high emotional competency get success at their work place than people with low emotional competency (Carmeli, 2003). This study aims to scrutinize the influence of each dimension of emotional intelligence as it is laid down by Goleman on the discretionary behaviour of college teachers.

1). Self-awareness

It is a competency of an individual to

realize his mood and understanding its effect. It is an intrapersonal skill of an individual to realize his various emotional state and assess the same and its impact. The level of self-awareness decides the level of self-confidence.

2.) Self-management

It is a personal competency of an individual to monitor his own emotion and to check his disruptive emotions, handling changes in a flexible manner and pursuing his goals even when facing some barriers.

3.) Social awareness

It is a social competency of an individual to understand the emotional state of others and being a good listener to others and caring for them.

4.) Relationship Management

It is a social competency of an individual to get along with others, being empathetical toward others and handling conflicts in a right manner.

METHODS

A. Sample

400 structured questionnaires were issued to faculties of arts and science colleges in Kancheepuram, out of which 310 filled in questionnaires were received. Only 284 questionnaires were found to be usable for the study.

B. Procedure

The level of organizational citizenship behavior and emotional intelligence have been measured. The four dimensions of emotional intelligence as conceptualized by Daniel Goleman and five dimensions of organizational citizenship behavior formulated by Podsakoff et al., have been adopted for conducting this study. Correlation was calculated to find out the relationship between the variables taken for the study. Hierarchical multiple regression was done to assess the impact of each dimension of emotional intelligence on the level of organizational citizenship behavior among the faculty members. Age and gender were kept as control variables and dimensions of emotional intelligence are taken as influencing variables for this study.

C. Measures

A structured questionnaire has been adopted for study. The emotional intelligence dimensions as specified by Daniel Goleman is used, which comprised of questions relating to self-awareness, self-management, social awareness and relationship management. The questionnaire also included demographic variables and five dimensions of Organizational Citizenship Behaviour. The demographic variables in the study are gender, age, academic qualification, marital status, educational qualification and work experience. Organizational Citizenship Behaviour among the faculty members was measured by using with a 24-item scale, containing five dimensions viz., altruism, courtesy, civic virtue, conscientiousness and sportsmanship (Organ, 1988; Podsakoff et al., 2009).

RESULTS

As a first step the Cronbach alpha internal consistency was calculated. The reliability test of the variables shows Cronbach alpha value as 0.83 for emotional intelligence variables and .534 for organizational citizenship behavior. The general rule of thumb is that, Cronbach's alpha of .70 and above is considered as good value, .80 and above is accepted as better value, and .90 and above is the best one. The emotional intelligence scale is .84 which is considered as better. But for organizational citizenship behavior it is less than .70. So, in order to improve the reliability, based on the item-total statistics as shown by SPSS the variable sportsmanship was removed and reliability value increased to .81. Thus, the organizational citizenship behavior was studied with four dimensions only by excluding sportsmanship.

The descriptive statistics were calculated. 48% of the respondents are in the age group of 35 to 45 years followed by 23% in 45 to 55 years age group. 50% of the respondents are from self-financing colleges, followed by 41% of the respondents from aided colleges. 54% of the respondents are working in temporary position followed by 43% in permanent position. 51% of the

respondents are earning less than Rs.25,000 per month as salary. 24% of the respondents and 23% of the respondents are having the teaching experience of 5 years -10 years and 10 years – 15 years respectively. 48% of the respondents are M.Phil. while 47% are Ph.D. in their respective discipline. 77% are female respondents and 23% are male respondents in this sample.

The dimension wise emotional intelligence mean score was ascertained as: Self-awareness – 4.24, Self-management – 3.96, Social awareness – 4.03 and Relationship management – 4.0. Likewise mean score was ascertained for five dimensions of organizational citizenship behavior also. They are: Altruism – 4.35, Courtesy – 4.47, Civic virtue – 4.28, Sportsmanship – 3.03 and for Conscientiousness – 4.52.

TABLE I
MEAN, STANDARD DEVIATION, CRONBACH ALPHA AND CORRELATION OF THE VARIABLES TAKEN FOR THE STUDY

	Mean	**SD**	**Cronbach Alpha**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Age	40.56	8.96		---									
Gender				-.163**	---								
Self-Awareness	4.24	0.48	0.706	.065	.088	---							
Self-management	3.96	0.53	0.706	.044	.064	.539**	---						
Social awareness	4.03	0.59	0.785	.212**	.081	.484**	.591**	---					
Relationship management	4.00	0.60	0.837	.114	.103	.464**	.544**	.714**	---				
Altruism	4.35	0.51	0.805	.156**	.089	.461**	.401**	.487**	.582**	---			
Courtesy	4.47	0.64	0.784	-.018	.163**	.605**	.414**	.407**	.447**	.567**	---		
Civic virtue	4.28	0.53	0.770	.031	.097	.429**	.425**	.485**	.541**	.610**	.538**	---	
Conscientiousness	4.52	0.58	0.817	.083	.001	.389**	.309**	.302**	.340**	.516**	.520**	.491**	---

**. Correlation is significant at the 0.01 level (2-tailed).

The Table 1 shows correlation among control variables, influencing and influenced variables taken for this study. Age of the respondents is weakly correlated with the level of social awareness ($r = .21$, $p < .001$) and with the level of altruism ($r = .21$, $p < .001$) of the respondents. Another control variable gender has a very weak positive correlation with courtesy ($r = .16$, $p < .001$). It is clear from the table 1 that none of the control variables have the significant correlation with the variables relating to organizational citizenship behaviour.

A strong positive statistically significant correlation ($r = .61$, $p < .001$) is found between level of self-awareness and courtesy. A moderate correlation exists between self-awareness and altruism ($r = .46$, $p < .001$). The correlation between self-awareness is found to be moderate positive

between self-awareness and civic virtue (r = .41, p < .001) and weak positive with conscientiousness (r = .39, p < .001).

A moderate positive relationship is found between self-management and civic virtue (r = .43, p < .001), self-management and courtesy (r = .41, p < .001), and between self-management and altruism (r = .40, p < .001). The level of social awareness is moderately correlated with altruism and civic virtue (r = .49, p < .001). The relationship management is moderately and positively related with altruism (r = .59, p < .001) and with civic virtue (r = .54, p < .001).

In order to find out the unique contribution of various dimensions of emotional intelligence in determining the organizational citizenship behaviour among the college faculty members, a hierarchical regression has been done. Age and gender are assumed as control variables. Initially, the independent variables have been scrutinized for collinearity. The collinearity statistics revealed the VIF as less than 2 for all the variables, and collinearity tolerance as greater than 0.76.

As a first step, control variables age and gender were entered as independent variable with organizational citizenship behaviour as dependent variable. In step 2 self-awareness one of the dimensions of emotional intelligence was entered as independent variable. In step 3, self-management was entered and in step 4, social awareness was entered. Finally, the relationship management was entered.

The results of step 1 revealed that, the control variables age and gender contributed only 1.3% of the variance (adjusted R^2 = .013), which was significantly different from zero ($F_{(1, 281)}$ =2.94, p<.05). Among the two control variables, gender is found to be statistically significant variable (β = .13; t= 2.09; p < .005).

The results of step 2, revealed a significant contribution by self-awareness. That is, the change in variance accounted for (ΔR^2) 33%, which is considered as significant (β = .58; t= 11.94; p < .001). Change in R square was computed as 0.036, (β = .23; t= 4.03; p < .001) due to addition of the self-management in step 3. In step 4, social awareness found to be contributed to the extent of 0.037 variance (β = .25; t= 4.22; p < .001). Relationship management, which was incorporated in step 5 accounts for(ΔR^2) 0.051variance which is also considered as statistically significant (β = .33; t= 5.16; p < .001).

TABLE II SUMMARY OF HIERARCHICAL REGRESSION ANALYSIS

	B	**R^2**	**ΔR^2**	**Sig.F**
Step 1				
Age	0.19			
Gender	0.54			
		0.20	0.20	0.055
Step 2				
Self-awareness	2.22			
		0.35	0.33	0.000
Step 3				
Self-management	0.78			
		0.39	0.04	0.000
Step 4				
Social awareness	0.78			
		0.42	0.04	0.000
Step 5				
Relationship Management	1.01			
		0.47	0.05	0.000

It can be concluded that all the four dimensions of emotional intelligence make significant contribution and influences the level of organizational citizenship behaviour and among them all the self-awareness is the most significant predictor, followed by

relationship management. All the independent variable put together contribute for 46.3% variance.

DISCUSSIONS

Correlation analysis was done to find out nature of relationship between the dimensions of emotional intelligence and organizational citizenship behavior. Among all, self-awareness is found to be strongly related with courtesy. Relationship management has moderate relationship with and altruism and civic virtue. Conscientiousness does not have any significant relationship with any of the other variables. It has only moderate to low relationship with self-awareness.

Hierarchical regression is a significant method which helps to predict the specific contribution being made by every independent variable. It is accepted that the more the value of adjusted R square, the more will be the predictive power of the variable. The demographic variables gender and age do not predict any variance in the level of organizational citizenship behavior(Turnipseed & Vandewaa, 2012). The self-awareness is found to be a strong predictor of courtesy. Relationship management is found to have a linkage with altruism and civic virtue. The linkage of conscientiousness with the emotional intelligence variables are comparatively low. Social awareness and self-management are more or less equal predictors of organizational citizenship behavior. All the four dimensions of emotional intelligence put together makes a model significantly fit.

SUMMARY

The linkage between emotional intelligence and organizational citizenship behavior were already been analyzed by various studies. Higher the emotional intelligence , the level of organizational citizenship behavior will also be high (Hasidim, 1998). Faculty members those who wish to go for extra mile will make significant contribution for the growth of their Institutions and also for the betterment of students and peers.

The emotional intelligence do predict the two specific organizational citizenship behavior variables viz., altruism and conscientiousness (Korkmaz & Arpaci, 2009). A positive relationship between emotional intelligence and organizational citizenship behavior has also been confirmed (Hasidim, 1998). More such research is required to conform the findings of the study.

LIMITATIONS

The emotional intelligence of the faculty members was assessed based on their self-assessment report. A large sample could have helped to generalize the results of this study. The mixed model has been taken for this study. The other models could have brought into light some more/different predictions of the emotional intelligence and its impact on organizational citizenship behavior. Faculty members working in Arts and Science Colleges located in Kanchipuram District alone were taken for the study.

FUTURE STUDY

Studies with large sample size taken from different stream and from different locations can be undertaken in future. Studies on examining the gender effect on emotional intelligence and organizational citizenship behavior can also be undertaken. In order to find out whether the dimensions of organizational citizenship behavior are stable, a longitudinal approach can also be adopted.

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THE INFLUENCE OF AGE AND GENDER ON INVESTMENT BEHAVIOUR OF EMPLOYEES

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ABSTRACT

Investment plays a significant role in the development of a country's economy because it bridges a gap between money savers and borrowers. A recent survey exhibits that there was a drastic increases in the number of investors below the age of 35 and number of female investors in last 4 years. This study intends to examine the influence of age and gender on the investment behaviour of employees in Chennai. The extensive earlier literatures proved that Demographic factors are influencing the investment behaviour/ pattern though the concept of investment behaviour is a cognitive in nature. The data collected for this study is through primary source with the sample size of 150 employees. This study used Chi-Square test to understand the relationship between Age and Risk Aptitude & Gender and Risk Aptitude. The author adopts T-Test to examine the influence of Age and Gender towards the Type of Investment. Analysis of Variance (ANOVA) been adopted to understand the significance of Age and Gender towards the percentage of investment.

Key words: *Risk aptitude, Investment Behavior, Investment Pattern, Demographic factors, Investment Decision Making.*

BACKGROUND

In the sense of economy, an investment is the acquisition of goods which are not used today but in future to create wealth. In financial view, an investment is a monetory asset purchased with an intention to earn incomein future or the same be sold at a greater price tto earn profit.

The day-to-day usage of the term investment can mean a variety of things, but to a common man it usually refers to some sort of money obligation. For example, a commitment of money to buy a new fridge or vehicle is certainly an Investment from an individual's view point. But these are so in general and extended sense of the word, since rate of return calculation is not involved and there is no expectation of financial return or capital growth.

Financial investment is a specific form of the general and extended sense of investment. Investors to distinguish between the pseudo-investment concept of consumer and the real investment concept of the businessmen often use the term financial investment.

In a nutshell, the term financial investment would imply the employment of funds with the objective of obtaining additional income or growth in value of investment at a future date.

The Investment Behaviour of an Individual is influenced by various factors viz Demographic, Psychological, Behavioural, Economic and so on., But in this study, the author concentrates on the influence of demographic factor (with specific to Age and Gender).

METHODOLOGY

Objectives of the Study

This study aims to identify the association of twin Demographic factors viz Age and Gender towards type of investment, percentage of investment and risk aptitude of investors.

Sampling & Data Collection

Data for this study are collected through primary souce by circulating Questionnaire via Google Forms. The questionnaire for this study has been classified into 2 different part viz demographic questions and investment related questions. Likert scale questions have also been asked the respondents to assess the risk tolerance and motives of the investment. This study concentrates only on the employees in Chennai city. The author collected 150 respondents using Random Sampling Technique.

Variables

The Dependent Variable (DV) of the study are Age and Gender where as Type of Investment, Percentage of Investment and Risk Aptitude are the Independent Variables (IV) of the study.

Tools for Analysis

Chi Square test, ANOVA and T-test are the major tools uded in this study to derive the results for the objectives. Chi Square test used to determine the association between age and risk aptitude of the investors and also identify the influence of gender and risk aptitude.Analysis of Variables (ANOVA) used to examine the association of Age and Gender towards the percentage of investment. T- test is used to identify the significance of age and gender towards the type of investment.

DISCUSSION

Age Band and Risk Aptitude

H_0: There is no significant association between age band and risk aptitude.

H_1: There is significant association between age band and risk aptitude.

Chi Square Test			
	Value	**df**	**Asymp. Sig. (2-sided)**
Pearson Chi-Square	4.364[a]	6	.628
Likelihood Ratio	4.556	6	.602
Linear-by-Linear Association	.183	1	.669
N of Valid Cases	156		
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 5.88.			

Source: Primary Data

Above table indicates, chi-square value as 4.364 and the significant value is 0.628, which is greater than p value 0.05 and hence null hypothesis is accepted and concluded that there is no significant association between age band and risk aptitude towards investment of the respondents.

Gender and Percentage of Annual Salary Income Invested

Analysis of Variance (ANOVA)					
	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between Groups	1.799	1	1.799	1.308	.255
Within Groups	211.893	154	1.376		
Total	213.692	155			

Source: Primary Data

Based on the above results, the significant value is 0.255 and it is greater than 0.05 so null hypothesis is accepted. Hence there is a no significant difference in the Investment % of the respondents with respect to their gender. **Gender of the respondents does not influence their percentage of annual investment**.

Gender and Percentage of Investment

Group Statistics					
	Gender	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Investment %	Male	88	2.86	1.341	.143
	Female	68	2.65	.910	.110

Source: Primary Data

Gender and Types of investment

Group Statistics					
	Gender	**N**	**Mean**	**Std. Deviation**	**Std. Error Mean**
Invested in Equity	Male	88	1.49	.503	.054
	Female	68	1.63	.486	.059
Invested in Mutual Fund	Male	88	1.38	.487	.052
	Female	68	1.54	.502	.061
Invested in Bank Deposit	Male	88	1.13	.333	.035
	Female	68	1.04	.207	.025
Invested in Jewellery	Male	88	1.30	.459	.049
	Female	68	1.26	.444	.054
Invested in Insurance	Male	88	1.19	.397	.042
	Female	68	1.19	.396	.048
Invested in Real Estate	Male	88	1.53	.502	.053
	Female	68	1.72	.452	.055
Invested in Chit	Male	88	1.91	.289	.031
	Female	68	1.88	.325	.039

Source: Primary Data

Independent Sample Test						
Variables		**Levene's Test**		**T**	**df**	**Sig. (2-tailed)**
		F Value	**Sig**			
Invested in Equity	Equal variances assumed	6.384	.013	-1.797	154	.074
	Equal variances not assumed			-1.805	146.514	.073
Invested in Mutual Fund	Equal variances assumed	3.113	.080	-2.123	154	.035
	Equal variances not assumed			-2.115	142.056	.036
Invested in Bank Deposit	Equal variances assumed	13.685	.000	1.759	154	.081
	Equal variances not assumed			1.862	147.812	.065
Invested in Jewellery	Equal variances assumed	.721	.397	.421	154	.675
	Equal variances not assumed			.422	146.357	.673
Invested in Insurance	Equal variances assumed	.004	.950	.031	154	.975
	Equal variances not assumed			.031	144.388	.975
Invested in Real Estate	Equal variances assumed	19.268	.000	-2.403	154	.017
	Equal variances not assumed			-2.435	150.346	.016
Invested in Chit	Equal variances assumed	1.176	.280	.543	154	.588
	Equal variances not assumed			.535	135.203	.594

Source: Primary Data

Hypothesis: There is no significant difference between the genders and their type of Investment.

i. Equity

Levene's test for equality of variances (Homogeneity) result shows that significant value is 0.013, which means both the gender are homogeneous, so t test for equal variance not assumed considered. The mean value men are 1.49 and that of women are 1.63, the mean difference is -0.14 which is insignificant. Based on the result, the significant value is 0.073 and it is greater than 0.05. So the null hypothesis is accepted and concluded that the average investment in Equity of the genders were equal.

ii. Mutual Fund

Levene's test for equality of variances (Homogeneity) result shows that significant value is 0.080, which means both the gender are heterogeneous, so t test for equal variance assumed considered. The mean value men are 1.38 and that of women are 1.54, the mean difference is -0.16 which is insignificant. Based on the result, the significant value is 0.035 and it is lesser than 0.05. So the null hypothesis is rejected and concluded that the average investment in Mutual Funds of the genders were not equal.

iii. Bank Deposit

Levene's test for equality of variances (Homogeneity) result shows that significant value is 0.000, which means both the gender are homogeneous, so t test for equal variance not assumed considered. The mean value men are 1.13 and that of women are 1.04, the mean difference is 0.09 which is insignificant. Based on the result, the significant value is 0.065 and it is greater than 0.05. So the null hypothesis is accepted and concluded that the average investment in Bank Deposit of the genders were equal.

iv. Jewelry

Levene's test for equality of variances (Homogeneity) result shows that significant value is 0.397, which means both the gender are heterogeneous, so t test for equal variance assumed considered.. The mean value men are 1.30 and that of women are 1.26, the mean difference is 0.04 which is insignificant. Based on the result, the significant value is 0.675 and it is greater than 0.05. So the null hypothesis is accepted and concluded that the average investment in jewelry of the genders were equal.

v. Insurance

Levene's test for equality of variances (Homogeneity) result shows that significant value is 0.950, which means both the gender are heterogeneous, so t test for equal variance assumed considered.. The mean value men are 1.19 and that of women are 1.19, the mean difference is 0.000 which is insignificant. Based on the result, the significant value is 0.975 and it is greater than 0.05. So the null hypothesis accepted and concluded that the average investment in Insurance of the genders were equal.

vi. Real Estate Property

Levene's test for equality of variances (Homogeneity) result shows that significant value is 0.000, which means both the gender are homogeneous, so t test for equal variance not assumed considered.. The mean value men are 1.53 and that of women are 1.72, the mean difference is -0.19 which is insignificant. Based on the result, the significant value is .016 and it is lesser than 0.05. So the null hypothesis is rejected and concluded that the average investment in Real estate property of the genders were not equal.

vii. Chit Funds

Levene's test for equality of variances (Homogeneity) result shows that significant value is .280, which means both the gender are heterogeneous, so t test for equal variance assumed considered. The mean value men are 1.91 and that of women are 1.88, the mean difference is 0.03 which is insignificant. Based on the result, the significant value is 0.588 and it is greater than 0.05. So the null hypothesis is accepted and concluded that the average investment in Chit Funds of the genders were equal.

Hypothesis Test Results

Independent Variable	Hypothesis	Result
Risk Aptitude	H_0: There is no significant association between age band and risk aptitude. H_1: There is significant association between age band and risk aptitude.	H_0 Accepted
Percentage of Income Invested	H_0: There is no significant association between gender and percentage of income invested H_1: There is significant association between gender and percentage of income invested	H_0 Accepted
Equities	H_0: There is no significant association between gender and investment in equity	H_0 Accepted

	H_1: There is significant association between gender and invewtm3nt inequity	
Mutual Funds	H_0: There is no significant association between gender and investment in mutual funds H_1: There is significant association between gender and investment in mutual funds	H_0 Rejected
Bank Deposits	H_0: There is no significant association between gender and investment in bank deposits H_1: There is significant association between gender and investment in bank deposit	H_0 Accepted
Jewellery	H_0: There is no significant association between gender and investment in jewelery H_1: There is significant association between gender and investment in jewellery	H_0 Accepted
Real Estate	H_0: There is no significant association between gender and investment in real estate H_1: There is significant association between gender and investment in real estate	H_0 Rejected
Chit	H_0: There is no significant association between gender and investment in chit H_1: There is significant association between gender and investment in chit	H_0 Accepted
Insurance	H_0: There is no significant association between gender and investment in insurance H_1: There is significant association between gender and investment in insurance	H_0 Accepted

CONCLUSION

The main intention of the study is to identify the association of age and gender towards type of investment, percentage of investment and risk aptitude of investors towards investment. This study come up with nine research hypothesis to understand the significance of dependent variables towards independent variables. The earlier literatures stated that there is a significant relationship between age and risk aptitude of investors but this study concluded that age doesn't influence risk aptitude of an individual. Based on the analysis, Gender doesn't influence the percentage of income to be invested but the results shows that male employees are investing more when compares to female employees. It has also concluded that Investment in Mutual Funds and Real Estate are influence by the gender.

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A STUDY ON JOB BURN OUT AND SATISFACTION OF ACADEMICIANS DURING THIS PANDEMIC TIME IN CHENNAI COLLEGES

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ABSTRACT

Job Burnout is the need of the hour. Due to new pedagogy of teaching and new methods of analyzing students performance, almost the entire community of Educationalist are getting affected by this default. It doesn't happen overnight, this happens over a long period of time. It affects mental, physical and emotional outcome of person who is affected by it. The study also emphasis on the need of satisfaction, the drawback of burnout and its impact on Organisational growth and its objectives achievement. This article explains the need, objectives, with the research methodology and it application with conclusion. The Study was conducted with a sample of 55 from the College Lecturers, to understand whether they undergo Job Burnout or they are satisfied with the job Profile and the job. The study applied various tools like Arithmetic Mean, Anova, Correlation and Regression. After the application of tools the conclusion is derived.

Key words:*Burn out, Stress, Mental Strength, Emotional Disturbance, Satisfaction.*

INTRODUCTION

When an employee is given an opportunity to work and grow according to their speed and need of them they won't experience Stress, but when they are given a target to be achieved within a short span and limited space of growth definitely they may experience dissatisfaction and result in stress and job burnout. Stress is a word attached with the work load for more than a century. But there is also a hidden term in the Human Resource Department called burnout. This article is going to analyse the research on job burnout and satisfaction existing in colleges.

NEED OF THE STUDY

When the whole world is silently witnessing the effect of Corona, lock down and losing of life. The teachers all over the world was still equipping their knowledge and adapting their teaching methodology with the current development in technology just to educate their students. We can challenge the whole world; yes none of the sector was working 24* 7 like the Educational Sector. Apart from taking care of their family, they have concentrated more on the profession. We can even proudly say, that from March 2020 till this date of ours, the only field which has not taken leave or break or even lack updation is only Educational Field. Due to this balance of career, personal and professional they have experienced more amount of stress and several people have also experienced Job burnout due to imbalance of their emotional, personalization and personal Accomplishment.

OBJECTIVES OF THE STUDY

- Emotional exhaustion in fraternity
- Depersonalization of Educationalist
- Personal Accomplishment
- Appreciation, Career Growth in Educational Field
- Satisfaction level of Teaching community during Pandemic.

SCOPE OF THE STUDY

- The study can be extended to more sample Sizes for better analysis.
- The Research is restricted to Chennai Colleges, can be extended to schools and other colleges all over Tamilnadu or India for better results.

RESEARCH METHODOLOGY

The sample is taken from 55 Assistant and

Associate Professors in Chennai College and the data which was collected are analysed using Arithmetic Mean, Anova, Correlation and Regression. The sample method adopted is convenient sampling.

ANALYSIS AND INTERPRETATION

AGE OF THE RESPONDENTS

TABLE 1.1 - AGE OF THE RESPONDENTS

	FREQUENCY	PERCENT
VALID 25 – 30	23	2.3
31 – 35	23	2.3
36 – 40	9	0.9
TOTAL	55	5.5

From the above table and chart, it's inferred that majority of respondents are between 25 – 30 and 31 - 35.

INCOME OF THE RESPONDENTS

TABLE 1.2 - INCOME OF THE RESPONDENTS

	FREQUENCY	PERCENT
VALID 5000	1	1.8
10000	1	1.8
15000	1	1.8
20000	2	3.6
30000	4	7.3
40000	12	21.8
45000	1	1.8
50000	12	21.8
56000	1	1.8
58000	1	1.8
60000	6	10.9
65000	1	1.8
70000	3	5.5
73000	1	1.8
80000	1	1.8
82000	1	1.8
90000	2	3.6
100000	1	1.8
120000	2	3.6
125000	1	1.8
TOTAL	55	100.0

From the above table and chart, it's inferred that majority of respondents income level is 40000 & 50000.

HYPOTHESIS

HO: There is no significant relationship between Satisfaction and Salary paid.

H1: There is significant relationship between Satisfaction and Salary paid.

ANOVA

TABLE 1.3- Anova table representing the relationship between Satisfaction and Salary paid.

SATISFACTION

	SUM OF SQUARES	DF	MEAN SQUARE	F	SIG.
BETWEEN GROUPS	.644	2	.322	1.276	.284
WITHIN GROUPS	25.472	101	.252		
TOTAL	26.115	103			

SATISFACTION		
DUNCAN[A,B]		
QUALITY OF WORK PERFORMED	N	SUBSET FOR ALPHA = 0.05
		1
1	10	1.7000
2	16	1.7500
3	10	1.9103
4	9	1.6588
5	10	1.5489
Sig.		.253

Means for groups in homogeneous subsets are displayed.

a. Uses Harmonic Mean Sample Size = 17.112.

b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I errorlevels are not guaranteed.

INFERENCE

From the ANOVA analysis it can be seen that the F value is 45.629 with a significant value of 0.284. In SPSS, if the significant value is greater than 0.05, then accept null hypothesis and reject alternate hypothesis. Thus, there is no significant relationship between Satisfaction and Salary paid.

CORRELATION

TABLE 1.4 - Correlation table representing the relationship between Depersonalisation and job burnout

HYPOTHESIS

HO: There is no significant relationship between Depersonalisation and job burnout.

H1: There is significant relationship between Depersonalisation and job burnout. Correlation

		BRAND YOU PREFER	SERVICE PROVIDED BYKIA
DEPERSONALISATION	PEARSON CORRELATION	1	.289**
	SIG. (2-TAILED)		.003
	N	55	55
JOB BURNOUT	PEARSON CORRELATION	.289**	1
	SIG. (2-TAILED)	.003	
	N	55	55
**. CORRELATION IS SIGNIFICANT AT THE 0.01 LEVEL (2-TAILED).			

INFERENCE

The Pearson correlation value = 0.289 and the significant value is 0.003. If the significant value is less than 0.05, then there is a strong positive correlation so we should reject null hypothesis and accept alternate hypothesis. Thus, there is a significant relationship between job burnout.

REGRESSION

representing the relationship between Emotional Exhaustion and Personal Accomplishment towards Job Burnout

HYPOTHESIS

HO: There is no significant relationship between Emotional Exhaustion and Personal Accomplishment towards Job Burnout.
H1: There is significant relationship between Emotional Exhaustion and Personal Accomplishment towards Job Burnout.

TABLE 5.5.1: Regression table

VARIABLES ENTERED/REMOVED			
MODEL	/ARIABLES ENTERED	VARIABLES REMOVED	METHOD
1	EMOTIONAL EXHAUSTION AND PERSONAL ACCOMPLISHMENT TOWARDS JOB BURNOUT		ENTER

a. Dependent variable: Emotional Exhaustion and Personal Accomplishment

b. All requested variables entered.

MODEL SUMMARY				
MODEL	R	R SQUARE	ADJUSTED R SQUARE	D. ERROR OF THE ESTIMATE
1	.614	.377	.358	.56291

Predictors: (Constant), Emotional Exhaustion and Personal Accomplishment towards Job Burnout.

ANOVA[A]						
MODEL		SUM OF SQUARES	DF	MEAN SQUARE	F	SIG.
1	REGRESSION	19.150	3	6.383	20.146	.000[B]
	RESIDUAL	31.686	100	.317		
	TOTAL	50.837	103			

a. Dependent Variable: Emotional Exhaustion and Personal Accomplishment towards Job Burnout.

b. Predictors: (Constant), Emotional

MODEL	UNSTANDARDIZED COEFFICIENTS	STANDARDIZED COEFFICIENTS	T	SIG.

		B	STD. ERROR	BETA		
1	(CONSTANT)	1.594	.386		4.132	.000
	EMOTIONAL EXHAUSTION AND PERSONAL ACCOMPLISHMENT	.311	.102	.323	3.043	.003
	JOB BURNOUT.	.173	.081	.169	2.127	.036

Dependent Variable: Emotional Exhaustion and Personal Accomplishment

INFERENCE

From the above table it is incurred that the calculated value 0.05 is higher than significant value 0.000, so null hypothesis is rejected and alternate hypothesis is accepted and there exist a significant relationship between Emotional Exhaustion and Personal Accomplishment

FINDINGS

This research help us to find out that, the Lecturers are over stressed with the work load and in the process of learning new updation for online classes, for teaching their students in this pandemic situations. Though the payment was made on regular basis, the pressure on them was more and they strive hard to balance their personal life with their profession and also in learning new platforms for teaching.

CONCLUSION

The result is derived from the sample of 55 and concluded that pressure on every individual is increasing in all forms from financial till basic requirements. Especially, this study showed that Lecturers also underwent and still undergoing pressure and stress due to the indifferent working condition and situation which will lead to stress and also Job burnout.

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AN ANALYTICAL STUDY OF FOREIGN DIRECT INVESTMENT EQUITY INFLOWS IN INDIA- A SECTOR LEVEL ANALYSIS

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ABSTRACT

Foreign Direct Investment (FDI) plays a vital role in country's development. It's the potential for contributive to the development through the transfer of economic resources, technology and innovative and improved management techniques on with raising productivity. Developing countries like Asian country would like substantial foreign inflows to attain the desired investment to accelerate economic process and development. It will act as a catalyst for domestic industrial development. Further, it helps in dashing up economic activity and brings with it different scarce productive factors such as technical information and social control expertise, that square measure equally essential for economic development. Asian country has been the foremost vital beneficiary of remote direct interest in most of its varied segments. It likewise assumes a vital job in the advancement of a nation. Asian country is that the biggest quality based mostly nation with the second biggest people on the earth, with the quality of law and extremely taught English talking work power, the state is taken into account as a protected spot of assurance for outside money specialists. The study covers the performance of FDI Equity inflows in India and the sector-wise performance of FDI Equity inflows in India. and also the sector-wise performance of FDI Equity inflows in India. The samples of sector-wise FDI inflows in Asian country square measure elect based mostly on the convenient sampling technique. A Sample of ten sectors has been elect supported the supply of information.

Keywords: *FDI Equity Inflows, Sector-wise, Relationship, Two-tail test.*

Introduction

Foreign Direct Investment (FDI) means investing in a country other than your home country. It involves, Foreign Direct capital inflows from one country to another. Wherein, foreign countries have an ownership interest or a say in the business. FDI is generally seen as an accelerator for economic growth and it can be undertaken by institutions, corporations and individuals. FDI equity inflows rise by 168% to USD 17.57 billion during April-June 2021-22.

One of the most vital instrument for developing economies is Foreign Direct Investment. For developing economies finding investors is always problematic. For attracting Foreign Investors countries with huge amount of resources are liberalizing their policies. A country having development opportunity and huge profit can attract Investors easily. Developed countries are in search of developing countries having easily accessible factors of Production. Thus, for developing economies Foreign Direct Investment is the way for development. Foreign direct investment (FDI) has been increasingly influential in the developing world over the last two decades, consequently a growing number of developing countries are attracting substantial and increasing quantities of FDI coming in. Theoretical economics literature identifies several mechanisms by which FDI inflows can benefit the receiving economy. Nonetheless the empirical literature has lagged behind and has had a harder time identifying the pros in the plethora of complexities in the real world. Conspicuously, a vast number of researchers have examined the relationship between FDI and economic growth but their findings varied. Despite the lack of firm conclusions, most nations continue to pursue policies targeted at increasing FDI inflows.

From Last two decade India has recorded GDP growth continuously. That resulted in reduction in poverty, increasing employment opportunities, and made India host country for Foreign Direct Investment. Modernization and advancement encourages investment worldwide. Thus, this study is relevant for developing countries who want to attract investors. By establishing relationship between different sectors, they are able to identify the one sectors' performance affecting another sector's. It is important to know the influencing sector which cause changes in the performance of other sector. This study is analyzing selected sectors relation by taking

into account last three years sector-vise performance of FDI equity inflows.

Rationale of the Study

One of the scares resources that has been used by a developing country like India is Capital. Since capital is scarce, there is problems regarding poverty, unemployment, health, education, research and development, technology obsolesce and worldwide competition. To acquire capital funds at lower rate FDI helps the developing nation. Which helps in increasing employment opportunities and decreasing poverty. This study helps to identify the sectors which are related to each other so that by increasing performance of one sector can lead to do increase in performance of other sector. In short we can say that FDI is important for those countries which are having limited amount of resources, lack of infrastructure facility, and lack of modernization. If a country wants to increase any of the above mentioned factors, FDI is must.

Literature Review

Tam Bang Vu, Byron Gangnes & Ilan Noy (2008), estimated that impact of FDI growth on Sector wise performance of china and Vietnam. Intriguingly, they found out the effects seem to be very different through economic sectors, with most of the beneficial impact concentrated in the secondary industries. Other sectors were not much beneficial.

Sharma, Khurana (2013), used a data from 1991-92 to 2011-2012 (post-liberalization period). Their paper also discussed the various problems about the foreign direct investment and suggests the some recommendations for the same. In the study found that, Indian economy is mostly based on agriculture. So, agricultural services were very much important. Therefore, the foreign direct investment in this sector should be encouraged.

Dhiman & Sharma (2013), examined the inflow of capital in terms of foreign direct investment (FDI) has definitely affect entire economy as well as the capital markets. Foreign direct Investment has provided ample opportunities as far as technological up gradation is concerned. In addition to this India has also gained the global managerial skills which were required badly to sharpen the managerial skills for Indian industry. From the current study it is quite evident that there is strong degree of correlation between FDI & Sensex, and FDI & Nifty.

Vyas A.(2015), identified The inflow of FDI in service sectors and construction and development sector, from April, 2000 to June, 2015 attained substantial sustained economic growth and development through creation of jobs in India. Computer, Software & Hardware and Drugs & Pharmaceuticals sector were the other sectors to which attention was shown by Foreign Direct Investors (FDI). Investor's interest in foreign direct investment is very poor in other sectors of India. So, he stated that FDI is always helps to create employment in the country and also support the small scale industries also and helps country to put an impression on the world wide level through liberalization and globalization.

B. Murugesan(2016) had elaborately analyzed the trend and growth of FDI inflows in India during the study period from 1990- 91 to 2011-12. The following sectors have received more FDI inflows in India such as, Services Sector, Telecommunications, Construction Activities, Electricals Equipment, Automobile Industry, Power, Metallurgical Industries, Hotel & Tourism, Food Processing Industries, Trading, Chemicals, Information & Broadcasting, Petroleum & Natural Gas, Agriculture Services and Mining. The study examines that the government may have to fame new design of the FDI inflows policy in such a way where FDI inflows can be used as a means for increasing country's production, saving and exports through the equitable distribution among the states by providing much freedom for the states, so, that they can attract more FDI inflows at their own level. FDI inflows can help to raise the output, productivity and trade at the sectoral level of the Indian economy

Phuyal, Sunuwar (2018), examined that the sector wise effects of FDI on economic growth in Nepal represented by gross domestic product (GDP) and FDI as

dependent and independent variables respectively, thereby identifying the direct effect of FDI on GDP using 10 years (2007 to 2016) sectoral data as main source of the information. The entire result of the inferential analysis predicts that FDI of industry, tourism and agriculture sectors have a very positive and significant impact on GDP during the stipulated timeframe. Finally, it is noted that formulation of new plan and policy will be a necessary condition but not sufficient step for the development, so the key recommendations are made for the effective steps and actions to be taken by the concerned authority to review and implement the introduced plan and policies, which in turn, will help in flow of FDI to achieve, accelerate, and sustain the high rate of economic growth in Nepal.

Bayar, Gavriletea (2018), concluded that foreign direct investment (FDI) inflows have increased considerably in the globalized world as of the mid-1980s. The main objective of this research is to examine connections between FDI inflows and financial sector development in Central and Eastern European Union countries between 1996 and 2015 with panel data analysis. Our findings reveal that there is no co-integrating relationship among FDI inflows, investments of foreign portfolio, and the development of financial sectors, but there is a one-way causality from development of financial sectors to FDI inflows over the short run.

A. Muthusamy, S. Karthika (2019), concluded that FDI in India has a critical job in the monetary development and improvement of India. FDI in India in different parts can achieve supported monetary development and advancement through the production of employments, an extension of existing assembling enterprises. The study covers only the performance of FDI Equity inflows in India and the sector-wise performance of FDI Equity inflows in India. The samples of sector-wise FDI inflows in India are selected based on the convenient sampling method.

Jana, Sahu, Pandey (2019), have examined that the motivation behind this empirical investigation comes from the inconclusive evidence produced by a flurry of previous empirical studies on foreign direct investment (FDI)-growth nexus. The study recognized the fact that the treatment of FDI inflows in an aggregate form instead of a sector-specific approach while correlating it with economic growth remains the most tenuous assumption of the previously conducted studies. The study used a number of econometric tests, such as Johansen's co-integration test, vector error correction model, Granger causality test, variance decomposition analysis and impulse response analysis, to arrive at robust results. The study evidences the inward FDI to be non-contributive to the agricultural output growth. However, a reverse causality is evidenced wherein agricultural output is found to be attracting more FDI into the sector.

A. Bhati (2020), Foreign Direct investment play a very important role in the development of the nation. Sometimes domestically available capital is inadequate for the purpose of overall development of the country. Foreign capital is seen as a way of filling in gaps between domestic savings and investment. India can attract much larger foreign investments than it has done in the past.

M. Shanmugam (2020), examined the role of financial development as well as the quality of governance play in mediating the impact of foreign direct investment on domestic private investment using a sample of 33 emerging economics over the period 1996-2013. Using the Bias Corrected Least Square Dummy Variable (LSDVC) estimator, the relationship between foreign direct investment and domestic private investment is estimated. Our findings show that the foreign direct investment has a positive and significant effect on domestic private investment. The study found out that there is no relationship between domestic financial development indicators and level of domestic private investment. Among the governance indicators, the measure of political stability has a negative and significant effect, while the rule and law has positive effect on the level of domestic private investment. Moreover, our findings show that neither domestic financial sector nor the quality of governance explained the extent to which the FDI inflows translate into domestic private investment in the host

countries.

Sharma, Deepak. (2020), focused on FDI in India during the last thirteen years. FDI has created new opportunities in India. The inflows rose in the last decade and stimulated the performance of the industries. It can be concluded that the sector and country level of the Indian economy, FDI has helped to raise the output, productivity and employment in some sectors especially in service sector and Mauritius at the top for investment in India in various sectors. So, they conclude that FDI is always helps to create employment in the country and also support the small scale industries also and helps country to put an impression at global level.

Bhattarai, Negi (2020), contributed positively to sales, profit, employment and wages of firms in India from 2004 to 2018. Based on descriptive and empirical analysis it can be examined that good sentiments of FDI in India in Modi–II years started in 2019 will prevent diminishing returns on capital and contribute towards sustainable growth in coming years.

Tirkey (2020), examined the important factors that determine Foreign Direct Investment (FDI) inflow to Odisha in India. The study is based on secondary sources of data from Department of Industrial Policy and Promotion Govt. of India, Directorate of Industries Govt of Odisha, Economic Survey of Odisha and Annual Survey of Industries Govt. of Odisha. Simple Ordinary Least Square (OLS) method is applied to analyze the determinants of FDI inflow to Odisha and found that huge availability of mineral reserve in the state has statistically significant impact on FDI inflow to Odisha whereas market size measured by Gross State Domestic Product (GSDP), availability of power, domestic investment measured by Gross capital formation and capital expenditure, and installed capacity of power have insignificant impact on FDI inflow to Odisha during the study period from 1994-95 to 2014-15.

Basak, Gupta, Ghosh (2021), observed that foreign direct investment plays a vital role in the development of a nation. The present research work aims to analyze the impact of FDI inflows on annual GDP and per capita GDP, that is, to understand the impact of FDI on Indian economy since the implication of LPG policy in India.

This paper focuses on FDI in India during the last thirteen years. FDI has created new opportunities in India. The inflows rose in the last decade and stimulated the performance of the industries. It can be concluded that the sector and country level of the Indian economy, FDI has helped to raise the output, productivity and employment in some sectors especially in service sector and Mauritius at the top for investment in India in various sectors. Indian service sector is generating the proper employment options for skilled worker with high perks. On the other side banking and insurance sector help in providing the strength to the Indian economic condition and develop the foreign exchange system in country. So, we can conclude that FDI is always helps to create employment in the country and also support the small scale industries also and helps country to put an impression on the world wide level through liberalization and globalization.

Research Methodology

Research Objective:

• To analyze the sector-wise performance of FDI equity inflows in India.

• To examine the effect of one sector's performance on another sector's performance.

Research Design:

The present research work is analytical in nature. It is exclusively established on Secondary data and is done to examine sector-wise performance of FDI Equity inflows.

Sources of Data collection:

The Study is based on secondary data, which are gathered from yearly report of RBI, DIPP-Department of Industrial Policy and Promotion reports, articles and monetary foundations sites.

Sampling Decision:

In present study the samples of sectors are selected based on the convenient sampling method. A Sample of 10 sectors has been selected based on the availability of data and their relatedness.

The following have been selected for the sector-wise to the study

1. Services Sector

2. Computer Software & Hardware
3. Telecommunications
4. Construction Development
5. Trading
6. Automobile Industry
7. Chemicals (Other Than Fertilizers)
8. Drugs & Pharmaceuticals
9. Construction (Infrastructure) Activities
10. Power

Period of the Study:

The present study covers a period of three years, taking from 2018 to 2020.

Data Analysis Technique:

For examining performance of different sector CAGR (Compound Annual Growth Rate) have been used. To examine relationship between the sectors Paired Two tailed-test has been used. Paired Two tailed test has been used to identify possibility of relationship between both the directions. The sector wise data collected from authenticated website and after that statistical analysis of sector has been performed using MS Excel.

Result and Discussion

The FDI Equity inflows during the year from 2018 to 2020. Table 1 shows the total equity inflows and CAGR.

Table 1:Sector-wise performance of FDI equity inflows in India during the period 2018 to 2020

(Amount in Million)

SR. NO.	SECTOR	2018	2019	2020	TOTAL	CAGR
1	Services	591,992.35	639,527.02	265,706.36	1,497,225.73	-23.44 %
2	Computer hardware and software	417,331.86	546,170.83	1,407,902.49	2,371,405.18	49.98 %
3	Telecommunication	162,112.61	324,084.08	11,908.57	498,105.26	-58.12 %
4	Construction development	15,616.59	32,347.86	29,628.30	77,592.75	23.80 %
5	Trading	343,735.40	348,458.26	147,183.08	839,376.74	-24.63 %
6	Automobile	167,626.91	212,533.95	54,671.67	434,832.53	-31.17 %
7	Chemicals (other than fertilizers)	136,260.99	72,299.89	47,066.89	255,627.77	-29.84 %
8	Drugs & Pharmaceuticals	23,427.17	32,423.50	34,627.60	90,478.27	13.91 %
9	Construction Infrastructure Activities	140,883.23	125,808.02	78,079.33	344,770.58	-17.86 %
10	Power	82,079.55	30,506.52	42,499.67	155,085.74	-19.70 %

Interpretation

The above table1 shows the amount of FDI inflows from 2018 to 2020. It gives the relevant details whether the sector-wise performance of FDI Equity inflow differed across the three years. To analyze the performance of sector's CAGR has been used which shows Compounded Annual Grade Rate. Computer hardware and software sector has the highest compound annual growth rate of 49.98 percent FDI equity inflow in India during the period. It is mainly due to Covid-19, there is increase in demand for computer and online software. The lowest demand is of telecommunication and automobile sector.

Hypothesis Testing

1. **Ho**: There is no significant relationship between FDI Equity inflows of services-sector and computer software & hardware Sector.
2. **Ho:** There is no significant relationship between FDI Equity inflows of telecommunication sector and Construction sector.
3. **Ho**: There is no significant relationship between FDI Equity inflows of Trading sector and Auto Mobile Industry Sector.
4. **Ho:** There is no significant relationship between FDI Equity inflows Chemicals (other than fertilizers) sector and Drugs & Pharmaceuticals of Sector.
5. **Ho:** There is no significant relationship between FDI Equity inflows of

Construction (infrastructure) sector and Power of Sector.

Table 2: Paired Samples Test

Pair	Sector	Paired Difference			t	d.f.	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean			
1	Service Sector- Computer hardware & Software	-291,393.15	737937.5857	426048.4637	0.684	2	0.565
2	Telecommunication - Construction	140,170.84	154824.9082	89388.20244	1.568	2	0.257
3	Trading- the Automobile industry	134,848.07	41808.93045	24138.39725	5.586	2	0.031
4	Chemical (other than fertilizers)- Drugs & Pharmaceuticals	55,049.83	51888.73144	29957.97306	1.838	2	0.2075
5	Construction (infrastructure) activities- Power	63,228.28	30105.7695	17381.57412	3.638	2	0.068

Source: Computed

INTERPRETATION

1. Compared to the services sector and computer software & hardware using paired sample t-test from the table no 2 it shows that the calculated value of 't' is 0.684 for degrees of freedom = 2, and at 5% level of significance of the two-tail test. P-value is 0.565 (Greater than the value of 0.05). Hence we may reject the null hypothesis with 95% confidence. It is clear that the calculated value of 't' is greater than that of the table. It reveals that there is significant relationship between the services sector and computer software & hardware of Sector FDI Equity inflows.
2. Compared to the telecommunication and Constructions using paired sample t-test from the table no 3 it shows that the calculated value of 't' is 1.568 for degrees of freedom = 2, and at 5% level of significance of the two-tail test. P- Value is 0.257 (Greater than the value of 0.05). Hence we may reject the null hypothesis with 95% confidence. It is clear that the calculated value of 't' is Greater than that of the table. It reveals that there is no significant relationship between Telecommunication - Construction FDI.
3. the value of 0.05). Hence we Compared to the Trading and the Automobile industry using paired sample t-test from the table no 5 it shows that the calculated value of 't' is 5.586 for degrees of freedom = 2, and at 5% level of significance of the two-tail test. P-value is 0. 031 (Greater than may accept the null hypothesis with 95% confidence. The calculated value of 't' is greater than that of the table. It reveals that there is significant relationship between the Trading and the Automobile industry Sector FDI Equity inflows.
4. Compared to the Chemicals (other than fertilizers) - Drugs & Pharmaceuticals using paired sample t-test from the table no 5 it shows that the calculated value of 't' is 1.838 for degrees of freedom = 2, and at 5% level of significance of the two-tail test. P-value is 0. 2075 (Greater than the value of 0.05). Hence we may reject the null hypothesis with 95% confidence. The calculated value of' is greater than that of the table. It reveals that there is no significant relationship between the Chemicals (other than fertilizers) - Drugs & Pharmaceuticals of Sector FDI Equity inflows.
5. Compared to the Construction (infrastructure) activities and Power using paired sample t-test from the table no 6 it shows that the calculated value of' is 3.638 for degrees of freedom = 2 and at 5% level of significance of the two-tail test. P-value is 0.068 (Greater than the value of 0.05). Hence we may reject the null hypothesis with 95% confidence. It reveals that there is a no significant relationship between the Construction (infrastructure) activities and Power FDI.

CONCLUSION

FDI in India has a critical job in the monetary development and improvement of India. FDI in India in different parts can achieve supported monetary development and advancement through the production of employments, an extension of existing assembling enterprises. The study covers only the performance of FDI Equity inflows in India and the sector-wise performance of FDI Equity inflows in India. The inflow of FDI in the Trading and the Automobile utilizing combined example t-test P worth is 0.031 (Less than the estimation of 0.05). To conclude it there is a relationship between Trading and the Automobile sectors with reference to FDI equity inflows. So by increasing performance of one sector, other sectors' performance also increases. It is important for the government to know that by giving importance to only one sector they can get FDI form both sectors as they are related.

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TECHNOLOGY- BASED LANGUAGE TEACHING

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ABSTRACT

Rapid and continuous technology advancement has been seen in last couple of years. This advancement has its influence on every aspect of human life, especially the education system. In this frame of reference, we can see huge modification in teaching styles, methods and approaches. The traditional approaches of teaching are proving to be incompetent and deficient to match the level of expectation of the students and their style of learning. Increasing usage of technology and ICT make it easy and convenient to learn and teach foreign languages like English. The intend of this paper writing is to highlight the importance of different technologies for language teaching, especially the language skills (listening, speaking, reading and writing) and to present the technology- based language teaching process. Different platforms are available on the internet which are enhancing the use of technology for feasible and innovative way of teaching language. This paper also focuses on the technology- based model for language teaching. As a result of this review study, it is evident that the technology- based language teaching helps teachers and students both to use different resources multi time as per their need in effective manner. It is also shown from this review analysis that technology- based language teaching requires proper planning and execution otherwise it can affect students' learning in negative manner.

Keywords*: Technology, language, ICT, technology-based teaching and language skills.*

Introduction

Rapid and continuous technology advancement has its influence on every aspect of human life especially the education system. In this frame of reference, the traditional approaches of teaching are proving to be incompetent and deficient to match the level of expectation of the students and their style of learning. Students of present era are technological sound. They wish to have technological environment for their best learning. It is evident from study by [1] that the involvement of multi-technologies in teaching- learning process helps in making students innovative and creative which enhances their learning. These technologies also engage students in T/ L process, makes lesson easy, interesting and productive. This involvement in teaching- learning process helps them to improve the use of technology for better use [2]. Role of technology inclusion is seen to be positive in modifying improving the activities and cognitive faculties of students by creating child- centered atmosphere in T/L process [3], [4]. Increase in students' confidence level and enthusiasm was seen by [5] in his studies. At recent time, the use of technology in English teaching increased and has its substantial influence on Education as well as society. English as foreign language has its strong bong with technology as it is feasible to have technology tools and devices to teach language skills instead of inviting foreign resource persons on permanent bases. In this study [6] considered introduction of technology in English teaching a significant chance of growth for both students and teachers. According to [7] the technology-based approaches and methods of teaching can be beneficial for English language teachers to develop the interest and motivation among their students. Study by [8] revealed that in addition to other benefits of technology based English teaching it also develops and improves the communication skills of both teachers and students. Along with this, students can know and learn about the different necessary components of language: fluency, pronunciation and intonation through technology- based English teaching. So, it is evident from these studies that technology- based English teaching helps in improving and developing language skills. Technology not just helps teachers in teaching English but allows them to recreate, design and modify teaching activities as per the need of students for this better learning [9]. Technology- based English teaching does not mean to keep advanced tools and devices

without knowing their proper use for students' benefit. So, teachers should be prepared and trained for implementation of techniques and strategies which are needed for technology-based English teaching [10]. More attention should be on how and why technologies are being used for English teaching [11].

Thus, the purpose of this literature review is to highlight the technology based English teaching process and contribution of technology to teach English language skills viz. listening, speaking, reading and writing skills. This study also focuses on the benefits of technology- based English teaching.

Methodology

A scope review study was adopted as research methodology for this study, which leads research to review literature based on new ideas, frameworks and theories. According to [12] the main aim of scope review study is to search all the relevant data and information related to the subject indeed of any boundaries. This type of study is independent of research design but just focuses on the relevancy of material to be searched. Based on this method, total 31 articles on technology-based English teaching were reviewed and analyzed. Terms like 'technology integration', technology inclusion', technology-based teaching, 'multi- media technology, 'ICT' 'technological tools and devices' are used to search relevant the articles for detailed information of technology- based English teaching. As teaching is directly associated with learning so, this study considers both the terms equally important for reviewing the literature. Further analyses focus on three major aspects: (1) Meaning of technology-based English teaching along with its benefits, (2) Process and framework of technology-based English teaching and (3) Role of technology- based English teaching to develop language skills.

Results and Discussion

Technology- based English teaching

The inclusion of technology in English teaching is well known now a days with the advancement in Education system. As per [13] the technology-based teaching is the effective way of transmitting information by teachers for effective learning of students. In views of [14] technology inclusion is a teaching strategy and in addition to this, [1] considered it as a comprehensive approach towards teaching English. Specially in English teaching, technology is taken as the most significant element of teaching and learning because it helps teachers in constructing the conducive environment for teaching keeping in mind the needs of individual students. It involves the use of multi-sensory approach for teaching which makes students more attentive, motivated and interactive while learning English. Following are some of the benefits of technology- based teaching given by [15]:

1) Develops critical and learning thinking among students for active and cooperative learning.
2) Hold up different learning styles of learners.
3) Provides motivation for learning.
4) Personalized development of learners.
5) Rises the student- teacher interaction.
6) Develops and upgrades communication skills.
7) Makes students innovative and creative.

In addition to this [16] stated that the technology based English teaching has different devices and tools which provides opportunities to students to improve their English. Along with this it helps teachers in lesson planning of English teaching [17]. Endless efforts by language teachers in technology inclusion will make teaching and learning of language more interesting, easy and effective.

Process of Technology- based English Teaching

Technology based teaching involves three main aspects: (i) learning the use of technologies, (ii) inclusion of technology in teaching and (iii) inclusion of technology for students' learning [18]. In other words, by [19] before using technology in teaching/ learning process teachers should develop in them the technological competency. In addition to it technology-based teaching must consider students' needs, abilities and levels so they can have maximum of benefits from it [1]. So, he recommended some steps which should be followed while implementing technology based English teaching. Figure 1 clearly shows these three steps of technology- based English

teaching for innovative and interactive teaching- learning process.

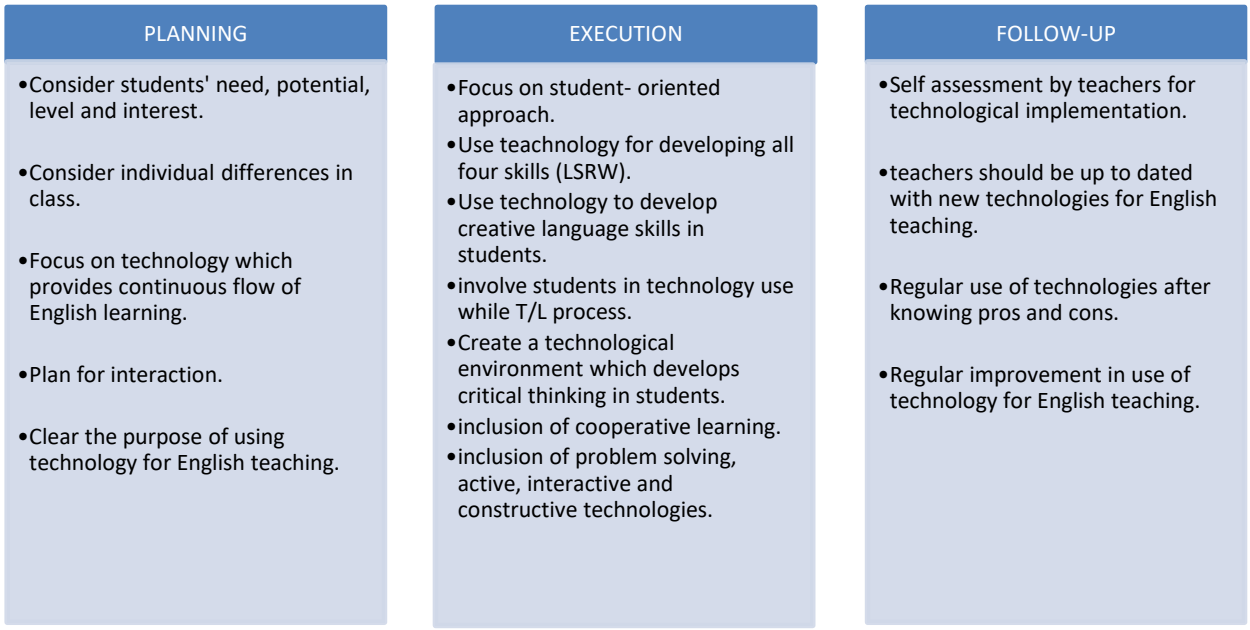

Fig. 1 Steps of Technology- Based English Teaching

Teacher should follow these steps for effective teaching of English with the help of different technologies. Unplanned and irrelevant technology use should be avoided by the teachers as it is the reason for students' distraction from studies. Other than this there is a frame work of technology- based English teaching given by [20] which elaborates three stages of effective use of multi- media for teaching English. According to her this framework will help English teachers to improve their learners learning habit and skills. The technologies which can be used under this framework comprised of online websites, computer aided programs, e-dictionaries, online chatting platforms and video clips. So, for proper understanding of this framework different stages are elaborated in Figure 2.

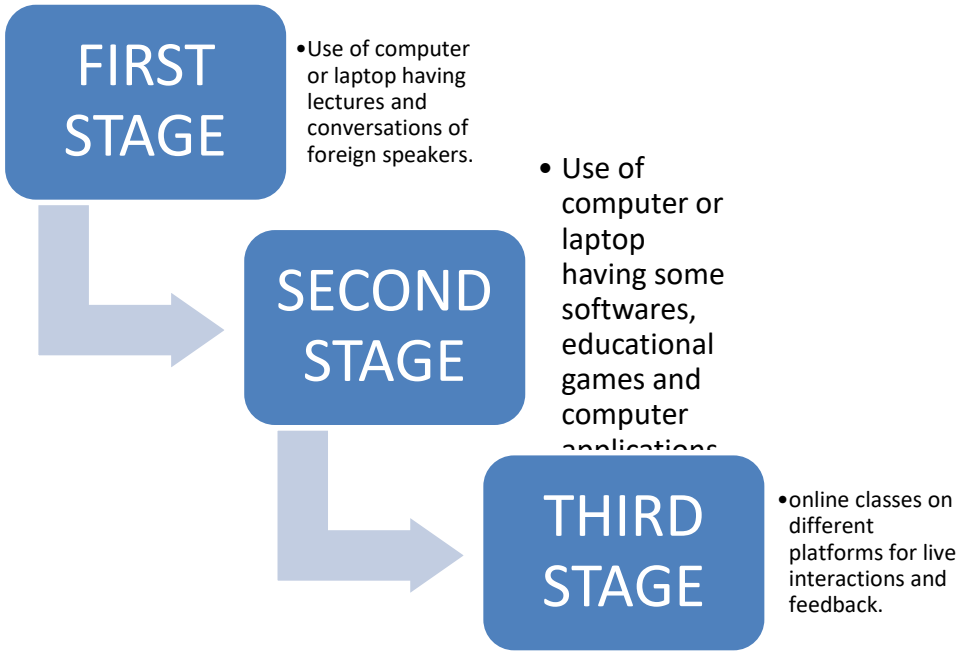

Fig. 2 Framework of technology- based English teaching

According to [20], these three stages can acquaint students and teachers with different technologies for their effective use to make teaching- learning process innovative and as per need of students.

(I) Use of computer or laptop having lectures and conversation of foreign speakers: First stage of this framework focuses on the presentation of audio- video clips on particular topic so that students can grasp the skills of English language by imitating the native speakers. Then students are provided with some incomplete sentences to check their knowledge they gained from presentation and after the completion of this assignment they are asked to present their responses by following the pronunciation, fluency and other necessary components of English speaking as per audio- video clips they saw and heard.

(II) Use of computer or laptop having some softwares, educational games and computer applications for students: this is a best means of personalized learning by the students. Here teacher acts as facilitator and guide students in every step of their assignment completion. After the presentation of their assignment students are provided with immediate feedback for their language improvement.

(III) Online classes on different platforms for live interaction and feedback: This is the last stage of this framework which provides an opportunity to students to be live on different online platforms for sharing their views, presentations and different assignments related to English language learning and usage. These platforms are means of immediate and world-wide feedback mechanism for students.

Role of technology-based English teaching for developing language skills

- Listening skill: First and foremost, skill of language learning is listening skill. In acquisition of any language listening skill plays very important role. In views of [21] listening does not mean just to hear something but to understand the meaning & pronunciation of words, fluency of language, accent, intonation and stress involved in speaking. It's necessary for learners as listeners to have understanding of all these factors at some time. For best development of listening skills among students' technology based English teaching is common now a days and even authentic also. In views of [22] media devices like radio and T.V are enhancing learners listening skills which further shows its impact on their ability to speak English accurately. Other tan these the devices like podcasts, audiotapes, tape recorders, videos, IPODs and use of online softwares and applications in developing listening skills can make students to understand the vocabulary, their pronunciation, accent of language and the intonation patterns.
- Speaking skill: In case of English language as second and foreign language then skill which is learnt at the last by the students is speaking skill. In his study, [23] focused on the use of language lab having different technologies for developing communication skills, especially speaking in students. There are certain web-based applications like internet voice chats on different platforms which gives opportunities to students to interact with native speakers as per their needs [24] and these applications of internet are evident to improve speaking skill of students [22]. [25] observed that the features of automatic voice recognition in smart phones have the potential to improve pronunciation and motivate learners for speaking.
- Reading skill: Reading is one of the skills of language learning which makes learner to improve and expand their vocabulary. In view of [26] computer-based reading activities make students to interact with digital text for independent learning of reading. Study by [22] stipulates that reading skills can be improved by using online dictionaries, browsing internet, using different softwares, online books/ texts/ newspapers, etc. All technological resources available on internet are useful for improving reading skills.

- Writing skill: According to [27] technology has encouraged students for writing and improving their writing skills. In addition to it, this is an effective way of developing self-paced writing skills [28]. Computer as technology helps students to use different features in their writing to make it attractive and grammatically accurate [22]. [29] found blog writing as one of the principal ways of teaching writing skills. It is recognized as real- digital environment for communication [30]. There are some other platforms like social media, online chats, e-mail writing, etc. which teach writing skills to the learners. E- portfolios are best way for learners to show case their writing skill. As per [31] social networks like facebook, twitter, etc. helps learners to choose & recognize effective words to make writing effective.

Conclusion

Reviewing 31 articles it is evident that the use of technology in English teaching and learning is very significant for the development of different skills associated with English language. Use of multi technologies in English teaching is helpful for both teachers and students. Technology not just makes teaching easy and meaningful but also helps in creating healthy and collaborative environment for T/L process. It focuses on personalized development of students which makes them innovative, creative and active learners. Technology- based English teaching also helps in developing and improving communication skills of both teachers and students. For effective use of technologies in English teaching teacher should follow the process and framework of Technology- based English teaching. Before using any technological tool for English teaching, teachers should know that which technology is the best means of teaching particular topic and how to use that technology for best outcomes in teaching-learning process. Self-assessment by teacher is one of the essential factors behind successful use of technologies for teaching. This is also evident from literature review that technology- based English teaching has its benefits to develop all the four language skills. There are variety of technologies like e-dictionaries, computer, IPADs, pod casts, audio- visual tapes, radio, T V, online chat media, online texts/ newspapers/ magazines/ journals/ books, social networks (facebook, twitter, you tube), etc. Along with these there are online platforms (Zoom, Google meet, Black-Board Collaborate Ultra, etc.) which helps in using multi- technologies/ media in one platform for making English teaching and learning both effective.

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ON SOME VERTEX MEAN LABELING FOR CYCLE WITH PARALLEL P_3 CHORDS

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ABSTRACT

In this paper, we study about the cycle with parallel P_3 chords, prove that the chain of cycles $C_{2n,m}(n \geq 3)(m \geq 2)$ with parallel P_3 chords and Edge connected cycle $C_{2n}(n \geq 3)$ with parallel P_3 chords possess vertex even mean labeling. We prove that the two copies of even cycles $C_{2n}(n \geq 3)$ with P_3 chords joining by the path P_m possess vertex even mean labeling.

Also, we prove vertex odd mean labeling for the cycle with parallel P_3 chords the chain of cycles $C_{2n,m}(n \geq 3)(n \geq 2)$ with parallel P_3 chords and Edge connected cycle $C_{2n}(n \geq 3)$ with P_3 chords possess vertex odd mean labeling. We show that the joining two copies of cycles $C_{2n}(n \geq 3)$ with parallel P_3 chords by the path P_m possess vertex odd mean labeling.

Keywords: *Mean labeling, vertex even mean labeling, parallel chords, vertex odd mean labeling, chain of cycles, Edge connected.*

Introduction

Labeling a graph by allotting the integers for the edges or vertices or both with certain constrains. Most of the labeling methods in graph are initiated by the Rosa[9] in 1967, later β-labeling was known as graceful labeling by Golomb[4]. Mean labeling was formed by Somasundaram.S and Ponraj[11] also, they showed results on gracefulness of cycle with parallel P_k chords. Gayathri.B and Gopi.R [3], are studied about the mean graphs related Cycle. Among the several types of mean labeling N.Revathi[8] initiated vertex even and odd mean labeling. Arockia Aruldoss.J, Pushparaj.S[1] and Raval.K.K and Prajapati.U.M[7] studied more on vertex even and odd mean labeling. A complete survey on graph labeling by J.Gallain[2] is widely used for reference by researchers. Govindarajan.R and Srividiya.V[5],[6] studied about the odd graceful and odd harmonious labeling on cycle with parallel chords. Uma Maheswari.A and Srividiya.V[12],[13],[14],[15],[16] proved the results for cycle with parallel chords with various labeling. A.Uma Maheswari and et.al[17][18] studied some labeling on cycle with parallel P_4 chords. Labeling graph serves in many applications Communication networks, Mobile telecommunication, coding theory etc., In past five decades various types of labeling are developed by the researchers. Here, we investigated the chain of cycle with P_3 chords, cycle connected by an edge with P_3 chords and the two copies of cycle with P_3 chords connecting by a path (P_n).

Definition 1: [14]

A cycle $C_n(n \geq 6)$ with parallel P_3 chord is obtained, cycle $C_n: u_0, u_1, u_2, \ldots \ldots u_{n-1}, u_0$ vertices by adding disjoint P_3 path between the couple of vertices $(u_1, u_{n-1}), (u_2, u_{n-2}), \ldots\ldots, (u_\propto, u_\beta)$ of $C_n$where $\alpha = \left\lfloor \frac{n}{2} \right\rfloor - 1$, $\beta = \left\lfloor \frac{n}{2} \right\rfloor + 2$ if n is odd or $\beta = \left\lfloor \frac{n}{2} \right\rfloor + 1$ if n is even. Then the graph G, $\frac{3n-2}{2}$ vertices and $2n-2$ edges if n is even and $\frac{3n-3}{2}$ vertices and $2n-3$ edges if n is odd.

Definition 2:[15]

A graph G, is said to be vertex odd mean graph if there exist an injection function $f: V(G) \to \{1, 3, 5, \ldots, 2q-1\}$ such that the induced mapping $f^*: E(G) \to I$ defined by $f^*(uv) = \frac{f(u)+f(v)}{2}$ are distinct for each edge uv. Such a function is named as vertex odd mean labeling.

Definition 3:[15]

A graph G, is said to be vertex odd mean graph if there exist an injection function $f: V(G) \to \{2,4,6,\ldots,2q\}$ such that the induced mapping $f^*: E(G) \to I$ define by $f^*(uv) = \frac{f(u)+f(v)}{2}$ are distinct for each edge uv. Such a function is named as vertex even

mean labeling.

Definition 4: [12]

The graph $C_{2n,m}$ is obtained by the m copies of cycle $C_{2n}(n \geq 3)$ by associating $v_{i,m}$ with $v_{i+1,m}$ for $(i = 1, 2, \ldots, n-1)$ where $v_{i,1}, v_{i,2}, \ldots, v_{i,m}$ are the successive vertices of cycle of m copies.

Definition 5: [13]

The graph G, is obtain by the edge connected to the cycle $C_{2n}(n \geq 3)$with path P_3 chords which are parallel, i.e., edge is connecting the j^{th}copy and $(j+1)^{th}$ copy of cycles, vertex having a degree 2 having m copies of cycle $(j = 1, 2, \ldots, m-1)$

In this article, the graph G has |V| of vertex set(order) and |E| edge set (size). Chain of cycle $C_{2n,m}(n \geq 3)$ with parallel P_3 chords has $|V(G)| = (3n-2)m + 1$, $|E(G)| = 2m(2n-1)$, edge connected of cycle $C_{2n}(n \geq 3)$ with parallel P_3 chords has $|V(G)| = (3n-1)m$, $|E(G)| = 4nm - m - 1$; $(m \geq 2)$. Also, the graph connecting the twin copies of cycle $C_{2n}(n \geq 3)$ with P_3 chords by the path P_m has, $|V(G)| = 6n + m - 4$, $|E(G)| = 8n + m - 5$.

MAIN RESULTS

Theorem 1: Every chain of cycles $C_{2n,m}(n \geq 3)$ with parallel P_3 chords accepts vertex even mean labeling.

Proof: Let us consider the graph $C_{2n,m}(n \geq 3)$, chain of cycles with parallel P_3 chords where, m be the copies of cycles. Let the vertex $u_{0,j+1}$ is identifying as $u_{2n-1,j}$ for $j = 1, 2, \ldots m$. Let $u_{0,j}, u_{1,j}, \ldots, u_{2n-1,j}$ $(j = 1, 2, \ldots m)$ be the vertices for the j^{th} copy of cycle $C_{2n,m}(n \geq 3)$ with parallel P_3 chords.

The vertex labelling was defined as, $f: V(G) \to \{2, 4, 6, \ldots, 8nm - 4m\}$

$f(u_{0,j}) = 8n(j-1) - 6j + 8; \quad 1 \leq j \leq m+1$

$f(u_{4i-3,j}) = 2(7i-5) + (8n-6)(j-1);$
$1 \leq i \leq \lfloor \frac{n}{2} \rfloor, 1 \leq j \leq m$

$f(u_{4i-2,j}) = 2(7i-2) + (8n-6)(j-1);$
$1 \leq i \leq \lfloor \frac{n}{2} \rfloor, 1 \leq j \leq m$

$f(u_{4i-1,j}) = 2(7i+1) + (8n-6)(j-1);$
$1 \leq i \leq \lfloor \frac{n-1}{2} \rfloor, 1 \leq j \leq m$

$f(u_{4i,j}) = 2(7i-1) + (8n-6)(j-1); \; 1 \leq i \leq \lfloor \frac{n-1}{2} \rfloor, 1 \leq j \leq m$

$f(v_{2i-1,j}) = 2(7i-4) + (8n-6)(j-1);$
$1 \leq i \leq \lfloor \frac{n}{2} \rfloor, 1 \leq j \leq m$

$f(v_{2i,j}) = 14i + (8n-6)(j-1); \quad 1 \leq i \leq \lfloor \frac{n-1}{2} \rfloor, 1 \leq j \leq m$

From the above equation, patterns of vertex even mean labeling are distinct.

The edges of chain of cycles $C_{2n,m}$with parallel P_3 chords are partitioned such as, $E(G) = \bigcup_{i=1}^{10} E_i$

$E_1 = f^*(u_{i,j}, u_{i+1,j}); i = 0, 1 \leq j \leq m$

$E_2 = f^*(u_{i,j}, u_{i+2,j}); i = 0, 1 \leq j \leq m$

$E_3 = f^*(u_{2i-1,j}, u_{2i+1,j}); 1 \leq i \leq n-2, 1 \leq j \leq m$

$E_4 = f^*(u_{2i,j}, u_{2i+2,j}); 1 \leq i \leq n-2, 1 \leq j \leq m$

$E_5 = f^*(u_{4i-3,j}, v_{2i-1,j}); 1 \leq i \leq \lfloor \frac{n}{2} \rfloor, 1 \leq j \leq m$

$E_6 = f^*(v_{2i-1,j}, u_{4i-2,j}); 1 \leq i \leq \lfloor \frac{n}{2} \rfloor, 1 \leq j \leq m$

$E_7 = f^*(u_{4i-1,j}, v_{2i,j}); 1 \leq i \leq \lfloor \frac{n-1}{2} \rfloor, 1 \leq j \leq m$

$E_8 = f^*(v_{2i,j}, u_{4i,j}); 1 \leq i \leq \lfloor \frac{n-1}{2} \rfloor, 1 \leq j \leq m$

If n is odd, then $i = \lfloor \frac{n}{2} \rfloor; 1 \leq j \leq m$

$E_9 = f^*(u_{4i-1,j}, u_{4i+1,j+1})$

$E_{10} = f^*(u_{4i,j}, u_{4i+1,j+1})$

If n is even, then $i = \lfloor \frac{n-1}{2} \rfloor; 1 \leq j \leq m$

$E_9 = f^*(u_{4i+1,j}, u_{4i+3,j+1})$

$E_{10} = f^*(u_{4i+2,j}, u_{4i+4,j+1})$

Induced edges of $C_{2n,m}$ is defined, as $f^*: E(G) \to I$

$f^*(u_{i,j}, u_{i+1,j}) = 8n(j-1) + 3(3-2j); i = 0, 1 \leq j \leq m$

$f^*(u_{i,j}, u_{i+2,j}) = 8n(j-1) + 6(2-j); i = 0, 1 \leq j \leq m$

$f^*(u_{2i-1,j}, u_{2i+1,j}) = 7i + 3 + (8n-6)(j-1); 1 \leq i \leq n-2, 1 \leq j \leq m$

$f^*(u_{2i,j}, u_{2i+2,j}) = 7i + 4 + (8n-6)(j-1); 1 \leq i \leq n-2, 1 \leq j \leq m$

$f^*(u_{4i-3,j}, v_{2i-1,j})$
$= 14i - 9 + (8n - 6)(j - 1); 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$
$f^*(v_{2i-1,j}, u_{4i-2,j})$
$= 14i - 6 + (8n - 6)(j - 1); 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$
$f^*(u_{4i-1,j}, v_{2i,j})$
$= 14i + 1 + (8n - 6)(j - 1); 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$
$f^*(v_{2i,j}, u_{4i,j}) = 14i - 1 + (8n - 6)(j - 1); 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

If n is odd, then $i = \left\lfloor \frac{n}{2} \right\rfloor; 1 \le j \le m$
$f^*(u_{4i-1,j}, u_{4i+1,j+1})$
$= 15i + 3 + (8n - 6)(j - 1)$
$f^*(u_{4i,j}, u_{4i+1,j+1})$
$= 15i + 1 + (8n - 6)(j - 1)$

If n is even, then $i = \left\lfloor \frac{n-1}{2} \right\rfloor; 1 \le j \le m$
$f^*(u_{4i+1,j}, u_{4i+3,j+1})$
$= 15i + 8 + (8n - 6)(j - 1)$
$f^*(u_{4i+2,j}, u_{4i+4,j+1})$
$= 15i + 11 + (8n - 6)(j - 1)$

From the above equation, induced edges are observed that are distinct. Hence, the graph $C_{2n,m}(n \ge 3)$ chain of cycles with parallel P_3 chords accept vertex even mean labeling.

Example 1: The vertex even mean labeling on chain of cycle $C_{6,4}$ with parallel P_3 chords is a vertex even mean graph, is shown in Fig.1.

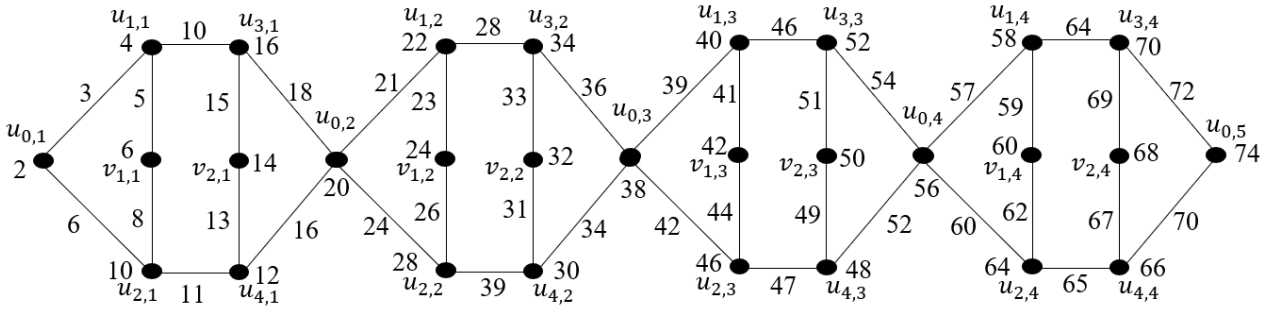

Fig.1. Chain of cycle $C_{6,4}$ with parallel P_3 chords

Theorem 2: Every chain of cycles $C_{2n,m}(n \ge 3)$ with parallel P_3 chords accepts vertex odd mean labeling.

Proof: Let us consider the graph $C_{2n,m}(n \ge 3)$, chain of cycles with parallel P_3 chords where, m be the copies of cycles. Where the vertex $u_{0,j+1}$ is identifying as $u_{2n-1,j}$ $(j = 1, 2, \dots m)$. Let $u_{0,j}, u_{1,j}, \dots, u_{2n-1,j} (j = 1,2,3, \dots m)$ be the vertices for the j^{th} copy of cycle $C_{2n,m}(n \ge 3)$ with parallel P_3 chords.

The vertex labelling was defined as, $f: V(G) \to \{1,3,5, \dots, 8nm - 4m - 1\}$

$f(u_{0,j}) = 8n(j-1) - 6j + 7; \quad 1 \le j \le m + 1$
$f(u_{4i-3,j}) = 8n(j-1) + 14i - 6j - 5; \quad 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$
$f(u_{4i-2,j}) = 8n(j-1) + 14i - 6j + 1; \quad 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$
$f(u_{4i-1,j}) = 8n(j-1) + 14i - 6j + 7; \quad 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$
$f(u_{4i,j}) = 8n(j-1) + 14i - 6j + 3; \quad 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$
$f(v_{2i-1,j}) = 8n(j-1) + 14i - 6j - 3; \quad 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$
$f(v_{2i,j}) = 8n(j-1) + 14i - 6j + 5; \quad 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

From the above equation, patterns of vertex labeling are distinct.

The edges of the graph $C_{2n,m}(n \ge 3)$, chain of cycles with parallel P_3 chords are partitioned such as, $E(G) = \bigcup_{i=1}^{10} E_i$

$E_1 = f^*(u_{i,j}, u_{i+1,j}); i = 0, 1 \le j \le m$
$E_2 = f^*(u_{i,j}, u_{i+2,j}); i = 0, 1 \le j \le m$
$E_3 = f^*(u_{2i-1,j}, u_{2i+1,j}); 1 \le i \le n-2, 1 \le j \le m$
$E_4 = f^*(u_{2i,j}, u_{2i+2,j}); 1 \le i \le n-2, 1 \le j \le m$

$E_5 = f^*(u_{4i-3,j}, v_{2i-1,j}); 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$

$E_6 = f^*(v_{2i-1,j}, u_{4i-2,j}); 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$

$E_7 = f^*(u_{4i-1,j}, v_{2i,j}); 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

$E_8 = f^*(v_{2i,j}, u_{4i,j}); 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

If n is odd, then $i = \left\lfloor \frac{n}{2} \right\rfloor; 1 \le j \le m$

$E_9 = f^*(u_{4i-1,j}, u_{4i+1,j+1})$

$E_{10} = f^*(u_{4i,j}, u_{4i+1,j+1})$

If n is even, then $i = \left\lfloor \frac{n-1}{2} \right\rfloor; 1 \le j \le m$

$E_9 = f^*(u_{4i+1,j}, u_{4i+3,j+1})$

$E_{10} = f^*(u_{4i+2,j}, u_{4i+4,j+1})$

Induced edge function of $C_{2n,m}$ is defined as, $f^*: E(G) \to I$

$f^*(u_{i,j}, u_{i+1,j}) = 8n(j-1) - 6j + 8; i = 0, 1 \le j \le m$

$f^*(u_{i,j}, u_{i+2,j}) = 8n(j-1) - 6j + 11; i = 0, 1 \le j \le m$

$f^*(u_{2i-1,j}, u_{2i+1,j}) = 8n(j-1) - 6j + 7i + 8; 1 \le i \le n-2, 1 \le j \le m$

$f^*(u_{2i,j}, u_{2i+2,j}) = 8n(j-1) - 6j + 7i + 9; 1 \le i \le n-2, 1 \le j \le m$

$f^*(u_{4i-3,j}, v_{2i-1,j}) = 8n(j-1) + 14i - 6j - 4; 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$

$f^*(v_{2i-1,j}, u_{4i-2,j}) = 8n(j-1) + 14i - 6j - 1; 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$

$f^*(u_{4i-1,j}, v_{2i,j}) = 8n(j-1) + 14i - 6j + 6; 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

$f^*(v_{2i,j}, u_{4i,j}) = 8n(j-1) + 14i - 6j + 4; 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

If n is odd, then $i = \left\lfloor \frac{n}{2} \right\rfloor; 1 \le j \le m$

$f^*(u_{4i-1,j}, u_{4i+1,j+1}) = 15i + 2 + (8n - 6)(j-1)$

$f^*(u_{4i,j}, u_{4i+1,j+1}) = 15i + (8n - 6)(j-1)$

If n is even, then $i = \left\lfloor \frac{n-1}{2} \right\rfloor; 1 \le j \le m$

$f^*(u_{4i+1,j}, u_{4i+3,j+1}) = 15i + 7 + (8n - 6)(j-1)$

$f^*(u_{4i+2,j}, u_{4i+4,j+1}) = 15i + 10 + (8n - 6)(j-1)$

From the above equation, induced edges are observed that are distinct. Hence, the graph $C_{2n,m}(n \ge 3)$ chain of cycles with parallel P_3 chords accept odd mean labeling of the vertex.

Example 2: The odd mean labeling of the vertex on chain of cycle $C_{10,2}$ with parallel P_3 chords is a vertex odd mean graph, is shown in Fig.2.

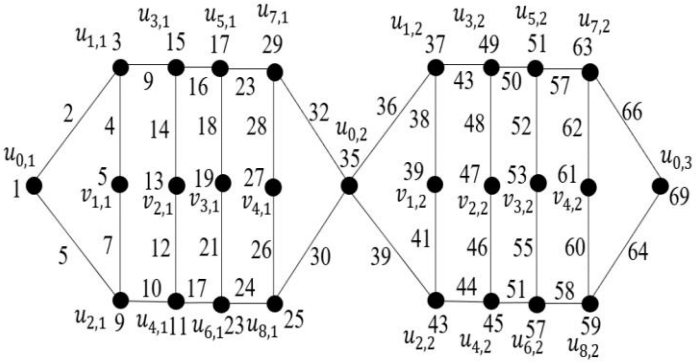

Fig.2 chain of cycle $C_{10,2}$ with parallel P_3 chords

Theorem 3: Edge connected cycle $C_{2n}(n \ge 3)$ with parallel P_3 chords accepts vertex even mean labeling.

Proof: Let us consider $C_{2n}(n \ge 3)$ with parallel P_3 chord, by connecting j^{th} copy vertex $u_{2n,j}$ to vertex $u_{1,j+1}$ of $j+1^{th}$ copy of cycle $C_{2n}(n \ge 3)$ $(j = 1, 2, \ldots, m)$ by an edge. Therefore, the resultant graph is G.

The vertex labeling is defined as, $f: V(G) \to \{2, 4, 6, \ldots, 8nm - 2m - 2\}$

$f(u_{i,j}) = 8n(j-1) - 4j + 6; i = 1, 1 \le j \le m$

$f(u_{2n,j}) = 2(4n-2)j; 1 \le j \le m$

$f(u_{4i-2,j}) = 2(7i-5) + (8n-4)(j-1); 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$

$f(u_{4i-1,j}) = 2(7i-2) + (8n-4)(j-1); 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$

$f(u_{4i,j}) = 2(7i+1) + (8n-4)(j-1); 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

$f(u_{4i+1,j}) = 2(7i-1) + (8n-4)(j-1); 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

$f(v_{2i-1,j}) = 2(7i-4) + (8n-4)(j-1); 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$

$f(v_{2i,j}) = 14i + (8n-4)(j-1); 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

From the above equation, patterns of vertex labeling are distinct.

The edges of the graph G, is partitioned as below $E(G) = \bigcup_{i=1}^{10} E_i$

$E_1 = f^*(u_{i,j}, u_{i+1,j}); i = 1, 1 \le j \le m$

$E_2 = f^*(u_{i,j}, u_{i+2,j}); i = 1, 1 \le j \le m$

$E_3 = f^*(u_{2i,j}, u_{2i+2,j}); 1 \le i \le n-2, 1 \le j \le m$

$E_4 = f^*(u_{2i+1,j}, u_{2i+3,j}); 1 \le i \le n-2, 1 \le j \le m$

$E_5 = f^*(u_{4i-2,j}, v_{2i-1,j}); 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$

$E_6 = f^*(v_{2i-1,j}, u_{4i-1,j}); 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$

$E_7 = f^*(u_{4i,j}, v_{2i,j}); 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

$E_8 = f^*(v_{2i,j}, u_{4i+1,j}); 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

$E_{11} = f^*(u_{2n,j}, u_{1,j+1}); 1 \le j \le m-1$

If *n* is odd, $i = \left\lfloor \frac{n}{2} \right\rfloor;\ 1 \le j \le m$

$E_9 = f^*(u_{4i,j}, u_{4i+2,j})$

$E_{10} = f^*(u_{4i+1,j}, u_{4i+2,j})$

If *n* is even, $i = \left\lfloor \frac{n-1}{2} \right\rfloor;\ 1 \le j \le m$

$E_9 = f^*(u_{4i+2,j}, u_{4i+4,j})$

$E_{10} = f^*(u_{4i+3,j}, u_{4i+4,j})$

Induced edge function of edge conntеced $C_{2n}(n \ge 3)$ are defined as $f^*: E(G) \to I$

$f^*(u_{i,j}, u_{i+1,j}) = 3 + (8n-4)(j-1); i = 1, 1 \le j \le m$

$f^*(u_{i,j}, u_{i+2,j}) = 6 + (8n-4)(j-1); i = 1, 1 \le j \le m$

$f^*(u_{2i,j}, u_{2i+2,j}) = 7i + 3 + (8n-4)(j-1); 1 \le i \le n-2, 1 \le j \le m$

$f^*(u_{2i+1,j}, u_{2i+3,j}) = 7i + 4 + (8n-4)(j-1); 1 \le i \le n-2, 1 \le j \le m$

$f^*(u_{4i-2,j}, v_{2i-1,j}) = 14i - 9 + (8n-4)(j-1); 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$

$f^*(v_{2i-1,j}, u_{4i-1,j}) = 14i - 6 + (8n-4)(j-1); 1 \le i \le \left\lfloor \frac{n}{2} \right\rfloor, 1 \le j \le m$

$f^*(u_{4i,j}, v_{2i,j}) = 14i + 1 + (8n-4)(j-1); 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

$f^*(v_{2i,j}, u_{4i+1,j}) = 14i - 1 + (8n-4)(j-1); 1 \le i \le \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \le j \le m$

$f^*(u_{2n,j}, u_{1,j+1}) = 4(2n-1)j + 1; 1 \le j \le m-1$

If *n* is odd, $i = \left\lfloor \frac{n}{2} \right\rfloor;\ 1 \le j \le m$

$f^*(u_{4i,j}, u_{4i+2,j}) = 8n(j-1) + 15i - 4j + 7$

$f^*(u_{4i+1,j}, u_{4i+2,j}) = 8n(j-1) + 15i - 4j + 5$

If *n* is even, $i = \left\lfloor \frac{n-1}{2} \right\rfloor;\ 1 \le j \le m$

$f^*(u_{4i+2,j}, u_{4i+4,j}) = 8n(j-1) + 15i - 4j + 15$

$f^*(u_{4i+3,j}, u_{4i+4,j}) = 8n(j-1) + 15i - 4j + 12$

From the above equation, we can observe that induced edges are distinct with succeeding copies of cycle. Therefore, edge connected cycle $C_{2n}(n \ge 3)$ with parallel P_3 chords is vertex even mean graph.

Example:3 An even mean labeling of vertex on three copies of cycle C_{10} with parallel P_3 chords connected by edge is vertex even mean graph is shown in fig.3

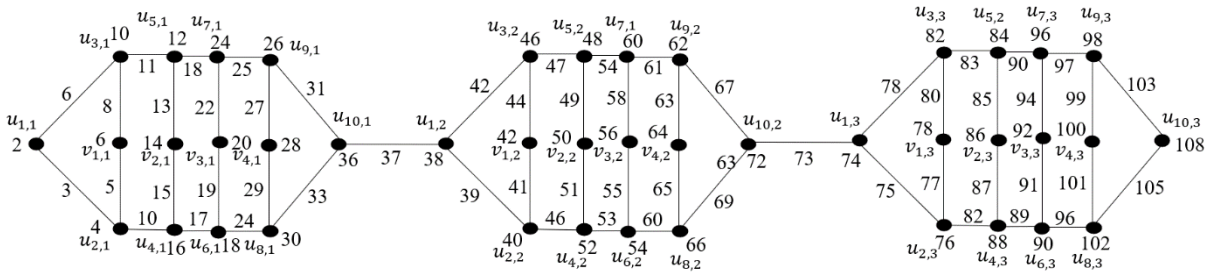

Fig.3 Three copies of cycle C_{10} with parallel P_3 chords connected by edge

Theorem 4: Edge connected cycle $C_{2n}(n \geq 3)$ with parallel P_3 chords accept vertex odd mean labeling.

Proof: Let consider $C_{2n}(n \geq 3)$ with parallel P_3 chords, by connecting j^{th} copy vertex $u_{2n,j}$ to vertex $u_{1,j+1}$ of $j+1^{th}$ $(j = 1, 2, \ldots, m)$ copy of cycle $C_{2n}(n \geq 3)$ by an edge. Therefore, the resultant graph is G.

The vertex labeling is defined as $f: V(G) \rightarrow \{1, 3, 5, \ldots, 8nm - 2m - 3\}$

$f(u_{i,j}) = 8n(j-1) - 4j + 5; i = 1, 1 \leq j \leq m$

$f(u_{2n,j}) = 4j(2n-1) - 1; 1 \leq j \leq m$

$f(u_{4i-2,j}) = 8n(j-1) + 14i - 4j - 7; 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor, 1 \leq j \leq m$

$f(u_{4i-1,j}) = 8n(j-1) + 14i - 4j - 1; 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor, 1 \leq j \leq m$

$f(u_{4i,j}) = 8n(j-1) + 14i - 4j + 5; 1 \leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \leq j \leq m$

$f(u_{4i+1,j}) = 8n(j-1) + 14i - 4j + 1; 1 \leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \leq j \leq m$

$f(v_{2i-1,j}) = 8n(j-1) + 14i - 4j - 5; 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor, 1 \leq j \leq m$

$f(v_{2i,j}) = 8n(j-1) + 14i - 4j + 3; 1 \leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \leq j \leq m$

From the above equation, the vertex labeling patterns are distinct.

The edges of the graph are partitioned as, $E(G) = \bigcup_{i=1}^{10} E_i$

$E_1 = f^*(u_{i,j}, u_{i+1,j}); i = 1, 1 \leq j \leq m$

$E_2 = f^*(u_{i,j}, u_{i+2,j}); i = 1, 1 \leq j \leq m$

$E_3 = f^*(u_{2i,j}, u_{2i+2,j}); 1 \leq i \leq n-2, 1 \leq j \leq m$

$E_4 = f^*(u_{2i+1,j}, u_{2i+3,j}); 1 \leq i \leq n-2, 1 \leq j \leq m$

$E_5 = f^*(u_{4i-2,j}, v_{2i-1,j}); 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor, 1 \leq j \leq m$

$E_6 = f^*(v_{2i-1,j}, u_{4i-1,j}); 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor, 1 \leq j \leq m$

$E_7 = f^*(u_{4i,j}, v_{2i,j}); 1 \leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \leq j \leq m$

$E_8 = f^*(v_{2i,j}, u_{4i+1,j}); 1 \leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \leq j \leq m$

$E_{11} = f^*(u_{2n,j}, u_{1,j+1}); 1 \leq j \leq m-1$

If n is odd, $i = \left\lfloor \frac{n}{2} \right\rfloor$; $1 \leq j \leq m$

$E_9 = f^*(u_{4i,j}, u_{4i+2,j})$

$E_{10} = f^*(u_{4i+1,j}, u_{4i+2,j})$

If n even, $i = \left\lfloor \frac{n-1}{2} \right\rfloor$; $1 \leq j \leq m$

$E_9 = f^*(u_{4i+2,j}, u_{4i+4,j})$

$E_{10} = f^*(u_{4i+3,j}, u_{4i+4,j})$

Induced edge function of $C_{2n}(n \geq 3)$ is defined as, $f^*: E(G) \rightarrow I$

$f^*(u_{i,j}, u_{i+1,j}) = 8n(j-1) - 4j + 6; i = 1, 1 \leq j \leq m$

$f^*(u_{i,j}, u_{i+2,j}) = 8n(j-1) - 4j + 9; i = 1, 1 \leq j \leq m$

$f^*(u_{2i,j}, u_{2i+2,j}) = 8n(j-1) + 7i - 4j + 6; 1 \leq i \leq n-2, 1 \leq j \leq m$

$f^*(u_{2i+1,j}, u_{2i+3,j}) = 8n(j-1) + 7i - 4j + 7; 1 \leq i \leq n-2, 1 \leq j \leq m$

$f^*(u_{4i-2,j}, v_{2i-1,j}) = 8n(j-1) + 14i - 4j - 6; 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor, 1 \leq j \leq m$

$f^*(v_{2i-1,j}, u_{4i-1,j}) = 8n(j-1) + 14i - 4j - 3; 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor, 1 \leq j \leq m$

$f^*(u_{4i,j}, v_{2i,j}) = 8n(j-1) + 14i - 4j + 4; 1 \leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \leq j \leq m$

$f^*(v_{2i,j}, u_{4i+1,j})$
$= 8n(j-1) + 14i - 4j + 2; 1$
$\leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor, 1 \leq j \leq m$

$f^*(u_{2n,j}, u_{1,j+1}) = 4(2n-1)j + 1; 1 \leq j$
$\leq m - 1$

If n is odd, $i = \left\lfloor \frac{n}{2} \right\rfloor$; $1 \leq j \leq m$

$f^*(u_{4i,j}, u_{4i+2,j})$
$= 8n(j-1) + 15i$
$- 4j + 6$

$f^*(u_{4i+1,j}, u_{4i+2,j})$
$= 8n(j-1) + 15i$
$- 4j + 4$

If n is even, $i = \left\lfloor \frac{n-1}{2} \right\rfloor$; $1 \leq j \leq m$

$f^*(u_{4i+2,j}, u_{4i+4,j})$
$= 8n(j-1) + 15i$
$- 4j + 14$

$f^*(u_{4i+3,j}, u_{4i+4,j})$
$= 8n(j-1) + 15i$
$- 4j + 11$

From the above equation, observed edges are labeled distinctly with succeeding copies of cycle. Therefore, edge connected cycles $C_{2n}(n \geq 3)$ with parallel P_3 chords is vertex odd mean graph.

Example:4 An odd mean labeling of vertex on four copies of cycle C_8 with parallel P_3 chords connected by edge is vertex odd mean graph is shown in fig.4

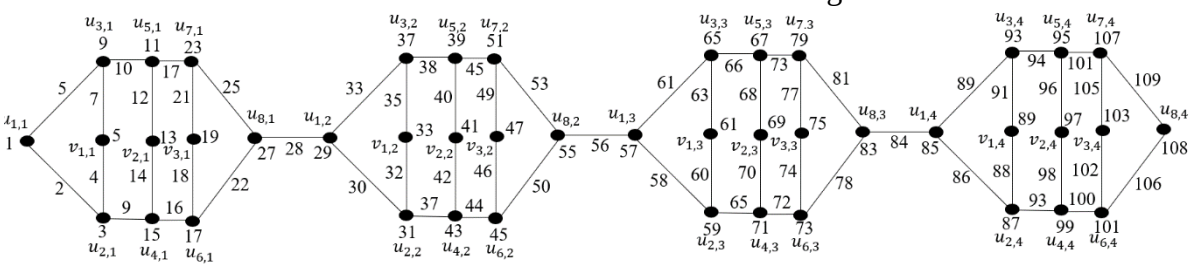

Fig.4 Four copies of edge connected cycle C_8 with parallel P_3 chords

Theorem 5: Joining two copies of cycle $C_{2n}(n \geq 3)$ with parallel P_3 chords by a path $P_m(m \geq 2)$ accepts vertex even mean labeling.

Proof: Let us consider two copies of cycle $C_{2n}(n \geq 3)$ with parallel P_3 chords. Let $u'_1, u'_2, \ldots, u'_{2n}$ and $u''_1, u''_2, \ldots, u''_{2n} (i = 1, 2, \ldots, 2n)$ are the vertices of first copy and second copy of cycle $C_{2n}(n \geq 3)$ with parallel chords P_3. Where $w_1, w_2, \ldots, w_m$ $(j = 1, 2, \ldots, m)$ be the vertices of path P_m connecting the two cycles which will be the same, i.e., $u'_{2n} = w_1$ and $u''_{2n} = w_m$.

The labelling of vertex is defined as $f: V(G) \to \{2,4,6, \ldots 2(8n + m - 5)\}$

Vertex labeling for the path, $f(w_j) = 8n - 4 + 2i; 0 \leq i \leq m-1, 1 \leq j \leq m$

The following patterns are, Vertex label for the first copy of the cycle,

$f(u'_1) = 2$

$f(u'_{4i-2}) = 14i - 10; 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor$

$f(u'_{4i}) = 14i + 2; 1 \leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor$

$f(u'_{4i-1}) = 14i - 4; 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor$

$f(u'_{4i+1}) = 14i - 2; 1 \leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor$

$f(v'_{2i-1}) = 14i - 8; 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor$

$f(v'_{2i}) = 14i; 1 \leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor$

Vertex label for the second copy of the cycle,

$f(u''_1) = 16n + 2m - 12$

$f(u''_{2n-4j}) = 8n + 14i + 2m + 8; 1 \leq j$
$\leq \left\lfloor \frac{n-1}{2} \right\rfloor, 0 \leq i \leq \left\lfloor \frac{n-3}{2} \right\rfloor$

$f(u''_{2n-4j+2}) = 8n + 14i + 2m - 4; 1 \leq j$
$\leq \left\lfloor \frac{n}{2} \right\rfloor, 0 \leq i \leq \left\lfloor \frac{n-2}{2} \right\rfloor$

$f(u''_{2n-4j+1}) = 8n + 14i + 2m + 4; 1 \leq j$
$\leq \left\lfloor \frac{n-1}{2} \right\rfloor, 0 \leq i \leq \left\lfloor \frac{n-3}{2} \right\rfloor$

$f(u''_{2n-4j+3}) = 8n + 14i + 2m + 2; 1 \leq j$
$\leq \left\lfloor \frac{n}{2} \right\rfloor, 0 \leq i \leq \left\lfloor \frac{n-2}{2} \right\rfloor$

$f(v''_{n-2j+1}) = 8n + 14i + 2m - 2; 1 \leq j$
$\leq \left\lfloor \frac{n}{2} \right\rfloor, 0 \leq i \leq \left\lfloor \frac{n-2}{2} \right\rfloor$

$f(v''_{n-2j}) = 8n + 14i + 2m + 6; 1 \leq j$
$\leq \left\lfloor \frac{n-1}{2} \right\rfloor, 0 \leq i \leq \left\lfloor \frac{n-3}{2} \right\rfloor$

From the above equation, pattern of vertex labelings are distinct.

The edges of the graph are partitioned as, $E(G) = \bigcup_{i=1}^{10} E'_i \cup E''' \bigcup_{i=1}^{10} E''_i$

For the path P_m,

$E''' = f^*(w_j, w_{j+1}); 1 \le j \le m-1, 0 \le i \le m-2$

Edge label for the first copy of the cycle,

$E'_1 = f^*(u'_1, u'_2)$

$E'_2 = f^*(u'_1, u'_3)$

$E'_3 = f^*(u'_{2j}, u'_{2j+2}); 1 \le i,j \le n-2$

$E'_4 = f^*(u'_{2j+1}, u'_{2j+3}); 1 \le i,j \le n-2$

$E'_5 = f^*(u'_{4j-2}, v'_{2j-1}); 1 \le i,j \le \left\lfloor \frac{n}{2} \right\rfloor$

$E'_6 = f^*(u'_{4j-1}, v'_{2j-1}); 1 \le i,j \le \left\lfloor \frac{n}{2} \right\rfloor$

$E'_7 = f^*(u'_{4j}, v'_{2j}); 1 \le i,j \le \left\lfloor \frac{n-1}{2} \right\rfloor$

$E'_8 = f^*(u'_{2j+1}, v'_{2j}); 1 \le i,j \le \left\lfloor \frac{n-1}{2} \right\rfloor$

If *n* is odd,

$E'_9 = f^*(u'_{2n-2}, u'_{2n});$

$E'_{10} = f^*(u'_{2n-1}, u'_{2n})$

If *n* is even,

$E'_9 = f^*(u'_{2n-2}, u'_{2n});$

$E'_{10} = f^*(u'_{2n-1}, u'_{2n})$

The Edge set for the second copy of the cycle,

$E''_1 = f^*(u''_1, u''_2)$

$E''_2 = f^*(u''_1, u''_3)$

$E''_3 = f^*(u''_{2j}, u''_{2j+2})$

$E''_4 = f^*(u''_{2j+1}, u''_{2j+3})$

$E''_5 = f^*(u''_{2n-4j}, v''_{n-2j})$

$E''_6 = f^*(u''_{2n-4j-2}, v''_{n-2j+1})$

$E''_7 = f^*(u''_{2n-4j+1}, v''_{n-2j})$

$E''_8 = f^*(u''_{2n-4j+3}, v''_{n-2j+1})$

$E''_9 = f^*(u''_{2n-2}, u''_{2n})$

$E''_{10} = f^*(u''_{2n-1}, u''_{2n})$

Induced edge function of a graph G is defined as $f^*: E(G) \to I$

For the path, P_m

$f^*(w_j, w_{j+1}) = 8n + 2i - 3; 1 \le j \le m-1, 0 \le i \le m-2$

Induced edges for the first copy of the cycle

$f^*(u'_1, u'_2) = 3$

$f^*(u'_1, u'_3) = 6$

$f^*(u'_{2j}, u'_{2j+2}) = 7i + 3; 1 \le i,j \le n-2$

$f^*(u'_{2j+1}, u'_{2j+3}) = 7i + 4; 1 \le i,j \le n-2$

$f^*(u'_{4j-2}, v'_{2j-1}) = 14i - 5; 1 \le i,j \le \left\lfloor \frac{n}{2} \right\rfloor$

$f^*(u'_{4j-1}, v'_{2j-1}) = 14i - 6; 1 \le i,j \le \left\lfloor \frac{n}{2} \right\rfloor$

$f^*(u'_{4j}, v'_{2j}) = 14i + 1; 1 \le i,j \le \left\lfloor \frac{n-1}{2} \right\rfloor$

$f^*(u'_{4j+1}, v'_{2j}) = 14i - 1; 1 \le i,j \le \left\lfloor \frac{n-1}{2} \right\rfloor$

If *n* is odd, $i = \left\lfloor \frac{n}{2} \right\rfloor$

$f^*(u'_{2n-2}, u'_{2n}) = 3(5i+1)$

$f^*(u'_{2n-1}, u'_{2n}) = 15i + 1$

If *n* is even, $i = \left\lfloor \frac{n}{2} \right\rfloor$

$f^*(u'_{2n-2}, u'_{2n}) = 15i - 7$

$f^*(u'_{2n-1}, u'_{2n}) = 15i - 4$

Induced Edges for the second copy of the cycle stated as,

$f^*(u''_1, u''_2) = 13n + 2m - 5$

$f^*(u''_1, u''_3) = 18n + 2m - 22$

$f^*(u''_{2j}, u''_{2j+2}) = 8n + 2m + 2 + 7i; n-2 \ge j \ge 1, 0 \le i \le \left\lfloor \frac{n-2}{2} \right\rfloor$

$f^*(u''_{2j+1}, u''_{2j+3}) = 8n + 2m + 7i + 3;\ n-2 \ge j \ge 1, 0 \le i \le \left\lfloor \frac{n-2}{2} \right\rfloor$

$f^*(u''_{2n-4j}, v''_{n-2j}) = 8n + 14i + 2m + 7; 1 \le j \le \left\lfloor \frac{n-1}{2} \right\rfloor, 0 \le i \le \left\lfloor \frac{n-3}{2} \right\rfloor$

$f^*(u''_{2n-4j+2}, v''_{n-2j+1}) = 8n + 14i + 2m - 3;\ 1 \le j \le \left\lfloor \frac{n}{2} \right\rfloor, 0 \le i \le \left\lfloor \frac{n-2}{2} \right\rfloor$

$f^*(u''_{2n-4j+1}, v''_{n-2j}) = 8n + 14i + 2m + 5; 1 \le j \le \left\lfloor \frac{n-1}{2} \right\rfloor, 0 \le i \le \left\lfloor \frac{n-3}{2} \right\rfloor$

$f^*(u''_{2n-4j+3}, v''_{n-2j+1}) = 8n + 14i + 2m;$
$1 \le j \le \left\lfloor \frac{n}{2} \right\rfloor, 0 \le i \le \left\lfloor \frac{n-2}{2} \right\rfloor$

$f^*(u''_{2n-2}, u''_{2n}) = 8n + 2m - 5$

$f^*(u''_{2n-1}, u''_{2n}) = 8n + 2m - 2$

By the induced edges, the labeling pattern of vertex is distinct. The graph permits the vertex even mean labeling.

Example 5: Vertex even mean labeling on Two copies of C_8 with parallel chords P_3, joining by the path P_4 is vertex even mean graph is shown in Fig.5

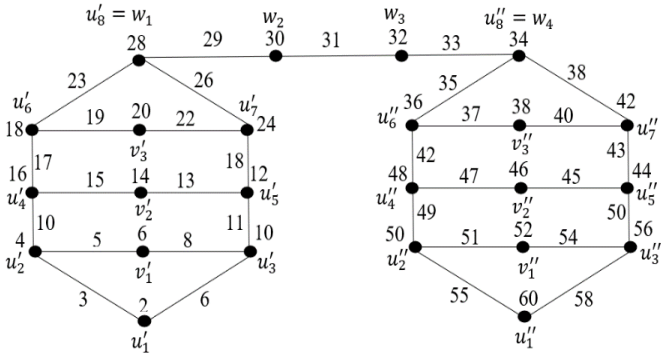

Fig.5 Two copies of C_8 with parallel chords P_3, joining by the path P_4

Theorem 6: ***Joining twin copies of cycle $C_{2n}(n \ge 3)$ with parallel P_3 chords by a***

path $P_m(m \geq 2)$ accepts vertex odd mean labeling.

Proof: Let us consider two copies of cycle $C_{2n}(n \geq 3)$ with parallel P_3 chords having $u_1', u_2', \ldots, u_{2n}'$ and $u_1'', u_2'', \ldots, u_{2n}''(i = 1, 2, \ldots, 2n)$ be the vertices of first copy and second copy of cycle $C_{2n}(n \geq 3)$ with parallel P_3 chords. Where $w_1, w_2, \ldots, w_m(j = 1, 2, \ldots, m)$ be the vertices of path P_m connecting the two cycles i.e., $u_{2n} = w_1$ and $u_{2n}' = w_m$.

We define the labelling for vertex as, $f: V(G) \to \{1,3,5, \ldots 2(8n + m - 5) - 1\}$

Vertex labeling of the path P_m,

$f(w_j) = 8n - 5 + 2i; 0 \leq i \leq m - 1, 1 \leq j \leq m$

The following patterns are, Vertex label for the first copy of the cycle,

$f(u_1') = 1$

$f(u_{4i-2}') = 14i - 11; 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor$

$f(u_{4i}') = 14i + 1; 1 \leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor$

$f(u_{4i-1}') = 14i - 5; 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor$

$f(u_{4i+1}') = 14i - 3; 1 \leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor$

$f(v_{2i-1}' v_{2i-1}) = 14i - 9; 1 \leq i \leq \left\lfloor \frac{n}{2} \right\rfloor$

$f(v_{2i}') = 14i - 1; 1 \leq i \leq \left\lfloor \frac{n-1}{2} \right\rfloor$

Vertex labeling for the second copy of the cycle,

$f(u_1') = 16n + 2m - 13$

$f(u_{2n-4j)}') = 8n + 14i + 2m + 7; 1 \leq j \leq \left\lfloor \frac{n-1}{2} \right\rfloor, 0 \leq i \leq \left\lfloor \frac{n-3}{2} \right\rfloor$

$f(u_{2n-4j+2)}') = 8n + 14i + 2m - 5; 1 \leq j \leq \left\lfloor \frac{n}{2} \right\rfloor, 0 \leq i \leq \left\lfloor \frac{n-2}{2} \right\rfloor$

$f(u_{2n-4j+1)}') = 8n + 14i + 2m + 3; 1 \leq j \leq \left\lfloor \frac{n-1}{2} \right\rfloor, 0 \leq i \leq \left\lfloor \frac{n-3}{2} \right\rfloor$

$f(u_{2n-4j+3)}') = 8n + 14i + 2m + 1; 1 \leq j \leq \left\lfloor \frac{n}{2} \right\rfloor, 0 \leq i \leq \left\lfloor \frac{n-2}{2} \right\rfloor$

$f(v_{n-2j+1)}') = 8n + 14i + 2m - 3; 1 \leq j \leq \left\lfloor \frac{n}{2} \right\rfloor, 0 \leq i \leq \left\lfloor \frac{n-2}{2} \right\rfloor$

$f(v_{n-2j)}') = 8n + 14i + 2m + 5; 1 \leq j \leq \left\lfloor \frac{n-1}{2} \right\rfloor, 0 \leq i \leq \left\lfloor \frac{n-3}{2} \right\rfloor$

From the above equation, patterns of vertex labeling are distinct.

The edges of the graph G are partitioned as, $E(G) = \bigcup_{i=1}^{10} E_i' \cup E''' \bigcup_{i=1}^{10} E_i''$

For the path P_m,

$E''' = f^*(w_j, w_{j+1}); 1 \leq j \leq m - 1, 0 \leq i \leq m - 2$

Edges set for the first copy of the cycle is given as,

$E_1' = f^*(u_1', u_2')$

$E_2' = f^*(u_1', u_3')$

$E_3' = f^*(u_{2j}', u_{2j+2}'); 1 \leq i, j \leq n - 2$

$E_4' = f^*(u_{2j+1}', u_{2j+3}'); 1 \leq i, j \leq n - 2$

$E_5' = f^*(u_{4j-2}', v_{2j-1}'); 1 \leq i, j \leq \left\lfloor \frac{n}{2} \right\rfloor$

$E_6' = f^*(u_{4j-1}', v_{2j-1}'); 1 \leq i, j \leq \left\lfloor \frac{n}{2} \right\rfloor$

$E_7' = f^*(u_{4j}', v_{2j}'); 1 \leq i, j \leq \left\lfloor \frac{n-1}{2} \right\rfloor$

$E_8' = f^*(u_{2j+1}', v_{2j}'); 1 \leq i, j \leq \left\lfloor \frac{n-1}{2} \right\rfloor$

If n is odd,

$E_9' = f^*(u_{2n-2}', u_{2n}')$

$E_{10}' = f^*(u_{2n-1}', u_{2n}')$

If n is even,

$E_9' = f^*(u_{2n-2}', u_{2n}')$

$E_{10}' = f^*(u_{2n-1}', u_{2n}')$

Edges set for the second copy of the cycle is given as,

$E_1'' = f^*(u_1'', u_2'')$

$E_2'' = f^*(u_1'', u_3'')$

$E_3'' = f^*(u_{2j}'', u_{2j+2}'')$

$E_4'' = f^*(u_{2j+1}'', u_{2j+3}'')$

$E_5'' = f^*(u_{2n-4j}'', v_{n-2j}'')$

$E_6'' = f^*(u_{2n-4j-2}'', v_{n-2j+1}'')$

$E_7'' = f^*(u_{2n-4j+1}'', v_{n-2j}'')$

$E_8'' = f^*(u_{2n-4j+3}'', v_{n-2j+1}'')$

$E_9'' = f^*(u_{2n-2}'', u_{2n}'')$

$E_{10}'' = f^*(u_{2n-1}'', u_{2n}'')$

Induced edges function for the graph is defined, as $f^*: E(G) \to I$

$f^*(w_j, w_{j+1}) = 8n + 2i - 4; 1 \leq j \leq m - 1, 0 \leq i \leq m - 2$

Induced edges for the first copy of the cycle

$f^*(u_1', u_2') = 2$

$f^*(u_1', u_3') = 5$

$f^*(u_{2j}', u_{2j+2}') = 7i + 2; 1 \leq i, j \leq n - 2$

$f^*(u_{2j+1}', u_{2j+3}') = 7i + 3; 1 \leq i, j \leq n - 2$

$f^*(u_{4j-2}', v_{2j-1}') = 14i - 6; 1 \leq i, j \leq \left\lfloor \frac{n}{2} \right\rfloor$

$f^*(u_{4j-1}', v_{2j-1}') = 14i - 7; 1 \leq i, j \leq \left\lfloor \frac{n}{2} \right\rfloor$

$f^*(u_{4j}', v_{2j}') = 14i; 1 \leq i, j \leq \left\lfloor \frac{n-1}{2} \right\rfloor$

$f^*(u'_{4j+1}, v'_{2j}) = 14i - 2; 1 \le i, j \le \left\lfloor \frac{n-1}{2} \right\rfloor$

If n is odd, $i = \left\lfloor \frac{n}{2} \right\rfloor$

$f^*(u'_{2n-2}, u'_{2n}) = 15i + 2$

$f^*(u'_{2n-1}, u'_{2n}) = 15i$

If n is even, $i = \left\lfloor \frac{n}{2} \right\rfloor$

$f^*(u'_{2n-2}, u'_{2n}) = 15i - 8$

$f^*(u'_{2n-1}, u'_{2n}) = 15i - 5$

Induced Edges for the second copy of the cycle,

$f^*(u''_1, u''_2) = 13n + 2m - 6$

$f^*(u''_1, u''_3) = 18n + 2m - 23$

$f^*(u''_{2j}, u''_{2j+2}) = 8n + 2m + 7i + 1; n - 2 \ge j \ge 1, 1 \le j \le n - 2, 0 \le i \le \left\lfloor \frac{n-2}{2} \right\rfloor$

$f^*(u''_{2j+1}, u''_{2j+3}) = 8n + 2m + 7i + 2;\ n - 2 \ge j \ge 1, 1 \le j \le n - 2, 0 \le i \le \left\lfloor \frac{n-2}{2} \right\rfloor$

$f^*(u''_{2n-4j}, v''_{n-2j}) = 8n + 14i + 2m + 6; 1 \le j \le \left\lfloor \frac{n-1}{2} \right\rfloor, 0 \le i \le \left\lfloor \frac{n-3}{2} \right\rfloor$

$f^*(u''_{2n-4j+2}, v''_{n-2j+1}) = 8n + 14i + 2m - 4;\ 1 \le j \le \left\lfloor \frac{n}{2} \right\rfloor, 0 \le i \le \left\lfloor \frac{n-2}{2} \right\rfloor$

$f^*(u''_{2n-4j+1}, v''_{n-2j}) = 8n + 14i + 2m + 4; 1 \le j \le \left\lfloor \frac{n-1}{2} \right\rfloor, 0 \le i \le \left\lfloor \frac{n-3}{2} \right\rfloor$

$f^*(u''_{2n-4j+3}, v''_{n-2j+1}) = 8n + 14i + 2m - 1; 1 \le j \le \left\lfloor \frac{n}{2} \right\rfloor, 0 \le i \le \left\lfloor \frac{n-2}{2} \right\rfloor$

$f^*(u''_{2n-2}, u''_{2n}) = 8n + 2m - 6$

$f^*(u''_{2n-1}, u''_{2n}) = 8n + 2m - 3$

Therefore, the induced edges are distinct by vertex odd mean labeling. Hence, the graph is vertex odd mean graph.

Example 6: On odd mean labeling of vertex on two copies of C_{12} with parallel chords P_3, joining by the path P_5 is vertex odd mean graph is shown in Fig.6

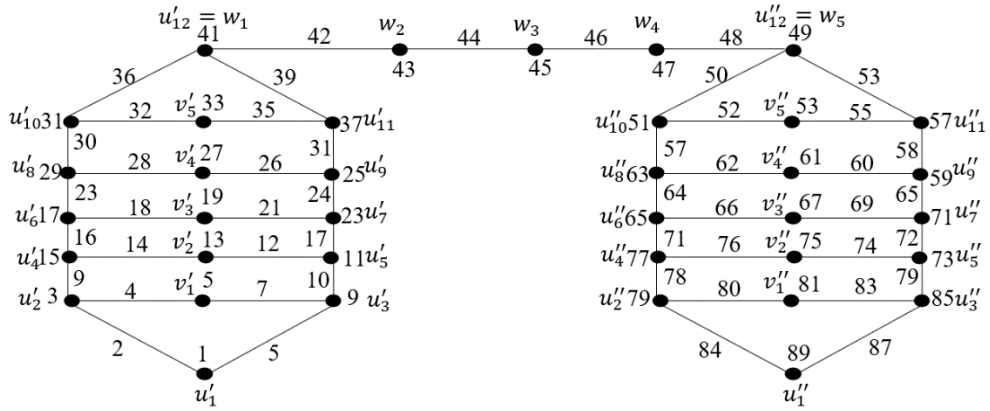

Fig.6 Two copies of C_{12} with parallel chords P_3, joining by the path P_5

Conclusion

We have concluded that the chain of cycles $C_{2n,m}(n \ge 3)$ with parallel chords P_3, Edge connected cycle $C_{2n}(n \ge 3)$ with parallel P_3 chords and joining twin copies of cycle $C_{2n}(n \ge 3)$ with parallel chords P_3 by the path P_m are the vertex odd mean graph and vertex even mean graph. There is a scope for checking whether cycles C_n with parallel chord P_5 is vertex even mean graph and vertex odd mean graph.

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SOCIAL STOCK EXCHANGE: DEVELOPING CONCEPTUAL UNDERSTANDING AND EXPLORING OPERATIONAL MODEL IN INDIAN CONTEXT

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ABSTRACT

Since independence, in India, we have been genuinely showing concern for overall upliftment of all sections and in particular, the deprived, disadvantaged segment of the society. The scarce national resources have been spent through various schemes initiated by the government together with scattered efforts put in by voluntary organisations. As proposed by Ministry of Finance in one of its formal address to the nation to create a separate platform for generating funds that can be channelise for welfare of the disadvantaged section of the society. The glory of an idea depends upon addressing certain core issues, such as raising needed resources, motivating different segments of investors, providing regulatory framework for its optimum utilisation together with appropriate reporting system for its sustainable functioning.

The very concept and initiative of establishing Social Stock Exchanges (SSEs) in India may certainly has an astonishing and revolutionary impact with parallel reciprocated outcomes on both the sides, the contributors and the beneficiaries. However, successful operationalisation deserves a vigilant approach in its design and the corresponding activities and processes to meet with predetermined objectives such as uplifting social welfare through healthcare, education, affordable housing, generating employment opportunities.

The paper is aimed at developing structural and operational model of Social Stock Exchange in India. It also highlights some core and vital dimensions of creating Social Stock Exchanges such as its expected performance, operational modalities, major obstacles and challenges in terms of spread of an idea, accumulating needed resources and generating an environment of mutual trust among the stakeholders on a common platform.

Keywords*— *Social Stock Exchange, Social Organisation, Social Finance, Impact Investors, Social Responsibility Investing

INTRODUCTION

In principle, the social system of the country decides remaining systems and deserves utmost significance in policy making agenda. Having spent 70 years of independence and allocation of an exorbitant number of scares national resources, the social sector and its aspired welfare has been rated as a depriving front. In the present-day context, the social sector has been a priority concern for policy makers with regard to ensuring basic amenities and making provision for physiological needs of different segments of the society, in general, and the deprived segment of the same, in particular. The rational for such concern is pillared upon an accepted phenomenon that the social sector is a powerful force that can empower the population and fight against an evil of Poverty, Illiteracy, Unemployment, Climate change problems and many other socio-economic issues. The welfare of the society certainly reduces the perils that has been mainly apprehended to the deprived and disadvantaged section of the society relating to health and hygiene, livelihood, education, gender equality, sanitation and such others humanitarian causes. The government expenditure was 3.8 per cent and 3.7 per cent of GDP for education and health respectively as per UNDP Human Development Report 2019. The said fronts have average resource allocation in the world 4.8 per cent and 10 per cent respectively and in particular, India has been spending less than Thailand (4.1 per cent and 3.7 per cent), Malaysia (4.7 per cent and 3.8 per cent), Bhutan (7.1 per cent and 3.5 per cent), Shri Lanka (3.8 per cent and 3.9 per cent) and Nepal (5.1 per cent and 6.3 per cent) respectively. The biggest democracy of the world, India, has been lagging far behind, as compared to not only some developed countries but, unfortunately, as compared to some of the developing countries of the world map, (KPMG Report) with regard to its allocation of resources/ expenditure on education and health, in terms of its

percentage of GDP. The reported trend of allocation of resources creates an inevitable need for participation of social and voluntary organisations to meet with these developmental challenges of the country. Taking deserving cognisance of the unfulfilled gap of aspired social enrichment, the Union Budget 2021-2022 proposes 137 per cent hike in health expenditure as compared to last year for strengthening efforts for preventive as well as curative health and well-being. However, the same budget proposal has curtailed expenditure on education by nearly 6 per cent as compared to the last year. The resource scares countries across the world have felt need to have forgoing partnership with private sector and social organisations to effectively functionalise the skeleton of the needed resources. There are various entities functioning in the social sector such as non - profit making organisations, non - governmental organisations, voluntary social service organisations of communities and social enterprises with the primary objective of achieving the aspired noble goal of social enrichment. The proposition to have Social Stock Exchange has been surfaced through the announcement of the Union Budget for the financial year 2019-20 in order to support enterprises and voluntary organisations aiming at social welfare and noble issues related to civilised society such as preservation and protection of genuine environment concern. The proposal had an advocacy to cover in its ambit fund raising through Equity, Debt and Mutual Funds.

COMPARISON OF WORKING MODELS OF SSE OF VARIOUS COUNTRIES ACROSS THE GLOBE

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Globally, Social Stock Exchange (SSE) is, even though, a growing concept but develop countries have started setting benchmarks with regard to its evolution and growth. For example, United States shown its legitimate concern for investment avenues since 1995 and it has grown at a compounding rate in the time span of 25 years. The impact investments in US has grown from $12 trillion in 2018 to $ 17.1 trillion in the year 2020 which is an increase of 42 per cent. In other words, it is representing 33 per cent of total assets of United States under professional management.

India is yet to get momentum in its growth story and probably requires proactive concern to promote the concept of SSE. The working model of those countries that have launch the platform unfold certain legitimate issues to get it established and set it going with momentum in India. To elaborate the few **Canada Social Venture Connexion (SVX),** is an online platform supported by Canadian Government opened in the year 2013. It helps fund raising by impact investment ventures by using public funding and private placement.

Similarly, Singapore opened the **Impact Investment Exchange (IIE)** which is again pillared upon a public funding model. The Social Enterprises can raise funds by issuing securities to a larger group of investors on a public platform, IIE facilitates trading in listed securities, including instruments like equity as well as bond. It provides exposure and foundation to recognised impact investors who are looking for transparent and liquid investment opportunities.

The SSE of **United Kingdom (SSX)** is serving as a catalyst that provides list of social enterprises to the investors to invest. It is basically a research platform which does not provide trading platform that helps connect potential impact investors with social organisations.

South Africa has **Social Investment Exchange (SASIX)** which was setup in the year 2006 that allows impact investors with a very little denomination and allow tax benefits too. The investors can have a choice of social avenues based on type and sector of the project. The platform keeps track of the accomplishment of projects and the corresponding impact generated.

I. KEY TERMINOLOGIES

- ✓ Social Organisation

It is a too generic term as it, in general covers all those businesses and non-business entities that has concern for social welfare and whose acceptance is depending upon the contribution made by them at the stated fronts. However, with reference to the present context, it includes all those organisations that have been actively deploying resources for common social welfare and devoting efforts for social services such as housing and education, environmental protection, public healthcare etc. They do not completely ignore profit element in the activities, however it is always acts at the secondary level.

- ✓ Impact Investment and Impact Investors

Impact investment means deploying resources into business entities that have been incorporated with an objective to devote efforts for making contribution towards generating positive and fruitful impact on social, economic and environment fronts along with financial returns.

Impact investors, in India, in particular, covers individual and institutional investors who have primary concern to promote non-profit based businesses through providing capital resources. They provide fund for promoting industries that has core concern for social welfare such as renewable energy, healthcare, education, agriculture, housing etc.

- ✓ Sustainable Development Goals (SDGs)

The term has been defined and adopted by all states of US in the year 2015 that gives a universal call to the whole world to work for welfare, peace and prosperity that mainly includes No Poverty, Quality Education, Good Health and Wellbeing, Clear Water and Sanitisation, Affordable and clean Energy, Industry, Innovation and Infrastructure etc. The statement of SDGs has a proposed target for their realisation by the year 2030.

PROPOSED STRATEGIC AND OPERATIONAL MODEL

The very construct to have Social Stock Exchange needs to be pillared upon certain concrete design that should have components to provide Regulatory support, Concurrent evaluation and Operational framework to implement statutory dimensions and monitoring functioning/performance on a regular basis. The strategic vision can be actualised through the prescribed proposed statutory framework that may narrate the vary cause for existence and functioning of the

SSEs. The component of the design also formulates legislative ambit and provides for compliances for smooth operationalisation, control and governance of SSEs.

An appropriate ministry of the central government shall *constitute a board* that may have nomination of some of its members who have sound knowledge and background of Judiciary, Finance, Economics and Social Welfare.

The second layer shall have proposed focus on operational aspects which in particular works for establishing and implementing strategic intent as laid down by the statutory framework. It provides for operational parameters against which the third layer would carry out control functions.

The third layer shall ensure appropriate superintendence and control of the legislative boundary prescribed for functioning of SSEs. It functions on a concurrent basis to ensure compliance of norms, procedures, formalities with their due properties.

India, in particular, does not have proven design and track record to promote and regulate impact investment, apart from giving rational direction to actualise CSR objectives and activities on the part of corporate entities. Therefore, it needs to develop a real time support system, within the proposed design of the Social Stock Exchange, which may facilitate in terms of ensuring contingent financial support, concurrent control through continuous evaluation of ongoing projects and transparent reporting of progress or otherwise of the same to the stakeholders. The proposed *'Nodal Agency'* should have representation from corporate tycoons, who have proved their worth not only in terms of managing business entity successfully but equally unfold concern for social welfare through voluntary efforts for mankind. The said agency shall independently perform role in generating contingency fund, through mechanism of reserves and surplus, to support the dipping projects that are otherwise a fertile proposition and suffered adversely, for the time being, due to administrative incompetence or lacunas.

Furthermore, it should discharge constructive role by carrying out continuous evaluation of ongoing listed projects, on predetermined parameters, to ensure optimum allocation and uses of invested resources through impact investment. The Nodal Agency should be empowered to report necessary information about all or major ongoing projects, as the case may be, in order to appraise real time performance to all stakeholders. The proposed agency shall have independent identity, functioning and shall have suggestive role for other major components of this skeleton such as regulatory framework, operational design and control mechanism. In order to have genuine value creation through assesses it is essential to have a *complementary component* in the design that may carry out functions related to providing guidance and support.

to the potential investors to have successful entry in the stock exchange mechanism, carry out evaluation and certification for the proposed social projects looking for getting listing, under the light of preconceived parameters, primarily focussing on social welfare agendas. The agency should be legitimately empowered to issue 'Due Diligence Certificate' to the proposed projects upon fulfilment of predefined criteria. The agency shall function under the direct superintendence and control of the Regulatory framework designed for SSEs. The impact investors are required to report about any major events of the listed projects, including discrepancies and inadvertence, even after listing till their completion.

The governing framework of SSEs consist of different activities, tasks, functions and jobs related with providing platform for investment and trading. It also covers reflection of concern and promotion of activities related with providing opportunity for raising of fund to meet with social objectives. The SSEs create predefined mechanism for listing and trading of different types of selected securities such as equity, debt instruments and other permitted avenues through funds. It is also proposed to ensure adhering predefined objectives with transparency and any attempt for *ultra virus* transactions to be curb *ab initio.*

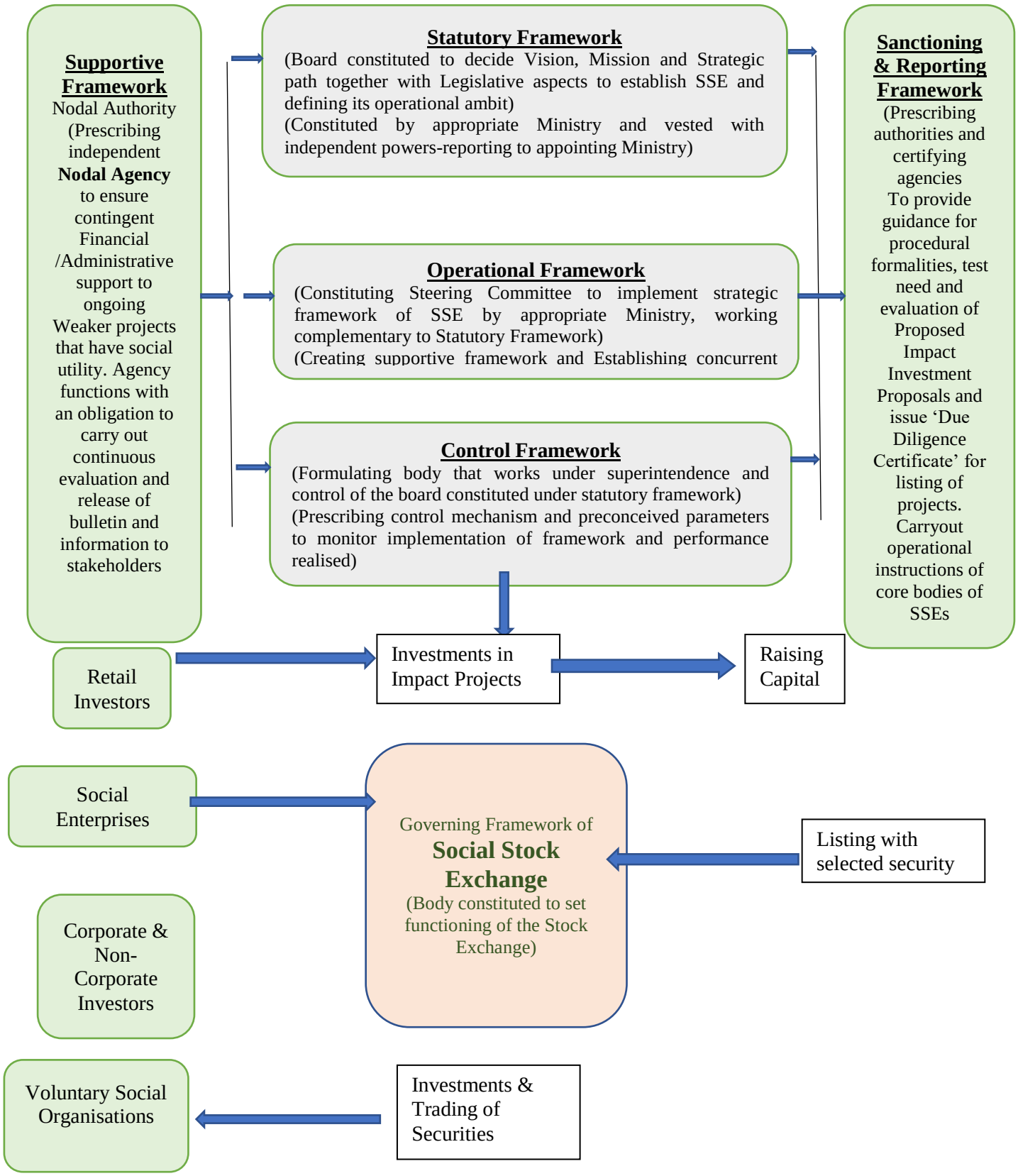

Fig. 1 Proposed Framework (Model) for Social Stock Exchange in India (Structural and Operational Model)

Fig. 2 Proposed Framework (Model) for Social Stock Exchange in India (Structural and Operational Model)

CHALLENGES AND MITIGATION

Since the conceptual framework and the operational model is new to the domestic system, it has to have its originality to address different issues likely to get surfaced when the model is made operationalised. The blind imitation of concern, different components and modality from nations who have achieved more than reasonable success in operationalisation of impact investment, may be fatal and lead to grave consequences, if applied in India. Therefore, a constructive thought, in a collective manner, is well deserved to ponder into various issues, challenges together with mitigation strategies, related with successful launching and operationalisation of the model. Following may be the major issues required to be address with appropriate proactive provisions to avoid obstacles in successful functioning of Social Stock Exchanges in India:

1. Since socio-cultural variables differ nationwide, the social need or good is also different to different civilised society. What may be the deserving avenue of social investment in one nation may not be always found appropriate to a particular nation. Therefore, in India, the policy statement should unfold parameters and narration to cover organisations within the ambit of a social enterprise. An attempt to be put to explicitly define type of services, its modality for governance together with the ways in which social/ environmental benefits likely to be generated out of the project, without any ambiguity whatsoever.
2. Another area of challenge is to ensure conceptual and operational clarity on the part of entities, with regards to complying with standing guidance such as permitted avenues for investment, pre conceived social impact and welfare, meeting with financial expectations of the involved participants etc. Along with defining the scope of Social Enterprises, as mentioned earlier, it is essential to clarify their role in terms of clarity of objectives, Social and environmental impact/ benefits generated, financial requirements and transparency. Furthermore, as the participation in SSE requires strict compliance in terms of Social, Environmental and Financial aspects, the parameters of this evaluation need to be defined with due diligence on the part of the SSE.
3. The proposed model of SSE involves many aspects like statutory, operational, appointment of nodal agency, guidance for procedural aspects to the players, issuance of due diligence certificate, evaluating social and environmental benefits along with financial returns and maintaining reserve fund to support the impact projects. All these aspects require fund which finally leads to transfer of the cost to SSE investors. These costs need to be planned and transferred carefully in order to avoid high transaction cost to the investors because it will be difficult for the small players to bare this cost and which may hinder their participation in SSE. It is proposed to have tax concession on a selected basis to marshal needed resources to create appropriate base to meet with fund requirement. Attempt to be made to relate tax benefits with duration of investment to ensure balance and promotion or furtherance of the objective.
4. The novelty feature of the proposed model is to have supportive frame work in terms of constitution of 'Nodal agency' to facilitate the participants and operators in addition to provide inputs to the regulatory bodies. The significant role is assigned to nodal agency in the proposed model of SSE in terms of providing contingency fund to rehabilitate otherwise a good project that could not either generate adequate resource at the initial stage of its launching or might not have done well due to lack of administrative competence and deserving timely support, financial or otherwise. The nodal agency should have nomination from variety of fields

that may include finance, law and judiciary, corporate and social welfare. Initially, attempt to be made to generate the needed contingency fund, to feed the objective of providing support, with the support of sparing resources from the government and gradually by periodically imposing reasonable cost on participants and operators. There has to be clarity of role and functions assigned to the nodal agency, as it is going to be the most significant component of the supportive framework.

5. The crucial part of the proposed model is to develop parameters to carry out rational measurement of performance and comparison of the same with the pre-conceived objectives of social projects. The SSEs need to provide fair yardsticks that may not only measure financial results but equally through lights on accomplishment of social welfare, as may be claimed by participants while launching the social project. The deeper insight into the said proposition invokes some other vivid issues as in a particular project, the involved social sector, welfare objectives and the corresponding beneficiaries are going to be different and different projects may require separate evaluative framework to have performance measurement. The said aspect can be taken care of by segregating framework in accordance with stratification of social sector and providing separate policy guidance to carry out the proposed evaluative functions.
6. In order to have fertile and sustainable functioning of SSEs, it is essential to clearly identify financial instruments which can be used for impact issuers and investors. It is equally obligatory to give constructive thought to the tax treatment likely to be generated out of operations. This requires government to integrate/ synchronise tax legislation with social sector to attract investors and promote the rational of SSEs. Since individual and corporate participants are going to play vital role, it is essential to have rationalisation, in terms of simplification in terms of understanding and availing of advantages of the same.

II. Path Ahead for Institutionalizing SSE in India

Having developed the strategic and operational model of SSE, the consequent crucial step is to shape an eco-system for institutionalising and implementing this structure. The proposed model of SSE is a complex structure/framework with multiple components working in synchronisation like Statutory, Operational and Control framework, Nodal agency, Reporting framework, Impact Investors and Institutions. Furthermore, these components involve legal structure, tax structure and finalisation of the project having Sustainable Developmental Goals. Institutionalising SSE requires comprehensive support system to facilitate registration process of social enterprises, capacity building of these enterprises, providing breathing funds through nodal agency and to comply with reporting framework in terms of social, economic and financial goals. The structure of SSE should ensure providing an investor and investee friendly environment with transparent and clear frameworks and policies.

The key stakeholders in SSE would be Government, regulatory bodies affiliated to government, legal bodies, Social enterprises, members of nodal agency, rating and certifying agencies and impact investors.

In order to operationalised strategic intent of the proposed framework of SSE, certain preconceived principles deserve appropriate focus:

1. It is proposed to shape the model with central decision making in terms of policy resolution from an appropriate ministry of the central government that may encompass purpose and ambit of establishing SSEs.
2. With regard to various components and support system, it is proposed to have their constitution by the competent authority operating at the central government. This should have an enriching special feature to release autonomy, with regard to their functioning which is required to have monitoring and control mechanism

through continuous reporting to the constituting authority.

The operational efficiency of the proposed model is pillared upon flexibility and adoptability of various components that are going to function in a synchronised manner which can be ensured through maximum possible autonomy in decision making coupled with concurrent control.

CONCLUSIONS

The historical data on combined government expenditure (Centre and State) towards social services such as education, public health and hygiene, affordable housing, public transport etc, as a proportion of GDP has scaled considerable heights and moved from 6.2 per cent to 8.8 per cent during the time period 2014-15 to 2020-21. An astonishing aspect of the said increase of public expenditure is that it was having spread in all major social sectors. However, for a developing nation like India, where major challenges crop-up due to its population and in specific to make appropriate provision for bare necessities of human life. Government concern and efforts deserve support of social enterprises working towards social welfare. The rational for the proposition is pillared upon the basic principle of economic that always remind us that the resources are always scares and required to be put in to an optimal use to realise pre-determined goals. Funding through deploying sources of capital from organised and scattered sources of various segments of general public is of and immense significance for upliftment of deprived segment of the society. Successful operationalisation of phenomenon of SSEs in India may be instrumental for shining sun for those who have been victimised through the grave hands of fate!!!

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UNDERSTANDING THE INFLUENCE OF BRANDING AND LOYALTY STATUS WITH RESPECT TO GADGETS AMONG COLLEGE STUDENTS IN INDIA

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ABSTRACT

Brand management is a function of marketing that uses different ways to improve a brand's perceived value ove;r time. Effective brand management allows product prices to rise while also increasing customer loyalty through brand associations and brand awareness. Hence, effective branding allows businesses to stand out from the competition and create a loyal consumer base. The paper tries to understand the purchase behavior of college students with respect to electronic gadgets combined with analyzing their brand loyalty. As more and more brands make its way to every door step due to globalization and Technology, it becomes important to understand the reason for choosing a single brand from a pool and also the impact this creates on those who can't afford it. The survey that has been conducted on over 170 samples shows the attributes that students prefer and also the overall psychological impact. To comprehend student's points of view, the obtained data was evaluated using R software.

Keywords: *Branding, Gadgets, Globalization, Loyalty, Technology.*

INTRODUCTION

A strong brand allows consumers to understand what the company stands for and what it has to offer. By giving specific information about a company, a product, or a service, a brand distinguishes it from others in the marketplace. The present scenario has forced companies to take a step back and evaluate the context in which your brand and associated experiences will be built to create more relevant experiences. Customers will be more loyal to your company if you have a strong brand. A strong brand sets your products apart from the competition. It gives your company a professional appearance.

The primary goal of branding is to build a trust with the customers. It says the expectation of a product or service from the consumer perspective. It will add value to the company. According to Philip Kotler "Branding is the process of giving a meaning to specific organization, company, products or services by creating and shaping a brand in consumer's minds". This definition gives an idea of must-have knowledge to create a brand image for long standing customer relationship in this competitive market place.

The 21st century has seen a tremendous brand offering that gives lot of preferences to the customer. The fascination towards branding has gone into another heights. In the minds of customers, a brand is a collection of memories. Values, beliefs, and even personality are all represented through a brand. It is a collection of functional, emotional, and rational associations and benefits that have captured the attention of the target market. The pictures and symbols linked with the brand or its benefits are known as associations. Brand associations are developed when the products are tangible, reliable and saleable. Impressive brand association supports the organisation to get good image, and sustain in the energetic market.

The new research done by Collinson group revealed that 83% of Indian customers expect quality branded products and willing to maintain a long-term relationship with the brand. According to Philip Kotler, the consumer connect with the brand has four dimensions. 'Hard core Loyals' defined as the consumer who has a long- term relationship with the brand/product. These types of customers increase the 20% of basic value and these people majorly contribute to the company's revenue. 'Split Core Loyals' represents the consumer who are loyal to more than two or three brands and significantly increase the company's turnover. 'Shifting Loyals' expressed as moving from one product to another when the other product offers more choices to those consumers. 'switchers' acted as the people who keeps on moving from one brand to another without having any attachment with any products. On the other hand, youngsters are more likely to explore lots of brands. Because brand loyal clients advocate the brand favourably, higher levels of loyalty result in lower marketing

costs. It also serves as a technique of launching and releasing other products that are targeted at the same clientele for a lower cost. It also prevents new competitors from entering the market. Brand loyalty is an important factor in determining brand equity.

The importance towards gadgets has enormously increased during pandemic. It's difficult to think of a work that hasn't been made easier by technology in the age of computers and smart phones. Electronic devices and displays are being used increasingly often, and children are being exposed to them at an earlier and earlier age. Over the last few decades, our use of technologies such as televisions, computers, laptops, e-readers, and cell phones has expanded tremendously. This paper tries to understand the impact of branding and brand loyalty with reference to Gadgets among College students in India.

REVIEW OF LITERATURE

Sandeep Saxena et al (2021) explains perception of quality associated with global companies, evaluating the brand's capabilities and competencies, competitor brands' strategies, and customers' perspectives. The paper considers challenges such as Economic assistance, Emotional appeal, Socio-Cultural factors, Distribution channels etc.

U. Thiripurasundari and P Natarajan et al (2011) tries to indicate that brand preference and loyalty are essential factors in establishing brand equity with the strength of a brand determined by how buyers perceive it with respect to Car Manufacturing firms.

Jessy John et al (2010) looks into the reasons behind hard core consumer loyalty, especially in the face of high-quality rivals. Also providing insights into customers' loyalty being improved by quality, customer service, and value-added offerings.

Sunita Kumar et al (2015) analyses the reason for what today's consumers believe brand to be a key factor in their purchasing decision, with purpose of the study trying to find how customers feel about using private labels and national branded products to meet their demands and expectations.

Sita Mishra et al (2015) studies the significance of developing long-lasting and strong customer relationships that benefit both the consumer and the enterprise In order to respect customer relationships, this article also seeks to understand the relationship between consumer brand loyalty and socio demographic characteristics.

Dr.G.V. Vijaysri et al (2019) examines the Consumer electronics market in India and the factors influencing such as rise of disposable income, consumer preferences, availability, etc. with a special mention to “Make in India” that could largely contribute to the sector’s growth prospects. It also studies about consumer electronics' percentage of overall exports, as well as its contribution to GDP, has continuously risen over time which makes Consumer Electronics sector is critical to India's economic growth.

OBJECTIVES

1. To understand the attributes preferred by students while choosing a product.
2. To examine the brand association reasons among students.
3. To study the Loyalty status of students.
4. To find the most preferred branded product segment among students.

RESEARCH METHODOLOGY

The objectives mentioned above have been analysed using the following research methodology.

A. Data Collection

The information gathered for this study is primary data. A well-crafted Questionnaire has been distributed, and data for the study has been gathered. The information was gathered between July and August of 2021. The study's sample size is 170 people.

Questionnaire is divided into two parts, the first half of it contains information pertaining to the demographics while the other half is about brand loyalty and association.

B. Statistical Tools

The data analysis and interpretation were done by graphs generated through R software package.

R Package

R, a programming language and free software, was established by Ross Ihaka and Robert Gentleman in 1993. R comes with a

plethora of statistical and graphical tools. Only a few of the topics covered include machine learning methods, linear regression, time series, and statistical inference. It's similar to the S language and environment created by Bell Laboratories' John Chambers and colleagues. R is extremely extensible and provides a large range of statistical and graphical tools (linear and nonlinear modelling, traditional statistical tests, time-series analysis, classification, clustering, and so on). It has various features for producing and developing intriguing static images, including graphic maps, mosaic plots, and biplots, among others.

DATA INTERPRETATION

Understanding the attributes students prefer while choosing a product

Preference	Age	Male	Female
Advertising Channel	15-20	0	1
	21-25	0	0
Advertising Theme	15-20	0	1
	21-25	0	0
Brand name	15-20	1	1
	21-25	1	3
Color	15-20	0	0
	21-25	0	1
Packaging	15-20	0	0
	21-25	1	0
Popularity	15-20	2	5
	21-25	3	3
Price	15-20	2	1
	21-25	2	1
Product Features	15-20	26	62
	21-25	15	34
Status Q	15-20	0	3
	21-25	1	0

Table. 1 The attributes students prefer while choosing a product

The chart shows the different attributes contributing to brand prefernce among college students. The other factors used for indepth study are demographic factors like Age, Gender along with preference attributes. Through Chart, it is clear that the Brand prefernce majorly depends upon Product features among both Male and female gender irrespective of age gap. Next preferred attribute is Popularity among female from 21-25 age group and male gender from 15-20 age group. Status Quo and Brand Name are also considered prominent features along with Price by students while other factors like advertising theme, colour, packaging are among the least favourites chosen.

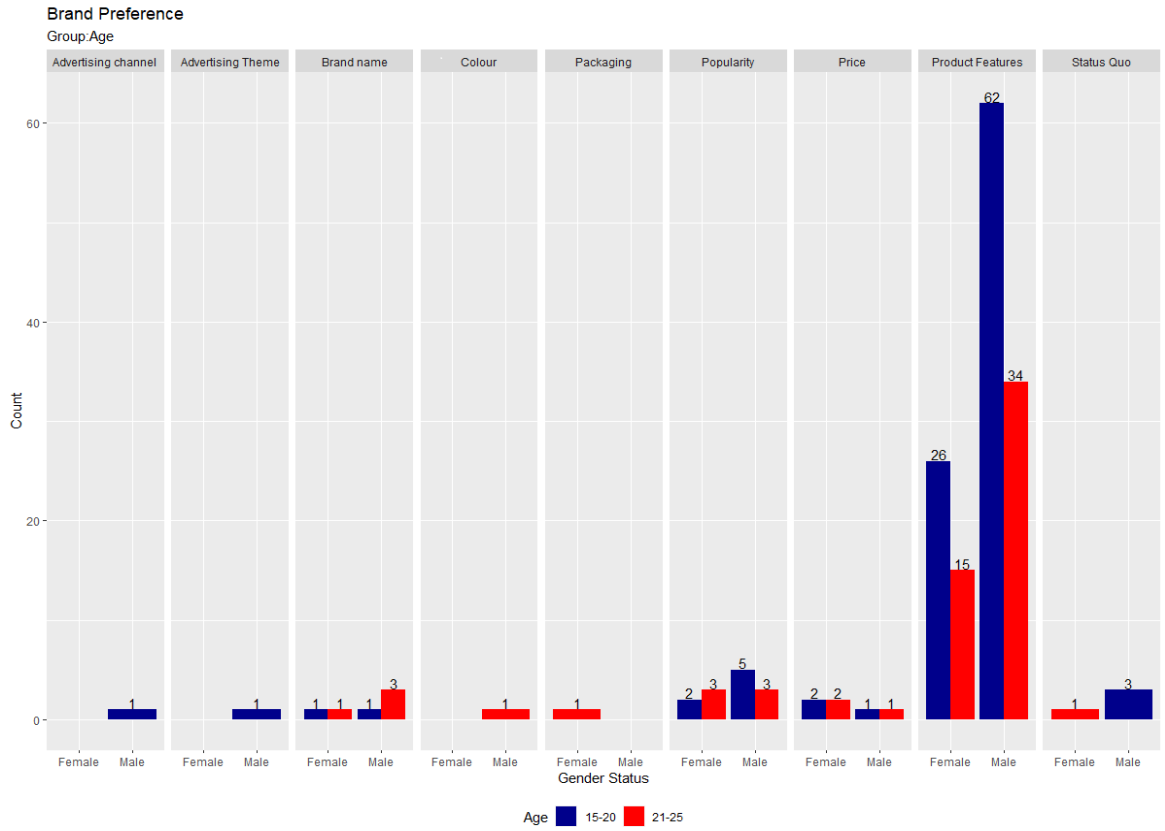


Chart. 1 The attributes students prefer while choosing a product

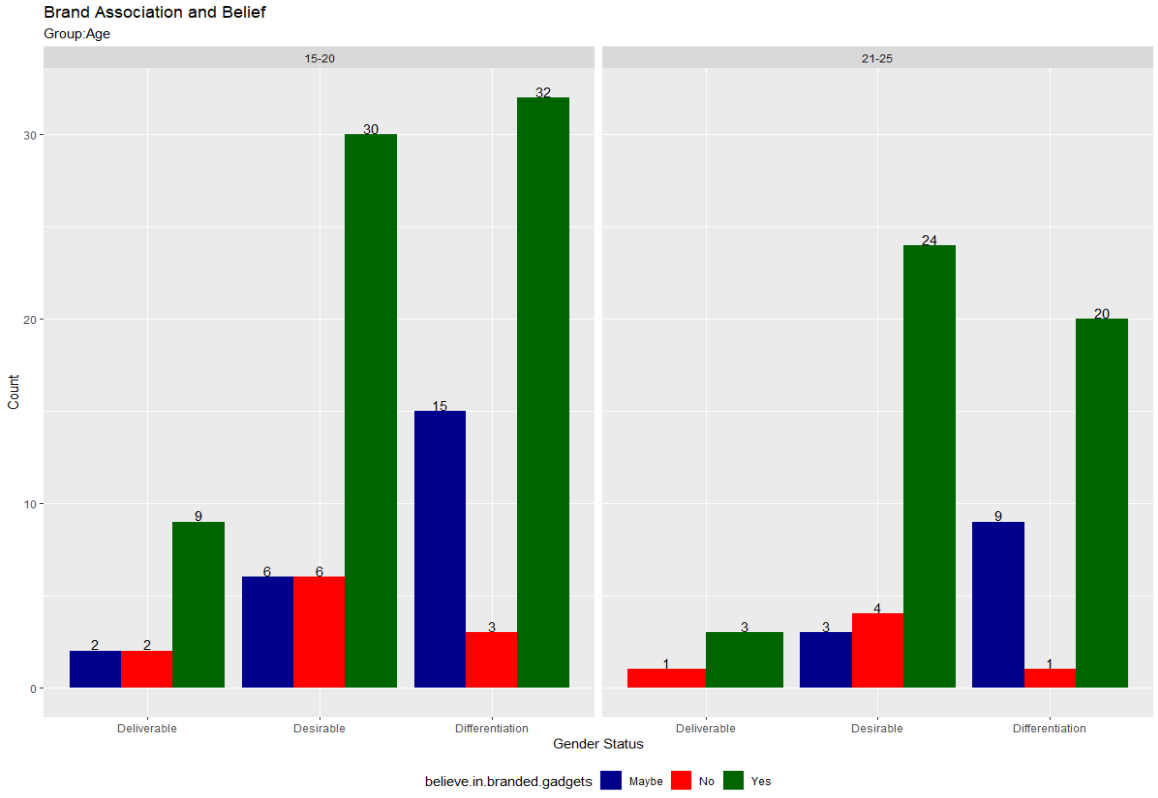
Examining the brand association reasons among students

Brand Association: Reason	Belief in Brands	15-20	21-25
Deliverable	Maybe	2	0
	No	2	1
	Yes	9	3
Desirable	Maybe	6	3
	No	6	4
	Yes	30	24
Differentiation	Maybe	15	9
	No	3	1
	Yes	32	20

Table. 2 The brand association reasons among students

The chart below shows the reason for being associated with brand with demographic factor Age and belief in branded products. Through the Chart, it is clear that there needs to be product/service differentiation to the customer highly felt by 15-20 age group students who believe in brands. Few students from 15-20 age group feel differentiation might be the reason for brand association. Next factor comes down to desirability to customer according to both age groups who believe in branded products followed at last by deliverability by the company.

Chart. 2 The brand association reasons among students



Studying the Loyalty status of students

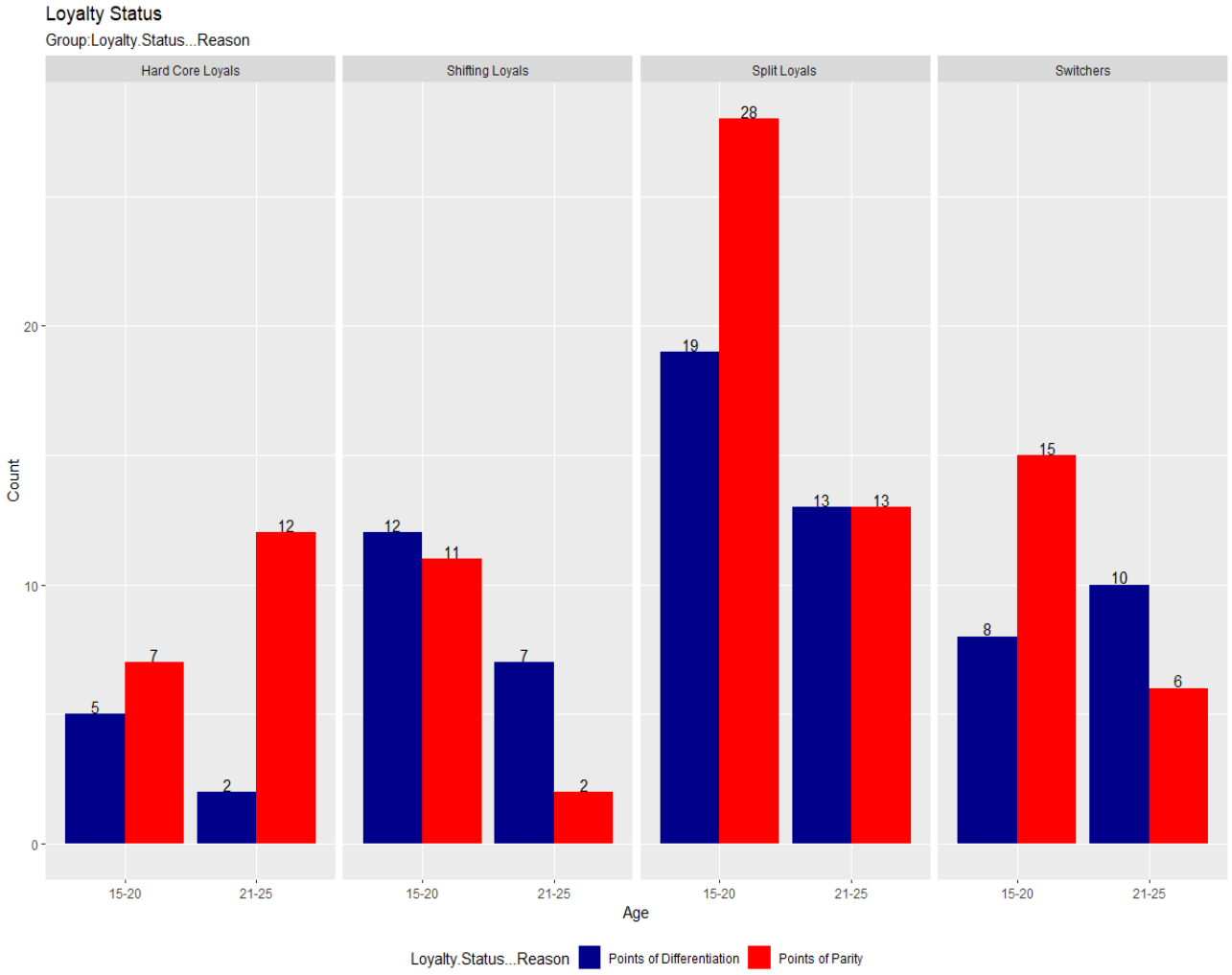
Loyalty Status	Loyalty Status: Reason	15-20	21-25
Hard Core Loyals	Points of Differentiation	5	2
	Points of Parity	7	12
Shifting Loyals	Points of Differentiation	12	7
	Points of Parity	11	2
Split Loyals	Points of Differentiation	19	13
	Points of Parity	28	13
Switchers	Points of Differentiation	8	10
	Points of Parity	15	6

Table.3 The Loyalty status of students

The Chart below shows insights on Student Loyalty Status and the reason behind it combined with the demographic factor 'Age'. From the Chart it is clear that Split Loyal is clearly dominating other categories of Loyalty Status with Points of Parity given more importance than points of

differentiation. Switchers category has 15-20 category people choosing points of parity for their choice, whereas 21-25 category choose differentiation as the reason for being switchers. Age group 15-20 prefer being Shifting Loyals with almost equal emphasis on points of parity and differentiation. Hard Core loyals from 21-25 category clearly have chosen points of parity over differentiation.

Chart.3 The Loyalty status of students



Finding the most preferred branded product segment among students

Products	Age	Male	Female
Camera	15-20	1	2
	21-25	0	1
Headphone	15-20	0	1
	21-25	2	0
Laptop	15-20	17	22
	21-25	4	11
Mobile	15-20	11	44
	21-25	17	26
Play Station	15-20	1	1
	21-25	0	3
Power Bank	15-20	0	1
	21-25	0	0
Smart Watch	15-20	0	3
	21-25	0	1
Tablet	15-20	1	0
	21-25	0	0

Table.4 The most preferred branded product segment among students

The Chart shows data about most preferred branded product according to students along with Demographic factors like Age and gender. From Chart it is clear that Mobile seems to be the top priority in both genders and age groups. Next comes the laptop category with 15-20 category's male and female preference followed by Play Station, Camera and Smart watch.

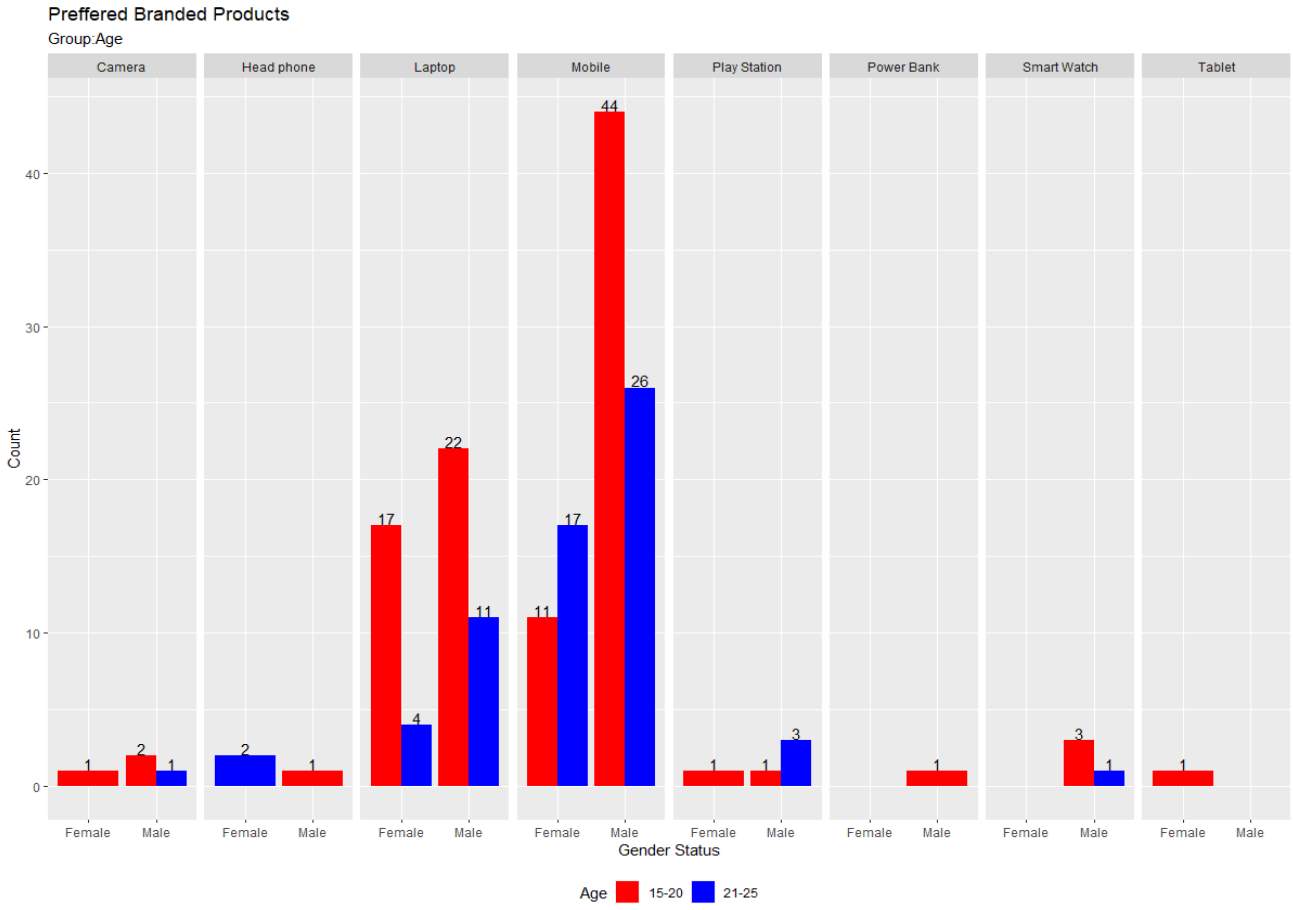


Chart.4 The most preferred branded product segment among students

FINDINGS

- 70% students say they believe in branded gadgets.
- 80% students have chosen product features as the reason for their brand preference.
- 47% students feel that product/service differentiation to be an important reason for being associated with a brand followed by Desirability to customer which accounts to 42%.
- 34% students feel that being associated with a brand creates a brand for themselves.
- Majority of students remain to be Split Loyals (Consumers who shift Loyalty from One brand to another) with the main reason being points of parity i.e., the benefits associated with the product.
- Among the most preferred branded product category, Mobile takes the top priority followed by Laptop segment.

CONCLUSION

In the current context of India, with a maximum student population of 35.11 percent increase, it is critical to understand their brand preferences. This study divided viewers into four groups depending on age and gender, with the survey focusing on college students' brand preferences and loyalty to brands. In terms of gadgets, the data interpretation clearly stated that young people preferred mobile phones over other products. It has been noticed that the majority of college students have a good attitude of becoming 'Split loyal consumers'. College students aren't obsessed with a single brand. They would always choose the top brands if they had a choice. They can become a' hard core Loyal consumers' if marketers use them wisely and increase the desirability to customer, deliverable by the company and show differentiation in product/service offered.

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INCLUSION OF VEGETABLES IN PUBLIC DISTRIBUTION SYSTEM: AN EFFECTIVE ROAD FOR AGRI-PRENEURSHIP

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ABSTRACT

Public distribution system is established by the Government of India under the banner of the Ministry of human affairs, aiming to turn down poverty and to guarantee food security. The public distribution system is known as fair price shops and is called as ration shops as widespread. For ages items like rice, wheat, kerosene are sold through ration shops for all cardholders, but vegetables are excluded from the list. Vegetables are considered as basic essential food like wheat and rice for people. Adding vegetables to the ration items list can help the ration cardholders in getting the basic food amenities at one stretch at a government regulated price. Moreover, this can help the agri-preneurs in a big way. If the government procures vegetables like rice and wheat, the agri-preneurs would not find difficulty in marketing their products and in further it will encourage them to do a mass production of agri-products, and it leads to self-reliance. Marketing within their area will be advantageous, since the act of agents, wholesalers, and retailers is reduced and furthermore the transportation price also can be reduced. This concept can be beneficial for agri-preneurs, for ration cardholders and finally for the economy even in a pandemic situation. Additionally, if the government regulated price started to prevail in the market, all the double-dealing strategies against the agri-products such as hoarding and black marketing can be shortened. Agriculture sector, being the main contributor of GDP (Gross Domestic Product) can achieve even more through a PDS oriented marketing approach and also there will be a crowd of youth in the agriculture sector.

Keywords: Public Distribution System, Agri-preneurship, Covid Pandemic, Agri-marketing, Ration list items.

Introduction

In India, the Public Distribution System has been playing the role in poverty reduction and providing food security. It is widely called fair price shops and ration shops. Items such as rice, wheat, and kerosene are distributed among the ration cardholders based on their annual income level and the number of members in the family. FCI (Food Corporation of India) accompanying other state agencies procure wheat and paddy at a minimum support price and then make it available to the society at subsidized rates. This concept made the cardholders survive from poverty.

The PDS benefited the agri-preneurs more, the procurement of paddy and wheat by the FCI at a government regulated price helps since to find a demand for their products and the mass production makes their agribusiness productive. Likely, inclusion of vegetables in PDS can reap more profit. In India, a greater part of the population belongs to farmers, and they carry it as their main livelihood. Agriculture sector being a major contributor of GDP (Gross Domestic Product) can revamp the GDP through the introduction of vegetables through ration shops and also the economy can enhance their self-reliance.

The COVID pandemic has struck India in 2020 and so it's quite difficult for the agri-preneurs to find a market for their products and so for the customers. During the pandemic period people hardly went outside, so access to the market was also difficult. In this sense, the distribution of vegetables through ration shops can make a revolution among agri-preneurs and the cardholders.

Statement of the problem

The Public Distribution System has been playing the role in poverty reduction and in bringing forth food security for ages. Food essentials like rice and wheat are distributed through this PDS, but the price and quantity issued is different among the cardholders. The

distribution is based on income and number of family members. Items apart from rice and wheat such as kerosene and sugar are also given out to the cardholders and all those products are procured from the agri-preneurs through FCI and other government agencies directly. This lends a helping hand to the agri-preneurs to find a market for their products, and additionally they will get a minimum price from the government. This is an encouragement for other farmers, particularly youth to come into the agriculture sector. Higher production of agricultural products can lead to self-reliance and higher Gross Domestic Product. Kerala being an agrarian state can improve a lot with the advancement of the agriculture sector. Even though production in vegetables can bring self-reliance, the trouble to find a market for the products back out the existing farmers and youth from agriculture. Introduction of vegetables through PDS can be a solution. But questions like why vegetables are not included in PDS? What are the factors favoring it? What are the existing challenges in including vegetables in PDS? And finally, how can inclusion of vegetables in PDS help the agri-preneurs? In this light studies regarding these are rare, and the existing study is relevant.

Objectives of the study

- To identify whether the inclusion of vegetables in the Public Distribution System can help the card holders.
- To identify the marketing challenges of agri-preneurs.

Research Design and Methodology

The study uses descriptive study with a qualitative approach, which provides insight into the benefits of inclusion of vegetables in the Public Distribution System. The study uses secondary data sources for data collection. It includes the government institutions like Krishi Bhavan, interviewing the ration shop dealers and heads of Padasekhara Samithi present in Shoranur Municipality in Palakkad District of Kerala, from online websites related to Public Distribution System & Agri-preneurship, from online newspapers and finally from previous literatures related to agri-preneurship and PDS. The Krishi Bhavan is one of the pioneer institutions in agriculture, which is undertaken by the Department of Agriculture. Padasekhara Samithis performs as an institution which promotes group farming and sells the paddy to the FCI and the ration shop dealers are those who supply the ration to the beneficiaries. In this study, a direct personal interview has been taken from ration shop dealers and various heads of Padasekhara Samithi. The interview questions for ration shop dealers were based on whether the inclusion of vegetables will benefit the agri-preneurs and whether it is adequate to distribute the vegetables through ration shops. The heads of Padasekhara Samithi were asked questions based on procurement of paddy and whether inclusion of vegetables in PDS will benefit the agri-preneurs. It was used to explore the benefits of inclusion of vegetables in PDS and to find the marketing challenges faced by the agri-preneurs. The most recent data is taken for secondary data to state the relevance of the concept in the present scenario.

Limitations of the study

The study is extracted from secondary data is one of the limitations. The opinion of the ration shop dealers or the heads of Padashekara Samithis might vary.

Literature review

In this study, previous literature has been taken from various digital libraries like EBSCO, IEEE Xplore and from ResearchGate, a social networking site and from publishers like Elsevier, Economic & Political Weekly, Springer and Taylor & Francis. Some of the literature has been taken from various journals like Review of Agrarian Studies, SIES Journal of Management, The IUP Journal of Supply Chain Management etc.

India came up with a world's most substantial Public Distribution System (PDS) in 1965,

and then it was changed to Targeted Public Distribution System (TPDS) in 1997. Along with that Warehouse Receipt Development Act, 2007 was also brought into picture to make the stock and credit facilities of farmers easier (Chauhan et al., 2014). Through PDS, the impoverished sector is provided with the food grains at a subsidized rate. PDS is a joint initiative of both the central and state government. The factors that can attract customers to the PDS shops are increasing the delivery days, implementing a customer grievance system, e-Ration card and SMS system (Mohapatra & Mahalik, 2016). The COVID-19 outbreak made the present PDS unfit for distributing the products for the needy on time. The IoT architectures help the PDS to find the demand for their products (Upadhyay et al., 2020).

The PDS system and various dynamic programs of government on self-sufficiency of food made many businesses grow in the agriculture sector. The PDS in India is one of the largest PDS among other countries in the world (Perspectives & Talent, n.d.). Horticulture farmers face many problems compared to other farmers in harvesting and marketing their products. The One Nation One Ration (ONORC) scheme is very much effective for a country like India. But the current PDS system should be modified by including physical delivery of products (Kumar et al., 2020).

India will have a surplus in wheat and coarse cereals by 2030, but that will not reflect in the case of pulses and edible oils. If the productivity and irrigation does not increase, there will be a deficit in the grains. Farmers' cooperatives, self-help groups and farmer producer companies can be formed to encourage farmers in increasing productivity and reducing risks related to marketing (Joshi, 2016).

Most of the farmers in the country are now concentrating on cash crops more than food crops. But this will reduce the nutritional status in the country (Parasuraman & Rajaretnam, 2011). There was a positive impact in buying other items such as pulses, oils, vegetables, and sugar since the rate of rice was reduced in ration shops. That is, savings on the rice made them buy other products (Kishore & Chakrabarti, 2015). The activities after the harvest of agricultural products need to be improved. The sector which handles post-harvest activities can be grouped as an industry and can manage these activities as entrepreneurs with the farmers. The agricultural distribution system should be revamped with the help of the government (Parwez, 2014).

The countries which were dependent on food imports were likely to face a food shortage if the pandemic continued. The international trade in goods related to agriculture was reduced during the Covid lockdown period as the exports and economy were affected. The daily market arrivals fell during the Covid pandemic (Ramakumar, 2020). During the Covid pandemic the farmers of Odisha had agricultural income losses because of the high cost of labor supply and to find a market for their crops. The Farmers in Haryana face challenges in obtaining diverse foods (Ceballos et al., 2020).

Discussions

Public Distribution System

India introduced the Public Distribution System in 1965. Now, it has emerged as an important Government Policy to ensure food safety and to issue food grains at fair prices. PDS is a joint initiative of both the central and state governments. It is known as fair price shops or ration shops. Commodities like wheat, rice, sugar, and kerosene are allocated for distribution. The state governments or the UT can decide upon whether to add other items like pulses or oil. In 1997, Targeted Public Distribution System (TPDS) was introduced by the Government of India with the aim to revitalize the poor.

Under the banner of the central government, Food Corporation of India (FCI) collects, stores, transports food grains and finally

allocates it to the state governments. Its main aim is to ensure MSP (Minimum Support Price) for farmers and to make the products available at fair price for the weaker sections. In India, PDS is implemented based on a ration card, which is a booklet in which the distributed items are recorded manually. The items are distributed to the cardholders on the basis of their income. The color codes given for the ration card varies according to the annual income, such as yellow card (Antyodaya Anna Yojana scheme), pink card (Below Poverty Line), blue card (Non-priority subsidy), white card (Non-priority). 'One Nation One Ration Card' scheme was introduced in India on July 31, 2021, by the central government. National Food Security Act (NFSA) aims to avail ration card items from all over the country.

In India since 2017 it has been mandatory to use Aadhaar based biometric systems, i.e. Epos (electronic Point Of Sale) for purchasing of items from ration shops. The main purpose of this system is to reduce the leakages of food grains in ration shops. But it has certain disadvantages over the beneficiaries, for instance if the beneficiary is an old person, and he cannot travel to the ration shop then probably he won't get his ration items. And if there is a network issue, the long que in the ration shops couldn't be resolved. The biometric system in PDS is adopted in different ways in different states.

The Covid pandemic in India has changed the normal life of everyone and all the distribution was affected. The Covid pandemic and the biometric system was a massive barricade for the people to collect the food grains from ration shops. Along with the other food grains extra food grains, pluses, and ration kits were given by the central and respective state governments during the Covid pandemic, and it was a helping hand towards the ration cardholders especially for those who lost their employment due to Covid pandemic. The extra food grains and pulses means extra procurement by FCI and the agri-preneurs are very much benefited. Agribusiness has a lot of employment opportunities if the government procurement of food grains along with the vegetables is increased.

Fig 3.1.1 Public Distribution System

Marketing challenges of Agri-preneurship

India is a country in which agriculture is considered to be their prime activity for livelihood. There are many activities engaged in the agriculture sector from production to its marketing such as preparing the soil, sowing the seeds, watering, fertilizing the plants, harvesting, sorting and grading, storage, transportation, and distribution. So, the agriculture sector includes a lot of employment opportunities if utilized effectively. This mode of agriculture made the term agri-preneurship emerge. Agri-preneurship basically means entrepreneurship in agriculture, and it has many constraints to face like the marketing issues, lack of infrastructure facilities, high distribution charges, lack of technological advancement, insufficient storage facility and unawareness of various government programs. Marketing issue was the major issue among all since without sales and without fair prices the agriculture sector can't withstand the high production cost.

Public Distribution System, acts as a good distribution system for agriculture products because the farmers will get a minimum support price for their products, and they can find a market for their products. The producers of rice and wheat can find it as a good source of revenue if the products are being procured by the FCI in bulk. But that cannot be applicable in the case of vegetables since in Kerala vegetables are not included in the ration items, even though it is an essential food item. So, the agri-preneurs of vegetables find it hard to obtain a market with fair prices.

For instance, the villages Kanthallur and Vattavada of Idukki district in Kerala lack a proper marketing channel to sell their farm products and more often they only get one-third of the market prices. The lack of timely payment from the Horticorp to various societies in which farmers sell their farm produce made many of them give up their cultivation. But many of them returned to it during the Covid pandemic. Horticorp had a three-year due i.e., ₹ 11 lakhs for the year till 2020 and so the farmers' marketing society from its own funds paid the farmers the due amount. The farmers' marketing society then decided to stop the procurement of the farmers' produce and because of that, the agri-preneurs were forced to undersell the crops to the middlemen from Udumalpet market of Tamil Nadu. And this is not just the case of agri-preneurs in Idukki district.

The agri-preneurs will be in more trouble if they can't sell the cultivated products and because of this reason the entry of youth is low in this sector. The Covid pandemic made the marketing of agriculture even riskier and there are several other challenges that have been faced by the agri-preneurs in marketing of their agricultural produce, they are as follows.

- Disruption in procurement of vegetables
  The FCI procure food grains such as rice and wheat in bulk and provide a MSP for the products. But that is not the case in vegetables. There is no proper channel to procure the vegetables and fruits from the farmers. So, they were forced to sell their products to middlemen at a low rate.
- Shortage of labor
  There is a massive shortage of labor in the agriculture sector. Even though technological advancements have happened in the industry, still there are works that need high labor efforts. The labor shortage made the wages per labor to increase and that made farmers recurring considerable losses. The timely supply of the products were affected because of lack of availability of workers in the agriculture sector.
- Limited operation of government agencies
  The government agencies in collecting the harvested vegetables are meager. There are no APMC mandis present in Kerala, but there are other government agencies or co-operative societies which procure the horti crops. Vegetable and Fruit Promotion Council Keralam (VFPCK) is an initiative by the Kerala Horticulture Department to promote the production of horticulture crops. Through the Swasrya Karshaka Samithis (SKS) the SHGs sell their farm produce. But that is too limited. So, more government agencies should come up to facilitate the agri-preneurs in selling their products.
- Major shutdowns in retail agriculture markets
  The intention behind converting the 'Rural Haats' or village markets to agricultural markets is to lend a helping hand for the small and marginal farmers to find a market for their products. As part of the 2018-19 national budget, it was decided to ameliorate 22,000 rural markets into agricultural markets. Out of them 1106 Rural Haats belong to Kerala, in which 6 of them are under local bodies and the remaining are under private bodies. But since no state/ UT have submitted the proposal to convert the Rural Haat no fund has been issued till 2020. So, the shutdowns of the village market worsened the situation of agri-preneurs in marketing.
- Lack of support system
  The support system for agri-preneurs needs to be improved a lot. Support from the government in the form of Farmers

SHGs, E-marketing opportunity, marketing society, providing subsidies, providing funds etc must be encouraged to make the life of farmers even better.

- High competition
  The agri-preneurs of horti crops face a high competition from the markets of different states, especially from Tamil Nadu. Since the competition is high, the farmers are compelled to sell to middlemen of other state markets at a very low rate. High production cost and low revenue from farm products made the farmers end up the cultivation.
- Lack of marketing organization
  Agri-prenuers face a lack of marketing organizations to decide upon which product, at which place and at what price it to be promoted. The lack of unity among the farmers can affect their income. Without a proper marketing channel like other businesses, agribusiness cannot flourish in the industry. A good example can be quoted from Muvattupuzha Taluk of Ernakulam district in Kerala. Eco shop is an initiative for marketing of agricultural products of rural farmers by the agricultural department. The farmers present their idea about the eco shop and their products to the apartment owners in Kochi and to help this initiative. There was a good response from the consumers about this initiative and their products. Likely, many more marketing organizations should emerge.
- High distribution charges
  The inaccessibility of resources on time is a key problem of the farmers, particularly for the farmers in the rural area. And probably the intermediaries involved in distributing the farm produce will doubtlessly escalate the prices of agricultural products in contrast to urban areas.
- Lack of infrastructural facilities
  Transportation, fair electricity connection, communication facility, proper irrigation, weather information and other technological advancements are the prerequisites to upgrade the agriculture industry. For instance, the satellite-based Geographic Information System (GIS) is an aid for the farmers in adding quality for the products but more often the rural areas are technologically stay backed.
- Lack of timely payment
  Timely payment is an act of encouragement for the efforts taken by the agri-preneurs. Nearly all the farmers' society make the payment for the farmers from their fund. Without the revenue the farmers will be in a debt trap and so the government should ensure timely payment for the products.

Covid Pandemic and Public Distribution System

India faced a lockdown due to Covid pandemic in 2020. The lockdown turned down every economic activity in the country. The supply and demand of goods were fatally affected. Apparently, the marketing of essential items such as vegetables and fruits was demanding a great effort. A fall in imports lead to high prices since the goods which depend on intermediate goods ceased the production and the sectors which depend on exports were also at the edge of concern. Globally, the price of wheat and rice rose due to the ban of exports. The significance for self-sufficiency reached heights. Consequently, the value of agriculture and allied activities was in great consideration.

The rural markets, farmer's society and several other markets that functioned were declined. The CMIE (Center for Monitoring Indian Economy) tries to find the markets that reported price and market arrivals during the lockdown period in India from AGMARKNET. It is a government website which provides the count of market arrivals and the prevailing prices in markets across the country. If the prices and the arrivals are not reported regularly, the market is considered as closed. The number of reported markets fell from 2081 in February 2020 to 1776 in March 2020. It further reduced to 1727 in April 2020 and then showed a slight increase to 1901 in May 2020 (Fig 3.3.1). From the above data, it's very evident that the supply chain of the agriculture sector was severely affected.

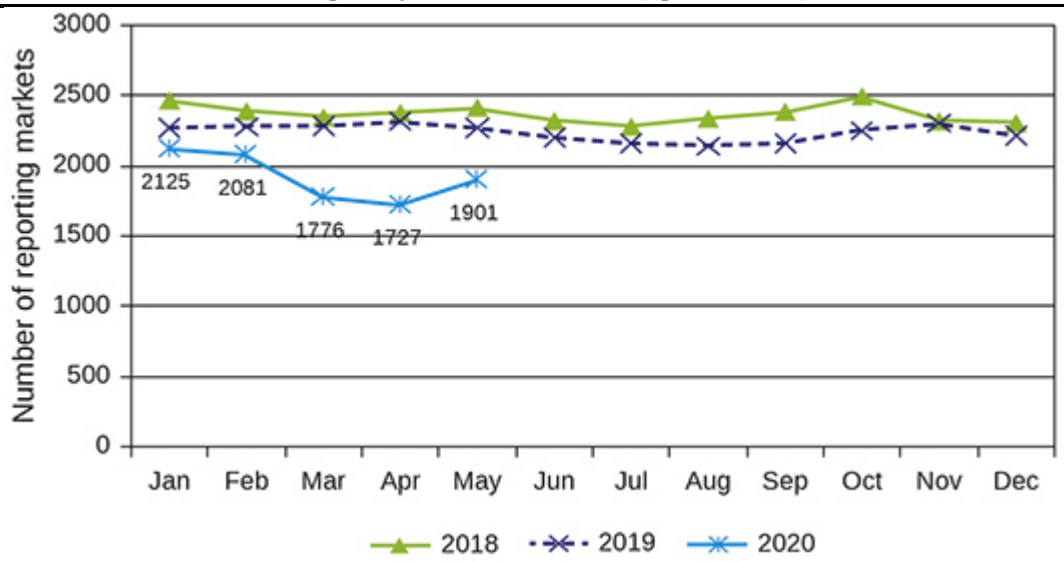

Fig 3.3.1 Number of reporting agricultural markets, AGMARKNET, India in 2018, 2019 and 2020

Source: CMIE

The lockdown across the country caused a severe unemployment crisis, many lost their jobs and everyone was locked to their houses without any income and moreover travelling was hard. The Public Distribution System (PDS) was playing a great role by providing food essentials like wheat, rice etc. The Covid pandemic brought several changes to the consumption pattern and the buying behavior of the people. The dependency of people on PDS was hiked during the lockdown period. An online survey conducted by Center for Socio-economic and Environmental Studies (CSES) in Kochi, finds that about 92% of the households who hold ration cards purchased from ration shops. In that, 16% of them were purchasing the ration items for the first time after a long gap. Since, the non-priority category is relying on PDS, that can raise the pressure of the state government and so the need for food essentials is in a surge. Along with rice and wheat, other items such as pulses and ration free kits are distributed by the state government of Kerala and the survey also points out that the PDS was a relief for the people during the Covid pandemic.

The necessity for food essentials had a massive spike during the Covid pandemic, and so the procurement from the agri-preneurs must be escalated to meet the demand of the ration hard holders. Furthermore, other food essentials like vegetables can be added to the PDS. The Covid pandemic sowed the seeds of digitalization in every sector, particularly the agriculture sector and the agriculture markets. The shortage of labor, customer preferences for good quality and food safety, a hike in the demand for agricultural products were the major motives behind the spike of growth rate of the digital agriculture market from the estimated 5.6 billion in 2020 to the projected 6.2 billion by 2021(Fig 3.3.2).

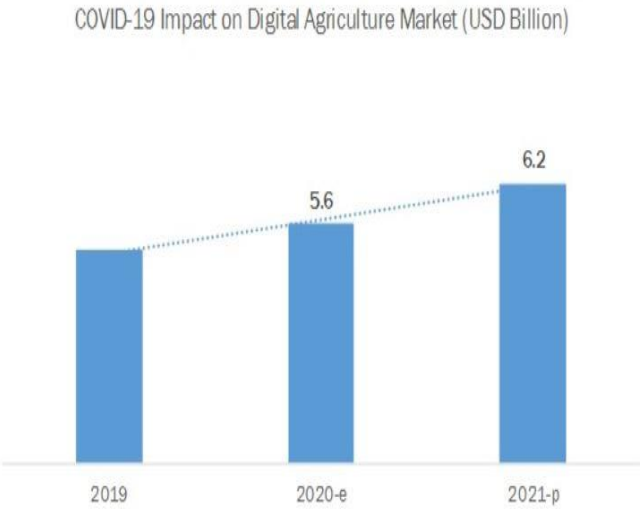

Fig 3.3.2 Covid-19 impact on Digital Agriculture Market

Source: Press Release, Investor Relation Presentation, Annual Report, Expert Interview, MarketsandMarkets Analysis

Inclusion of vegetables in PDS

In India, the lion's share of the workforce belongs to the agriculture sector. According to the data of the Periodic Labor Force Survey (PLFS) conducted by the National Statistical Office (NSO) around 40% and above labor force are still employed in the agriculture sector from 2017-18. As the economy grows rapidly, the share of agriculture in Gross Value Added (GVA) must be increased. Food items count 40% weight in Consumer Price Index (CPI) of India. These insights into the fact that, an average household of India spent his/her 40% of the income for consuming food. So, if the availability of food essentials is increased, then the Gross Domestic Product (GDP) can be increased.

The PDS system in India is one of the largest of its kind in the world, with around 1 billion or more people who have access to the ration shops. The main intention behind the PDS system was to ensure food security and to reduce the poverty level. The food subsidies are the main attraction of PDS. The central government procures food grains at MSP through FCI and distributes it to the state governments. The off take of food grains have surged into ever record-breaking heights since more people tend to buy the ration items than before. After the procurement, the stock level in the central pool was from the lowest of 59.85mt in 2016 to 109.44mt in 2021 (Fig 3.4.1) . The capacity should be increased further to meet the demands of the people.

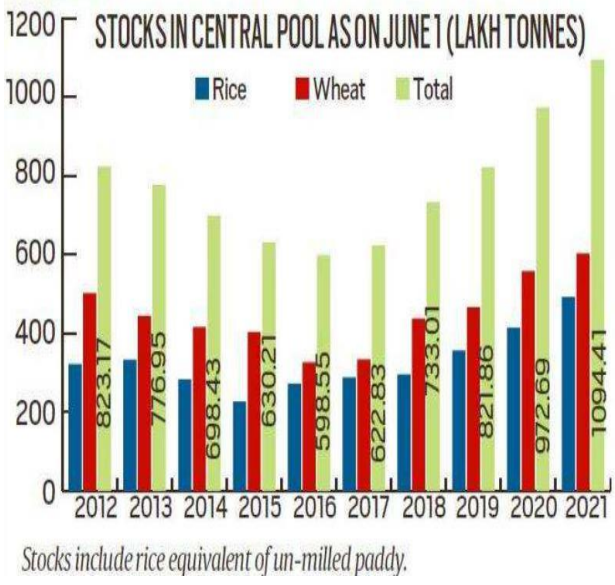

Fig 3.4.1 Stocks procured as on June 1, 2021

Source: Department of Food and Public Distribution

The procurement, storage, transportation, and distribution is done under the government intervention and so the producers of wheat and rice can have a secure revenue. But that is not the case of vegetable producers. The agri-preneurs in the field of vegetable production do not have any government intervention. Most of the farmers go bankrupt because of high losses from their cultivation. The Kerala state has witnessed for 25 farmers suicide death since 2016 according to the National Crime Records Bureau due to flood to properties and crops in 2018-19, failure on repaying the bank loans that have taken stood as the crucial problems faced by the agri-preneurs. According to a comprehensive study by National Sample Survey Organization in 2013, 78% of the households engaged in agriculture of Kerala are in debt with an average of ₹ 2.13 lakhs. So, farmers' suicide still count until a government intervention in vegetable production is taken.

The inclusion of vegetables in PDS can be a better solution for the empowerment of agri-preneurship. If the government initiates the procurement of vegetables like wheat and rice, the agri-preneurs will get a minimum price which is more than the price if they sell to the middlemen. The government should open a warehouse to collect the vegetables from the agri-preneurs in municipalities or municipal corporations or in panchayats. It must be opened according to the number of farming societies or farmers present in that particular area. So, the farmers nearby can come and sell their products through this warehouse of PDS. The procured vegetables are then distributed to the ration shops in that particular district at a price lower than the market. Since there are no other middlemen apart from the government, the agri-preneurs will get more price for their products. The government can also earn more since the selling price is higher than the procurement price, even though it is lower than the market price. At times, there will be excess vegetables that have been collected from the

agri-preneurs and in that case, the government can distribute it to other districts, or they can export the excess. Through this, the vegetables can be distributed within a week to the beneficiaries who possess a ration card and the perishability of vegetables does not even come into the picture.

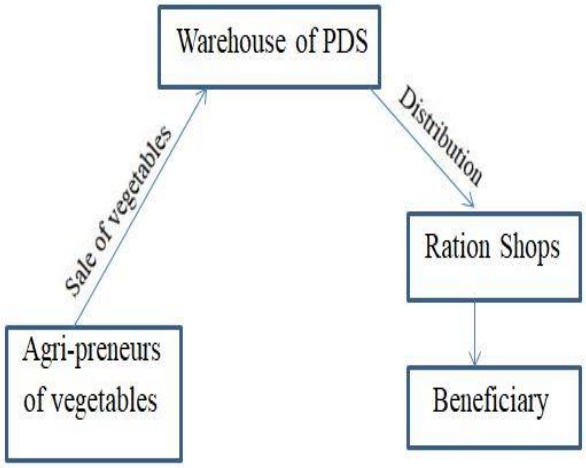

Fig 3.4.2 Distribution of vegetables through PDS

Including vegetables in Public Distribution System have numerous benefits as follows

- Fair prices for agri-preneurs
  The government will fix the prices for the vegetables procured from the agri-preneurs. The agri-preneurs can have more income since the price will be more than the price given by the middlemen.
- Revenue for both government and agri-preneurs
  Both the government and the agri-preneurs benefit if the vegetables are included in the PDS. A Higher procurement price than the price given by middlemen protects the interest of agri-preneurs. The selling price higher than the procurement price and lower than the market price will benefit the government.
- Timely payment of loans
  Since the farmers can earn from this without risk, they can repay the loans on time. Timely payment of loans can make the life of the agri-preneurs better and can reduce the suicide rates of farmers.
- Encourage the youth
  Agri-preneurship can be considered as an employment opportunity maker. If the existing farmers in the sector are benefited, then obviously the youth will also make their entrance.
- No more fallow lands
  Fallow lands will be used by the existing farmers to cultivate more vegetables to get more income. So, the lands converting to fallow lands can be reduced.

- Avoidance of travelling long distance to sell the products
  The agri-preneurs can sell their vegetables in the nearby warehouse of PDS and so there is no need of travelling long distances to the markets and selling their products.
- Prevent high competition
  If the vegetables are included in the PDS, then there will be no competition from other state markets or from other farmers, and they can sell their products with less risk.
- No middlemen
  The act of middlemen makes the product price rise without the benefit reaching to the agri-preneurs. Since the products are directly sold to the warehouse of PDS, there will be no act of middlemen like wholesalers, agents, private traders, retailers etc.
- Benefits to ration cardholders
  The ration cardholder or the beneficiaries of the PDS will be benefited if the vegetables are included in the PDS for the reason that they can consume the vegetables at a subsidized rate. Furthermore, they can have more organic and fresh vegetables.

Despite all the factors, the agri-preneurs of vegetables can be more benefited if the E-marketing possibilities and Farmers SHGs in agriculture is initiated with its significance. Additionally, the awareness of government policy and the support from the government must be improved.

Conclusion and Summary

In India, the agriculture sector is the largest contributor of workforce as well as in GDP. Around 40% or more people spend their income on purchasing food essentials. So, a high production in food grains and vegetables

can bring self-sufficiency in the country. The unprecedented nature of Covid pandemic turned down every economic activity in the country. The marketing of food essentials was demanding a great effort. Several markets, farmers societies that functioned declined due to the Covid pandemic. The marketing problems began to highlight as the main problem of agri-preneurs.

The Public Distribution System of India is the largest in the world, and food grains like wheat and rice are distributed through ration shops at subsidized rates. There is government intervention in the procurement of food grains, but that is not reflected in the case of vegetables. Moreover, the agri-prenerus of vegetable production has to undersell the products many times to the middlemen of other markets. They only manage to get one third of the market price of the goods. The cost of production is high but the revenue they earned from the market is not satisfactory and because of that many farm bankruptcies also increased.

Inclusion of vegetables in the PDS system can solve the problem faced by the agri-preneurs of vegetable production. The benefits of the concept can be concluded as fair prices for the products, revenue for both government and agri-preneurs, timely payment of loans can be done, it encourages the youth to enter into agriculture, the fallow lands can be reduced through prompting agriculture, long-distance travelling can be avoided, can be in a safe zone from high competition, the act of middlemen can be avoided, and finally, it benefits the ration cardholder by providing vegetables at subsidized rates. In conclusion, inclusion of vegetables in PDS is an effective road for agri-preneurship.

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FINANCING OF THE AGEING POPULATION FOR RETIREMENT USING BLOCKCHAIN TECHNOLOGY

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ABSTRACT

There is an immense transformation in the financial ecosystem with the adoption of innovative digital technology. The new innovative digital technologies have revolutionized the working of Indian Financial system. It has become imperative for the Government, policymakers, industry players, fund managers, financial advisors and the investors in the financial market to understand the concept and benefit of these new digital technologies. It has become essential to adopt and integrate this digital technology into the financial system for the growth and development of the economy. One of these digital innovations is Blockchain Technology.

The elderly population has been increasing in India. As per the report given by United Nation Population Fund in 2017, the elderly population was 77 million in 2001 and reached to 104 million in 2011 and estimated that it will triple and will reach around 300 million by 2050. The elderly population will be 20% of the total population in 2050. The ageing not only affects the old i.e., people above the age of 60 but also the younger population. Now, every individual wants to be financially independent at the time of retirement. The elderly does not want to depend on their children and the younger population also have their own larger financial commitment. Thus, it has become very important for all age group of people to plan for the Retirement.

The younger population are digital savvy and conduct all their activities on the digital platform. They are proficient in using E-commerce, online banking and financial services. They easily adopt to new technologies. They also lead the elderly with respect to technology. It is the right time to implement Blockchain like technologies and educate and encourage the younger generation to save and invest for the retirement.

This article examines the concept and principle of the Blockchain technology and the challenges faced by the financial security system for elderly in India and discusses the positive impact of using the Blockchain technology for retirement planning and subsequently strengthening the financial security system for the ageing population in India and contributing to the economic growth and development by way of increased savings and investment by the younger population.

Key Words *- Block Chain, retirement planning, ageing population, financial security system for elderly, financial technology*

INTRODUCTION

Blockchain, which is based on the Decentralised and Distributed Ledger Technology can benefit in the financing of the ageing population in a great way. The ageing population is increasing at an alarming rate in India. The population above the age group of 60 is likely to increase from 8% in 2015 to 19% in 2050. According to the Longitudinal ageing study of India, the elderly population will be 319 million by 2050.

In view of above statistics, India needs to strengthen its financial security system for the elderly. At present, it has become mandatory for citizens of all age groups to plan for retirement to lead a comfortable and dignified life during the advancing years. Thus, with the implementation of Blockchain Technology there can be a great revolution in India's financial security system for the ageing population. This article examines the positive impact blockchain can have on the financial security system for the elderly in India. There will be a potential increase in the rate of savings and investment among Indian investors towards retirement planning by adopting to blockchain technology. It will also lead to financial inclusion and a secured and sustainable retirement.

LITERATURE REVIEW

Taskinsoy, J. (2019) stated that many tools and applications running on blockchain will help to create a paperless digitalised world. Internet, marketing, asset management, traffic control, utilities (electric, gas and water) and social security (i.e., retirement benefits) can also be decentralised by using blockchain to provide more efficient and unrestricted access

to data. The regulators, lawmakers, central banks and Government should revolutionise by adopting to blockchain distributed ledger technology. It can be used in areas which are under government control.

N. Bakar and S. Rosbi (2018) has explained the Blockchain framework. The authors identified that the transaction fee in decentralized blockchain system will be lower as compared to the existing system. Secondly, the security of blockchain is highly reliable and transactions are recorded permanently except the character of anonymity which can lead to illegal activities. The findings will help the investor to frame the blockchain network. The better understanding of the blockchain will help investors make proper decision in their investment portfolio to make profit.

Perwej, A., Haq, K., & Perwej, Y. (2019) discusses about how Blockchain technology can be used in the market to benefit both the customers and the company. Blockchain technology helps in conducting financial transactions. Online and card-based payment methods have become dominant. Blockchain supports all these transformations by increased speed of transaction processing and greater efficiency in real time processing. Blockchain provides a robust environment for securing data sharing in real-time.

There have been various studies with regard to the understanding of the concept of Blockchain, the advantages and disadvantages of using Blockchain for digital financial transactions, usage of Blockchain in various industries but the study on the usage of Blockchain technology in financially securing the retirement is limited. Thus, this study attempts to examine the advantages of using blockchain in financing the ageing population and creating a retirement wealth which will further strengthen the country's financial security system for the elderly.

OBJECTIVES OF THE STUDY

1) To understand the Block chain Technology and its principles
2) To examine the challenges in the financial security system for the elderly
3) To discuss the impact of blockchain technology in the financial security system for the ageing population in India.

RESEARCH METHODOLOGY

Secondary data has been used for the study. The news articles, websites and journals are referred for secondary data collection.

DISCUSSION

A. Block Chain

The term Block chain consist of two words. Block and Chain. A block is like a page of a ledger or record book. Each time a page is completed with record of purchase or sale transaction, entry is made on the next page as each block has a certain storage capacity. Similarly, when a page or ledger is completed, it gives way to the next block in the Block chain and form a chain of irreversible digital transaction known as the "blockchain." Each Block is given an exact timestamp when it is added to the chain. So, all transactions are recorded in a chronological order. In simple words, Blockchain is the process of digital record keeping and asset tracking technology. Assets can be tangible or intangible. On Blockchain technology assets can be traded and recorded permanently in the chronological order of occurrence.

B. Important Features of Block chain

The three important most important features of blockchain technology are as follows.

1) *Transparency*: All the users of Blockchain network have access to the distributed ledger and its transactions. The transactions are recorded once avoiding duplication. Any participant on the network can check the blockchain for the authenticity of the transactions.
2) *Decentralisation*: There is no centralised Governing body to own, control and regulate the transactions. The users of the Blockchain network have the control. There are no financial middlemen or a bank or financial institution to authorise the transactions.

3) *Accountability*: It is difficult for anyone to amend or manipulate or tamper the data as the records are in the form of cryptograph. In case any of any mistake or inaccuracy of the transaction, it can be reversed by adding a new transaction and both the accurate as well as the inaccurate transactions are visible to all the participants in Blockchain. Hence the record of transactions is immutable which further builds immense trust and confidence among investors.

C. *Challenges in Financial security system for the elderly*

There is a crisis in the financial security system for the ageing population in India. Retirement Planning has become very challenging due to the following problems.

1) *Longer Life Expectancy*: The rapid advancement in science and technology and the development in healthcare and medicine has resulted to longer life expectancy. The retirement plans in India become inaccessible and more expensive as individuals age.
2) *Low returns from existing pension funds*: The already existing pension plans offered by the Government and private sector do not give the promised returns. The returns available from the existing retirement fund is low and does not take into account the inflation and rising cost of living. There has been a declining trend in the rate of interest on various fixed income securities of both the Government and private sectors and do not seem lucrative.
3) *Lack of Financial Literacy*: Majority of the population especially the younger working population lack the financial literacy and are not inclined to savings for the future. The younger generation need to be aware of the concepts like risk, inflation and compounding.
4) *Rising cost of living*: The cost of living has increased so much over last few years that the people are left with less or no income to save for the future.
5) *Complex Social Security system*: The social security system for the elderly also is very complex due to large number of players involved. The players include the regulatory bodies, government, banks, financial institution, financial advisors, financial agents, asset management companies, brokers, insurers etc. Lot of players in the industry will lead to mismanagement of funds and risk. Also makes the retirement plan expensive.
6) *Lack of transparency*: Majority of the citizens are not part of the Employer sponsored Plan like Employee Provident Fund. Only a small portion of the population working in private, public and Government sector have accounts in the Employee Provident Fund Organisation and have the benefit of saving for their retirement. The employees working in small businesses and the unorganised sector are not part of any of the Government sponsored schemes. The already existing accountholders are not aware about how their life savings are deployed and the returns as there is no proper disclosure about the performance of assets and liabilities with respect to the market. The transparency with respect to the investment operation is very essential for contributors of their hard-earned life savings towards retirement fund.

The above problems clearly states that one needs a practical solution so that all citizens of the country are covered under the financial security system for the elderly under one universal pension plan which is inclusive, low cost, simple, transparent, easily accessible and ensures safety and liquidity during old age and towards sustainable retirement.

There has been a fundamental change in the way the financial service sector and consumers interact with the growth of technology and digitalisation. In the same way, the Financial security system for the elderly will undergo a positive change with the adoption of Blockchain technology.

D. *Modern Solutions for solving the financial security crisis for the elderly*

The distinctive principles of Blockchain will provide modern solution to the challenges faced in the financial security system for the elderly in India in the following way.

1) *One Universal Pension system for all*: There will be one universal pension plan

for all the citizens. It will be an automated pension plan for all without any discrimination which is simple, flexible, low cost, easily accessible and can be customised according to individual needs.

2) *Transparent financial security system*: Every transaction with respect to retirement will be recorded in the distributed ledger and contributors will be able to view their transaction details whenever they want to. All contributors on the Blockchain network will be aware about the assets and fund where their life savings will be deployed and also the returns on their investment. They will also be aware of how much they need to save keeping in view the inflation, risk and the rising cost of living. The investors can make well informed choices.
3) *Elimination of middlemen*: With Blockchain there is no need for a single central authority. The financial institutions, fund managers, banks are no longer in control. The Financial security system for the elderly is simplified as the number of players are reduced. This also reduces the cost of making investment in Retirement fund. The formalities for making the investment are also reduced.
4) *Immutable*: Once the transaction is done it cannot be modified or tampered by anyone so the investors can be secured.
5) *Smart contracts*: Smart contracts are contracts between the buyer and seller of funds or asset which is not regulated by any central authority or intermediary. Since the contracts entered into are encrypted it ensures the delivery of funds or assets exclusively to the legitimate beneficiary only. There is also no other hidden cost like transaction processing fees due to elimination of middlemen.
6) *Efficient storage, documentation and management*: The retirement plan providers need to maintain record of large number of clients. Blockchain is designed for efficient storage, documentation and management of records.
7) *Trust and confidence*: Blockchain's automation, accuracy, and transparency builds up trust and confidence among the investors as there is cost reduction, risk management and increased client experience.
8) *Opportunity for financial service providers*: The financial service providers can use the blockchain network to strengthen the country's financial security system for the elderly and can encourage more savings and investments deployed in profitable investment projects which further increases the returns for the clients.

Limitations of Study

Blockchain is still a concept to be understood for the academicians, regulatory authorities and the industrialists in the country. Blockchain technology is in an incipient stage in India. It is going to take many years to implement and promote this technology for strengthening the financial security for elderly in India. The challenges for adoption of Blockchain technology are: -

1) Huge investment needs to be made in the adoption of blockchain network.
2) Large proportion of the population is still unbanked. Almost 48 percent of the population still do not have the Bank Accounts.
3) Those who are banked have poor infrastructure with respect to computer and internet facilities. They prefer cash transactions than online transactions due to longer processing time.
4) The lack of financial literacy is another challenge in the adoption and growth of blockchain technology.
5) The participants of small businesses and unorganised sector are still not part of any formal financial system.
6) The fact that Blockchain technology eliminates regulation by Central authority and other intermediaries cannot be easily accepted by lawmakers and policy makers as it may give rise to other illegal operations for which the cybersecurity in the country needs to be strengthened.

FINDINGS

Blockchain integrated into the existing financial security system for retirement

planning will strengthen the system and with proper outreach and educational programs will cover citizens of all sectors of the society. It will benefit by way of transparency, easy accessibility, low-cost fund for retirement, safety of funds and liquidity during the advancing years. Although it may take few years to revolutionise the financial security system for the elderly.

RECOMMENDATIONS

The Government, lawmakers and financial service sector players and investors can utilize the benefit of integrating blockchain into the financial security system for the elderly and can strengthen the industry and contribute more to the economy by understanding the benefits of adopting and promoting blockchain into the financial security system for the elderly. With the Government effort towards financial inclusion and digitalization of banking, it is possible to integrate blockchain into the system for retirement Planning for the millennial generation so that they can have a comfortable and dignified retirement life through various outreach educational programs on financial literacy.

CONCLUSIONS

In the current scenario, the people are using computers and electronic gadgets like smart phones for work as well as personal use. The digitalisation, e-commerce, online and mobile banking, usage of cashless cards has become part of everyone's life. This has become a driving force to integrate the blockchain in all the industries. The younger generation are also leading the older generation in all the technological innovations. Thus, the Blockchain technology integrated into the financial security system will have immense potential. to enable financial inclusion, generate returns, and help stimulate economic growth of the country and will also give equal opportunity to all section of the society to save for the future.

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DOES COOPERATIVE CREDIT ACCELERATE AGRICULTURAL DEVELOPMENT? AN EMPIRICAL STUDY.

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ABSTRACT

Indian economy is largely based on agriculture in which approx. 70% of the population is living in rural area. 15.4 percent of India's GDP is contributed by agriculture sector, which makes it important to develop the agriculture sector of the country. Financial institutions are contributing to the development of the agriculture sector by giving credit to the needful farmers and this credit flow also ends the dependency of farmers on moneylenders, among the financial institutes, cooperatives play a major role as it has branches to the grass root level. The purpose of the paper is to know about the impact of cooperative credit on agricultural development, satisfaction level of the farmers, and problems faced by the farmers at the time of credit acquisition. For measuring variables in the study the structured questionnaires are drafted. This paper covers only farmers from Hanumangarh district of Rajasthan. Data collection is done using Likert scale and data is collected from 384 farmers who are dependent on cooperatives for their credit need and for analysis of the impact Rank analysis, ANOVA analysis and Regression analysis is done. Ranking results of the study says that mostly the farmers are satisfied with the low interest rates of the cooperatives and find discomfort in arranging the guarantor for availing the loan, further it is found that the satisfaction level between different group of borrowers varies but the problems faced by these different groups are same and there is a positive and direct impact of credit on agricultural development and the farmers are very much benefited by the finance provided by the cooperatives. On the basis of the analysis, it is suggested that the cooperatives (PACS) should sanction the loan amount required by the borrower on nominal interest rates, bank should educate the farmers regarding loan and help them in getting guarantor.

Keywords: *Cooperative Credit, Agricultural Development, Satisfaction Level, Problems, cooperatives.*

Introduction

"In the village itself no form of credit organization will be suitable except the co-operative society, Co-operation failed, but co-operation must succeed". –All India Rural Credit Survey.

Agricultural credit is one of the crucial and basic inputs for agricultural development activities. In India, as majority of the population is dependent on the agriculture, so there is a huge need of proper agriculture credit because farmers are not stable in terms of cash. Earlier in the absence of the financial institutions, moneylenders were the ones who use to lend money to the farmers on huge rate of interest, but after independence the Indian government introduced institutional credit which is implemented through several agencies like cooperatives, commercial banks, regional rural banks, etc. to provide credit on nominal rates to the farmers. With the introduction of green revolution and modernizations into agriculture sector the need for credit has boosted.

Cooperatives provide credit on nominal rated to the farmers of the nation and its branches are up to the grass root level which means societies are established in the rural areas also, so that it gets convenient for the farmers to get easy credit. Primary cooperative societies cover almost all the villages of India. In agriculture credit the contribution of cooperative credit is increasing day by day.

Yet the cooperatives have a long way to go in their development, as in some areas or states cooperatives couldn't establish properly and on the other hand some dishonest members are not making it possible for cooperatives to work properly and due to which farmers are suffering.

The relevance of the study is to determine that does cooperative credit accelerates agricultural development and what is the impact of this credit on agriculture development and to know the satisfaction level of the farmers and the problems if any, faced by the farmers.

Review of Literature

A number of studies have been done in the field of Cooperative Credit. An effort is made to review few of them. Dakurah**, H.A., Goddard, E.W., Osuteye, N., (2005)** the study assess the attitude towards, and satisfaction of residents of Albert to their Cooperatives. it concludes that Analysis is done using the theory of planned behavior show that respondents' attitude towards their cooperatives is the single most important and significant predator of their patronization behavior. According to **Akram, W., Munir, S., Hashmi, M. H., Saleem, R., (2012)** focus of this paper is on the farmers borrowing behavior towards financial institutions and it classifies credit constraints which are faced by the farmers for the accessibility of institutional credit and also suggests remedial measures to make effective use of agriculture credit schemes. **Satyasai, K.J.S., Badatya, K.C., (2000)** argues for the refurbishing the system of rural credit but not cosmetic changes. The focus should be the satisfaction of eventual borrower at minimum cost possible. It indicates that real success only comes when the cooperatives take full benefit of their ability to have close by interface with the clients. This ability nearly matches alike ability of non-institutional local lenders and can never possibly be attained by other institutions. Further **Rachana, T., (2011)** studies the financial inclusion in the rural areas, reason for slow inclusion, satisfaction level of the borrowers towards the banking services and to access the performance of the banks which are mainly working in the rural areas which primarily includes cooperatives and RRB's. Conclusion indicates that there are many opportunities for the commercial banks to explore the unbanked rural areas. Though other financial institutions have better coverage but mostly they are running into losses. **Devaraja, T.S., (2011)** it investigate the issue in institutional credit in India. The study discloses that the delivery of credit into the agriculture sector remains to be inadequate. It has concluded that situation demands for concentrated efforts to argue about the credit flow to the agriculture, along with discovering new innovations in methods of delivery and product design through the better use of technology and correlated process. **Devi, R.U., Govt, S.R.K., (2012)** this paper analyze the role of cooperative credit into the development of agricultural sector of the state. The primary objective of study is to assess the performance of credit cooperatives by investigating its credit, deposits and impact of credit on beneficiaries. The study is basically based on secondary data and the paper concludes that the institutional credit upsurges the purchasing power of the beneficiaries and possibly because of this reason there is an increased use of modern inputs in the farming procedures. Further, **Pourtaheri, M., Papoli, M.H., Fallahi, A., (2012)** the main purpose of the study is to inspect whether cooperatives have a contribution to positive changes in the social, economic and environmental conditions amongst the two clusters of cooperatives which are managers and the members. The data is collected through questionnaire and one-sample T-test was applied in SPSS software. The study discloses that agricultural cooperatives are a profitable endeavor into the study area, but it seems that opportunities still remain for increasing the income if the constraints which are identified by the members and cooperative managers are addressed properly. Then **Bashir, M.K., Azeem, M.M., (2008)** the study was intended to examine the problem confronted by the farmers of Pakistan while availing the loan. It was found that the problems faced by small farmers in getting and returning the loan were more, which should be removed for better results and henceforth refining the quality and quantity of the agricultural products. Study concludes that the loan taken was misused, it also says that bank procedures are lengthy, interest rates are high, employees behavior is inappropriate, non-availability of loan on time, security problems, and repayment procedures are rigid. Further, **Oghenerobor Alufohai, G., & Jolomi Okorosobo, T. (2013).** The study assessed beneficiaries' satisfaction in managing the long-contract components involved in the farm credit delivery by cooperatives in Edo State. Study commends that advantage of external sources

of funds should be taken by the cooperative societies to boost the volume of their loanable funds. The simple random sampling technique was employed, data used was both primary and secondary and the Likert scale was used to measure the beneficiaries. **Gunes, E., Ozer, O. O., & Movassaghi, H. (2016).** The study explains that an attempt has been made to identify the factors which determine satisfaction of farmers in Turkey related to agricultural credit offered to them. Result of the study exposed that the socio-economic factors as age and educational level of farmers, alongside the size of the farm, family labor, financial ratios, willingness to purchase insurance, source of agricultural credit, types of credit and usage of credit card all significantly influences credit satisfaction among Turkish farmers. **Then, Sial, M. H., Awan, M. S., & Waqas, M. (2011).** This study explores the role of institutional credit in agricultural produce implying the time series data for the period 1972 to 2008. Cobb Douglas production function is assessed using OLS and all the variables are converted to per cultivated hectare. The results show that the agricultural credit, availability of water, agricultural labour force and cropping intensity are positively and significantly related to agricultural production. **Shuya, K., & Sharma, A. (2018).** The present study was conducted with the objective to obtain the information regarding the problem faced by borrowers as well as bankers while dealing with financial aspects. It was observed that highest incidence of the problem faced in the utilization of loan at the time of disbursement of bank loans by 100.00 percent respondents, followed by disbursement of loan/installment release by 55.00 percent other needs by 46.67 percent and the amount by 21.67 percent respectively. Further**, Chaturvedi, A., & Kaur, A. (2019).** the paper focuses on the satisfaction level of the beneficiaries who have availed credit from cooperatives and it also discusses the problems faced by them at the time of credit acquisition. It was found that cooperatives follow more formalities was the major problem faced by borrowers and concludes there is a significance difference between the groups of borrowers in the satisfaction level and the problems faced by them. Then, **Shuya, K., & Sharma, A. (2014).** Says that the recent study was undertaken on the sixty borrowers of cooperatives during 2009 to 2012 in Dimapur district of Nagaland to inspect the impact of loan on rural people, a resource used efficiency on pooled data along with different farm size group were fitted, which was found significant. It was witnessed that on rank based quotient the leading constraints was of amount of loan, followed by preparation of DPR, lack of technical guidance from bank, time of disbursement, subsidiary / rebate on loan, disbursement of loan, credit facilities and miscellaneous, from issued by the bank, knowledge about type of loan, bank interest rate, filling up of loan forms, repayment period etc at the lower scale**. Owusu-Antwi, G., & Antwi, J. (2010).** The determination of this paper is to recognize problems that have been hindering the effectiveness of Ghana's rural credit market. It is premised on the hypothetical understanding of rural credit market and smears the framework to inspect the feature of the rural credit market in Ghana. This paper would concern policymakers to put more emphasis on savings mobilization and to revisit interest rate policy, while providing economical and adequate credit to small and poor farmers. **Chaturvedi, A., & Sangwan, K. (2017).** It is a review paper which studies the management of the NPA, and the factors contributing to NPA in Rajasthan cooperative banks. And this paper concludes that absence of right to select borrower was the main responsible reason at appraisal stage, further at the sanction & disbursement stage bank officials were facing problems and at post disbursement stage the main reason of NPA was Non-submission of stock and other required periodical statements by borrowers, diversion of funds. Proper monitoring is not there.

By reviewing the literature, it was observed that majority of the studies are focusing on the attitude and behaviour of borrowers towards cooperatives and they talk about satisfaction and problems faced by borrowers. But the Impact of cooperative credit on agriculture development is not taken into consideration. Therefore, this study focuses

on the impact which cooperative credit has on the overall growth of the agriculture sector and alongwith it also studies the satisfaction and problems faced by borrowers of Hanumangarh District of Rajasthan.

Research Methodology

The population of this study comprises of the cooperatives of Hanumangarh district of Rajasthan. All the cooperative societies and the Primary Agriculture Cooperative Societies (PACS) are considered as sample. The selection of cooperatives among other financial institutions is due to numerous reasons. The cooperatives has its roots to the grass root level which means it also operates in village and provide agricultural credit to all the farmers of the area. And it also provide basic amount of credit without interest and without any security to the farmers and also follows less formalities, which has a larger impact on the society.

The purpose of the study is to know the impact of cooperative credit on agricultural development, satisfaction level of borrowers and the problems faced by them while availing credit.

Variables of the study	**Independent Variable**: Borrowed amount, Tenure of borrowed amount, Motive behind credit acquisition, Services availed at subsidized rates. **Dependent Variable:** Satisfaction level, Problems faced by borrowers, Agricultural development of beneficiary.
Objectives of the study	• To find out the satisfaction level of the beneficiaries of the cooperatives. • To find out the major problems faced by the borrowers during credit acquisition. • To find out the impact of cooperative credit on agricultural development
Hypothesis of the study	• Ho_1 : There is no significant difference between the satisfaction level and the problems faced by different group of borrowers during credit acquisition. • Ho_2 : There is no significant impact of credit acquisition on agricultural development.
Research Design	Descriptive and empirical research design has been used for the analysis.
Sampling Technique	Purposive sampling has been used.
Sample and Data collection	Primary data has been collected through a structured questionnaire, since the population of the study is finite so sample size is drawn from Krejcie and Morgan formula which is 384.
Statistical Tools	Rank Analysis, ANOVA, Regression

Analysis and Discussion

Table No. 1: Reliability Statistics

	Cronbach's Alpha	N of Items
Motive behind credit acquisition	0.608	8
Satisfaction level of beneficiaries	0.787	6
Problems faced by the beneficiaries	0.846	6
Services availed at subsidized rates	0.906	7
Agricultural development of beneficiaries	0.710	12

Source: Self-made based on Primary Data

During the reliability test of the scale question the value of Cronbach's Alpha should be equal to or more than 0.75, which is considered as a good value and the above table shows that Cronbach's Alpha for the motive behind credit acquisition is 0.608, satisfaction level of borrowers is 0.787, for problems faced by the borrowers during credit acquisition is 0.846, services availed at

subsidized rates is 0.906 and for agricultural development of beneficiaries is 0.710 so in all the cases value is satisfactory to deliver good results.

Objective 1: To find out the satisfaction level of the beneficiaries of the cooperatives.

Table No. 2: Weighted Average of Satisfaction of the Borrowers.

S.No	Satisfaction	Weighted Average	Rank
•	Services offered by employees.	12.89	4
•	Processing fees/charges	14.64	2
•	Sanction of required amount needed for production	11.82	6
•	Time taken for availing credit	13.20	3
•	Interest rate	14.75	1
•	Availability of subsidized products	12.39	5

Source: Self-made based on Primary Data

Table 2 reveals features of satisfaction of the borrowers during credit acquisition from cooperatives. Study shows that borrowers are highly satisfied with the interest rate fixed by the cooperatives followed by processing fees/charges ranked second, time taken for availing credit and so on, to compare the least satisfactory feature of the cooperatives.

Objective 2: To find out the major problem faced by the borrowers during credit acquisition.

Table No. 3: Weighted average of the problems faced by the borrowers.

S.No	**Problems**	**Weighted Average**	**Rank**
•	Credit policies and procedures are rigid	9.73	6
•	Delay in credit sanction	12.19	3
•	Cooperatives follow more formalities	9.77	5
•	Guarantor is not easily available	13.14	1
•	Undervaluation of land during loan sanction	11.28	4
•	Inadequate knowledge about credit facilities	13.12	2

Source: Self-made based on Primary Data

Table 3 reveals problems experienced by borrowers during credit acquisition from cooperatives. Study shows that Guarantor is not easily available, followed by inadequate knowledge about credit facilities, delay in credit sanction, to know the least ranked problem faced by the borrowers.

Hypothesis testing:

Ho_1 : There is no significant difference between the satisfaction level and the problems faced by different group of borrowers during credit acquisition.

Table No. 4: ANOVA

Statement		Sum of Squares	Df	Mean Square	F	Sig.
Satisfaction of borrowers	Between Groups	7.184	2	3.592	6.190	0.002
	Within Groups	221.080	381	0.580		
	Total	228.264	383			
Problems faced by borrowers	Between Groups	0.705	2	0.352	0.471	0.625
	Within Groups	285.147	381	0.748		
	Total	285.852	383			

Source: Self-made based on Primary Data

Table 4 shows the output of ANOVA analysis and test whether there is significant difference between our group means .It is observed that satisfaction of borrowers have significance

value 0.002 which is < 0.05, leads to rejection of null hypothesis. Therefore, it can be interpreted that there is a significant difference in the satisfaction level of different group of borrowers on the basis of tenure of borrowed amount.

On the other hand if we study the problems faced by borrowers, the significance value is 0.625 which is > 0.05 which leads to acceptance of null hypothesis. Therefore, it is concluded that there is no significant difference in the problems faced by the borrowers of different group on the basis of tenure of borrowed amount.

Ho_2 : There is no significant impact of credit acquisition on agricultural development.

The regression analysis was performed taking Agricultural Development as dependent variable and borrowed amount, motive behind credit acquisition and services availed at subsidized rates as independent variables. The result highlighting the statistically significant relationship is exhibited in the table.

Table No. 5: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.525[a]	0.276	0.270	0.50044

a. Predictors: (Constant), Borrowed amount, Motive behind credit acquisition, services availed at subsidized rates.

The column "R" signifies the **correlation coefficients.** It is considered to be the one measure of the worth of the predication of the dependent variable. The column "**R Square"** represents the proportion of variation in the dependent variable which can be explained by the independent variable. It is observed from table that **R^2** value is **0.276** which states that determinants of borrowed amount, Motive behind credit acquisition, services availed at subsidized rates (independent variables) explain 27% of variability of Agricultural Development (dependent variable).

Table No. 6: ANOVA

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	36.253	3	12.084	48.252	0.000[b]
Residual	95.168	380	0.250		
Total	131.422	383			

a. Dependent Variable: Agricultural Development

Table No. 7: Coefficients

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	1.709	0.123		13.846	0.000
Borrowed amount	0.104	0.020	0.251	5.081	0.000
Motive behind credit acquisition	0.313	0.039	0.377	7.977	0.000
Services availed at subsidized rates	0.087	0.022	0.205	4.047	0.000

a. Dependent Variable: Agricultural Development

The F-test result computed using SPSS in the form of ANOVA table are shown in above table. It tests whether the overall regression model is a good fit for the data. The null hypothesis in this test is "The model does not fit in the data". The p-value of the F-test in Borrowed amount, Motive behind credit acquisition and Services availed at subsidized rates is less than **0.05.** It means that the test is significant and null hypothesis is to be rejected at 5% level of significance. Therefore

the final linear regression equation is as follows:

Agricultural Development = 1.709 + 0.104(Borrowed amount) + 0.313 (Motive behind credit acquisition) + 0.087(Services availed at Subsidized rates)

Unstandardized regression coefficients, including the constant term of regression model, which are represented in Table No. 7, indicate the variation level of dependent variable with an independent variable when all the other independent variables are held constant. On the basis of the output, we can conclude that in all cases of borrowed amount, Motive behind credit acquisition and services availed at subsidized rates "Agricultural Development" is depending on them. Table no depicts that the unstandardized regression coefficient of Borrowed Amount is **0.104**; regression coefficient of Motive behind credit acquisition is **0.313** and regression coefficient of Services availed at subsidized rates is **0.087**. The significance value is less than 0.05, thus the Null hypothesis is rejected, and it was found that Borrowed Amount, Motive behind credit acquisition and Services availed at subsidized rates had a significant impact on Agricultural Development.

Conclusion

The study examines the impact of cooperative credit on Agricultural Development and the satisfaction level of borrowers during availing credit and the problems which are faced by the borrowers of the Hanumangarh cooperatives. The 5- Likert scale technique has been used in the questionnaire. For the different questions mean was calculated and ranking has been used to understand the satisfaction of the borrowers and the most prominent cause of problems faced by borrowers during credit acquisition in cooperatives.

The findings of the study highlights that the "Interest Rate" is the most satisfying feature of the cooperative the borrowers says that they have to pay very minimal or no interest on their loan and borrowers are least satisfied with the sanction of required amount required for production as Primary Agricultural Cooperative Societies sanction the basic amount for production to the borrowers without any interest which is not sufficient for the production. It is seen that the borrowers face most difficulty in finding the guarantor at the time of availing credit and the credit policies and procedures followed by the cooperatives are not rigid and are easy for the borrowers to comply with.

Regression Analysis results shows that there is a significant difference between the groups of borrowers in the satisfaction level. Where as in case of problems faced by there is no significant difference between the groups of borrowers in problems faced was observed. A significant impact of cooperative credit on agricultural development was also found by the regression results.

There are some boundaries to the study which are explained here. The data is collected from the 384 respondents only and based on that the results are drawn. The area of the study is confined to Hanumangarh district; it is recommended to supplement the research by undertaking study in another area in order to generalize the analysis. Further, this study is conducted on cooperatives only so it is recommended to the researchers to conduct study on another financial institution to widen the scope of the research. Moreover this study is conducted considering few variables which are satisfaction level of borrowers, problems faced by borrowers, agricultural development after credit acquisition, thus it is also suggested to make use of other indicators also to reveal the clear view of the impact of financial institutions on the growth of borrowers and the economy.

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SECURITY OF DATA AS A FACILITATOR FOR EFFECTIVE IMPLEMENTATION OF KNOWLEDGE MANAGEMENT

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ABSTRACT

We have been undergoing dynamic and turbulent changes due to the revolution of technology. Technology has given enormous data, and this has made the task of companies easier and also complicated with regard to its management and security issues. Proper use and safety only will ensure the desired results. Many companies have adopted knowledge management practices to face the stiff competition and also to satisfy their customer requirements to the latest products and services. This has necessitated the companies to look for varied and new measures to deal with the data security so that they are able to get the desired output from the assimilated and huge data. Data security with employee's satisfaction can go a long way in making the knowledge of the company to be effective and also direct it to the goals of the organization.

Key Words: Data driven, robust control, stress, data security, Technology, knowledge control.

I INTRODUCTION

Technology has changed the way business is being performed and now data has become the fundamental component of the global business infrastructure which provides the framework for decision making process and also assists in creating the foundation for work. An organisation relies on information collected from both secondary sources and also the information accessed through computer to perform its operations. . Knowledge management enables stock of knowledge and processes and process improvement that directs the organisation to a better course of action. Knowledge management has an upper hand over the traditional methods wherein time is spent only on looking out for an outcome rather than on the process. Process is usually ignored and thus has problems associated with proper outcomes at the desired points. Knowledge management dwells into vast quantity of data and tries to analyse, exploit them to add value and intelligence to decision making and operational business.

This diffusion of information has to be used prcasiouly and for the benefit of the corporate knowledge architecture. There are various reasons for data security in organisations. Some of the reasons for proper security measures and fencing of data in organisations include:

- Competition – Huge access to data is always at the risk of being hacked and also coming to the hands of the competitors. Organisations are thus very careful with regard to managing these crucial data. Organisations arrange for proper coding and decoding of information so that the purpose for which it has been retained is achieved.
- Information glut – Excessive information also at times creates problem with proper use and reaching the right place of usage. Sometimes the information goes to departments which either don't need them or they ignore such data causing the data to be unsecured.
- To have effective functions to cater to the knowledge workers – Data collected need to be streamlined to the required functional areas so that the knowledge workers use it effectively and efficiently. The proper channelling should make the data valuable to the workers who require them and they should be trained to pass on the sufficient information to the next line of workers in proper timing and required quantity.

STATEMENT OF THE PROBLEM

Organisations are always at the risk of threats and they should aim to secure their workplace through proper office security measures to prevent them. Even though organisations have varied types of risks, the most common type of risk often now faced by companies is the unauthorised access to data. Cyber security has thus now gained importance, laying down the need for

intense security setups. However the improvements and the latest technology up gradations have given way for physical security more reachable and also made it easier for the organisations to deal with the proper usage of huge data.

REVIEW OF LITERATURE

Malhotra (2000) in his study has noted that organisation should be inclined towards taking the philosophy of anticipation, reaction, and response to change, complexity and uncertainty. **Garfinkle (2002**) said organisation to have effective knowledge management practices must insist on choosing among alternatives, test and sell to match the changes before going in for final adoption. **Duek** (**2001**) in his study found that a person's temperament is a major influence on how that person views knowledge management. He said corporate guardians like caretakers, care givers are concerned with knowledge security and they ensure that no knowledge is wasted or lost. Data trustworthiness and its related problems require articulated solutions with data integrity, data quality, record linkage **(Ian2012**) and (**Sultana 2013)** data provenance.

There are various studies indicating the security of data and the use of knowledge management. But very few studies relate the need for security of data as an enabler for effective use of knowledge management practices. So here a study has been attempted to find the various factors which ensure the proper use and security of data for making knowledge management an easy practice.

OBJECTIVES OF THE STUDY

The objective of the study are listed below

- Factors that influence the implementation of security measures for effective knowledge management practices
- Effect and Relative Importance of the Driving factors in security of data

RESEARCH METHODOLOGY

In order to study the impact of security measures for effective implementation of knowledge management practices, a sample 300 respondents was selected. The researcher ensured that the sample of respondents poses adequate knowledge with respect to application and use of data in organisation. The study is based both on primary and secondary data. The convenience sampling procedure was used for selecting the samples from the vast population of Bank IT and ITES employees in the city of Chennai. In order to collect the responses from the employees, a structured questionnaire was framed based on the reviews. Both optional and Likert's five point scale statements were used in the questionnaire to ascertain the responses. A total of 300 questionnaires were distributed to the employees in the banks in Chennai. Out of which 50 questionnaires were rejected for incomplete responses and the study was restricted to 250 respondents.

ANALYSIS AND INTREPRETATION

Factors that influence the implementation of security measures for effective knowledge management practices

The factors which usually effects the working of the organisation for usage of knowledge management practices is identified as Creating culture, secure workspace, establishment and implementation of strong plans, disaster prevention and mitigation, strong firewalls and spread of contagion, ergonomics influence, training, work place stress, tailor made process, comfortable work systems, robust access and control, yearly security check. All the 12 factors were selected for factor analysis by using the principle component extraction with an orthogonal rotation.

The appropriateness of the data for the factor analysis is discussed in the following KMO and Bartlett's test.

Table 1 KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of sampling Adequacy		**0.963**
Bartlett's Test of Sphericity	Approx. Chi-square	4251.63
	DF	66

	sig	0.000

Source: Computed

The Kaiser-Meyer-Oklin (KMO) Measure of Sampling Adequacy (MSA) and Bartlett's test of Sphericity are applied to verify the adequacy or appropriateness of the data for factor analysis. In this study, the value of KMO for overall matrix is found to be good (0.963) and Bartlett's test of sphericity is highly significant ($p<0.001$). The results thus indicate that the samples taken are appropriate to proceed with the factor analysis.

Further to define the factors clearly, it was decided to delete any variable that had loading below+_0.50. With this criterion, a series of factor analysis was performed on the data. It is found after the analysis that, contribution of all variables is greater than 0.5. Hence there is no necessity to eliminate any variable form the analysis. After this preliminary step, factor analysis with principal component analysis as an extraction method was performed on the items.

Table 2 **Total Variance Explained**

Component	**Initial Eigen values**			**Extraction Sums of Squared Loadings**			**Rotation Sums of Squared Loadings**		
	Total	**%of variance**	**Cumulative %**	**Total**	**% of Variance**	**Cumulative %**	**Total**	**%of variance**	**Cumulative %**
1	**4.839**	**40.325**	**40.325**	**4.839**	**40.325**	**40.325**	**3.422**	**28.516**	**28.516**
2	**1.212**	**10.103**	**50.428**	**1.212**	**10.103**	**50.428**	**2.413**	**20.105**	**48.622**
3	**1.118**	**9.315**	**59.743**	**1.118**	**9.315**	**59.743**	**1.335**	**11.121**	**59.743**

Extraction Method: Principal Component Analysis. **Source: Computed**

Table 3 Rotated Component Matrix

No.	**Factors**	**Component**		
		Environment	**People**	**Process**
1	Creating a culture	0.771		
2	Secure workplaces	0.761		
3	Establish and implement strong plans	0.713		
4	Disaster prevention and mitigation	0.603		
5	Strong firewalls and spread of contagion	0.583		
6	Ergonomics influence		0.848	
7	Training		0.804	
8	Workplace stress		0.571	
9	Tailor made process			0.884
10	Comfortable systems			0.551
11	Robust access to control			0.550
12	Yearly security check			0.514

Source: computed

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalisation.

Total Variance Explained

The above table depicts the total variance explained with rotation.

The Eigen values for the three factors namely, Environmental factors, People and process are 4.839, 1.212 and1.118 respectively.

% of variance after the rotation for the factors 1, 2, and 3 are 28.516, 20.105 and 11.121

respectively. Cumulative % for the factors 1, 2 and 3 after the rotation are 28.516, 48.622 and 59.743 respectively. It indicates that the 3 factors extracted from the total of 12 variables have a cumulative % up to 59.743% of the total variance.

The reliability of these five variables belonging to the first factor group is measured using Cronbach"s Alpha and its value is 0.920. The reliability value of the three variables falling under the second factor group is 0.909. The reliability of the four variables of the third factor group is valued at 0.904. Since all the reliability values are above 0.9, the classification is highly reliable.

Rotated Component Matrix- After obtaining the factor solutions, in which all the variables have a significant loading on a factor, the researcher attempted to assign meanings to the pattern of factor loadings. Variables with higher loadings are considered more important and have a greater influence on the name or the label selected to represent a factor. The researcher has already examined all the underlined variables for a particular factor and placed greater emphasis on those variables with higher loadings to assign a name or a label to a factor that accurately reflects the variables loadings on that factor. All the 3 factors are given appropriate names on the basis of the variables represented in each case.

Factor I secure workplace, is the most important factor which explains 28.516% of the variation. The variables creating a culture (0.771). Secure workplace (0.761). Establishing and implementing strong plans (0.713), Disaster prevention and mitigation (0.603) and strong firewalls and spread of contagion (0.583) are highly inter correlated. These statements reflect the opinion of the employees towards the effectiveness and safety of the security measures in the environment of the organisation.

Factor II namely, explains 20.105% of the variation and consists of 3 variables. There is high correlation among the variables - Ergonomics influence (0.848) Training (0.804) and Workplace stress (0.571). The three variables reflect the safety features and security of data with respect to the people working in the IT and ITES companies.

Factor III namely, the process is 11.121% and it consists of 4 major variables. These variables are Tailor made process (0.884),Comfortable work process (0.551) Robust access to control (0.550) Yearly security check (0.514) and are highly inter correlated. These statements reflect the opinion of the employees with respect to the process of work involved and their security aspects.

Inference - Secure workplaces, Ergonomics influence and Tailor made process are the major factors contributing to the security aspects of employees and the data. Disaster prevention and mitigation, firewalls and spread of contagion are comparatively less looked into by the employees. Employees are more worried about their health and see to it that the time spent by them in the organisation does do any harm to their health and they are also able to contribute by having stress free work culture. Yearly security check, strong plans for action are all considered as regular practice which does not add any value to their work, but is considered as mandatory for any style of work culture. However, tailor made process to suit their habits and work mechanism is demanded by the workers. Organisations need to use the data to provide a secure workplace and also should safeguard the data for use in the future.

Effect and Relative Importance of the Driving factors in security of data

To assess the overall effect of the factors that determine the security of data and to analyse the relative importance of the individual dimension of the generated scale, Multiple Regression analysis is performed. The regression model considers the three groups of factors namely, Environmental factors, people oriented and process oriented as the independent variables and the overall preference of employees as the dependent variable. The strength of the relationship between the selected independent variables and preference towards the data security were studied and the results shows:

Table Effect and Relative Importance of the Driving factors in Employee preference for security of data for knowledge management practices

Table 4

No.	**Factors**	**Standardized Coefficient**	**SE**	**'t' value**	**'p' value**
	Constant	12.652			
1	Environment	3.438	0.361	9.522	0.000*
2	People	4.677	1.084	4.313	0.000*
3	Process	1.549	0.153	10.148	0.000*

***significant at 1% level**
Source: computed

The result equation is, Employees preference for security of data=12.652+ (3.438 x Environment oriented) + (4.677x People oriented) + (1.549x process Oriented)

It is noted that, one unit increase in employee's opinion is predicted from 3.438 unit increase in environment oriented, 4.677 unit increase in people oriented and 1.549 unit increase in process oriented factors. IT and ITES companies need to work for providing proper infrastructure which caters to the requirements of the environment, see satisfying the people working there and also has process which is not only comfortable, safe but is also having the latest techniques, measures which safeguards the data and is providing satisfaction to the employees.

SUGGESTIONS

- Employees should be educated and trained in the different methods of data interpretation.
- Work environment should be changed frequently with latest security measures
- Employees should be given proper work environment to enable them to work in a conducive work station.
- Creation of a culture around safety and security of data.
- When required use mechanical assistance for data protection.
- Create secure workspaces.

CONCLUSION

Recent times has seen the advent of technology into various work and has made the human resource to adapt itself to the requirements of the latest technological innovations. This has made the organisations to think of innovative ways to compete with others and also to have better work practices to get an edge over others. Knowledge management initiates new and better ways to perform with the abundant knowledge and reserves of information in the form of big data. This has to be used very carefully and its full advantage and benefits can be derived only if the organisation understands and uses these resources in a systematic way. Various techniques, methods have been identified for this purpose and proper training and exposure to them would enable employees to get the maximum from these secured data.

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REVERSE SHADOWING –AN ENABLER FOR BRIDGING THE GAP IN THE IT SECTOR

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ABSTRACT

Knowledge management uses technology as a tool to assist its individuals and groups in the creation, capturing, distribution and sharing of knowledge and serves as a facilitator for creating a new generation of employees who are quipped to transfer knowledge and expertise thereby becoming world class knowledge workers. Digital technology has created a competitive edge towards these indicators of economic growth and international competitiveness. Every IT product or service passes through a phase of knowledge transfer in its life cycle and the very purpose of collecting or capturing knowledge is to facilitate sharing. This transition requires expert systems to use human knowledge to solve the problems and to use the fragments of human know how into knowledge base by using appropriate knowledge tools.
A transformational shift has taken place, moving us from hardware to software centric growth with a wider usage of cellular networks. IT industry is now the digital pivot for most of the developing countries to harness and retain their human resources to tackle their learning skills. This requires reverse shadowing, wherein co-workers are made to understand the need to become more efficient in their job, by learning from their co-workers. This study tries to identify the role of job shadowing in the process of retaining employees in the IT Sector. Secondly the problems usually employees face when job shadowing is adopted for job transfer.

Key words: *Knowledge Transfer, Job Shadowing, Knowledge workers, Digital transformation, learning skills.*

INTRODUCTION

Global business environment has made business operations more complex with multiple information sources available through tools, methods and processes, wherein the organisations are looking at various angles to retain and acquire efficient workers. Today' technology driven environment demands human resources to be closely knit and more so the leader to be in the shoes of employees to manage the uncertainties at workplace. This is likely to improve the efficiency as well as the quality of decision at high levels over the period. Reverse shadowing will break the barriers in the work place and would definitely make the tasks attainable and also enable the organisation to achieve its goals. Information technology sector still more is concerned with higher turnover and always in the lookout for ways to manage the human resources effectively. Indian software industry is likely to reach US$ 100 billion by 2025 and is focussing to invest in international ventures, thus making it a global delivery centre with global footprints. Information technology is slowly but steadily up scaling itself with focus on digital up gradations. Digital practices and investment in digital projects shows an increase with almost 28% to 30% of the industries revenue coming from digital contribution. Information technology and digitalisation has made it mandatory for human participation. Organisation have started to recognise the importance of human potential for handling the issues in information. They are working to retain and acquire quality human resources to achieve the objectives of proper knowledge management. Job shadowing strengthens the relationship between the employees and develops cordial understanding by engaging in proper work process. Reverse shadowing makes it possible for fluidity in roles and benefits the mentor and mentee thereby helping the overall understanding in the organisation. Reverse mentoring has been used since 1990's by GE CEO Jack Welch, when GE executives were asked to pair with people below to learn the use of internet. It was noted that younger generation were more skilled with digital aspects and had the comfort with technology as against the senior workers(Joe Pang).The shift from traditional job shadowing at work and traditional mentoring to a shadow mentoring app is also beneficial. The mentee sees his or her shadow mentor approaches at work. By practice, the employee looks at the simple task to overall strategy as a shift from thinking to motivation.

OBJECTIVES

1. To understand the role of job shadowing in retaining the employees
2. To identify the problems associated with job shadowing leading to job transfer.

RESEARCH METHODOLOGY

The present study uses primary and secondary data. For the purpose of collecting primary data, a structured questionnaire was designed and distributed to the respondents. The filled in questionnaire was analysed using Statistical Package for Social Sciences. The simple random sampling procedure was used for selecting the samples from the vast population of IT sector employees in the city of Chennai. Both optional type and Likert's five point scale statements were used in the questionnaire to ascertain the responses.

A total of 600 questionnaire were distributed to the employees working in various IT companies in Chennai. Out of which 553 questionnaires were received and on scrutiny 53 questionnaires were rejected for incomplete responses and the study was restricted to 500 respondents.

SCOPE OF THE STUDY

Indian information technology sector is highly influenced by the global scenario and is also showing the resilience inspite of the economic downfall due to the pandemic. Information Technology, though new entrant after the independence as IT and ITES, it has shown tremendous growth to become the pillars of modern India. IT based products and services are now indispensable for any flourishing business. Chennai is no exception to the growth of Information Technology sector. Since the late 1990's the sector has become the major driver for the city's economic growth and Chennai is considered as an alternative place for IT absorption after Bangalore.

This sector has smoothly transitioned during the pandemic period thereby fulfilling all the commitment to the global customers by contributing to the growth of the state. The human potential has given a cutting edge to this transition. The new gen trained manpower have noted the contribution of the co-workers to be one of the main cause for such persistent successful adaption to new culture.

LIMITATIONS

- Due to lack of time the study is restricted to the city of Chennai.
- The number of respondents is limited to 500 respondents.

REVIEW OF LITERATURE

Job shadowing usually provides the atmosphere for building strong relationship between the employees and also helps in creating cordial understanding for proper work process. This as reverse job shadowing makes still more fluid for employees to learn not only from their seniors but also the juniors in similar roles. It is definitely a benefit for the mentor and mentee, but also would help the organisation to have smooth functioning. Indonesia Astra leading company Bank International developed employee development programme with the objective of increasing the competence, observing potential and also aimed at modifying the behaviour to identify the right employee placement. (Filisko, 2008: Parizek &Kesavan, 2002). This required developing employees through good orientation and also motivating them through proper coaching and monitoring. This will help employees to develop self-direction, self-esteem and improve efficiency. (Deans F, Oaklay L)Coaching employees one to one would hold employees more responsible and improve knowledge skills and wok performance. Coaching would help someone to be the best and direct them to the goals they dream. (O'Conrior T, Lages) Job shadowing allows students the opportunity to explore and experience first-hand the "World of Work". (Filisko, 2008: Parizek &Kesavan, 2002). Similarly students enrolled in online hospitality course showed stronger problem solving abilities than those in the traditional face to face (F2F) courses.(Cheng 2009)Experimental learning associated with job shadowing was much powerful than using the standard case study teaching tool. (McCarthy & McCarthy 2006).With these methodologies, human resource management mainly tries to coordinate people to achieve

the goals by aligning the goals of the business and thereby tries to provide satisfaction and contentment to the employees.

ANALYSIS AND DISCUSSION

FACTOR ANALYSIS ON THE VARIOUS STRATEGIES FRAMED TO MAKE JOB SHADOWING A SUCCESS

The following section analyses the various strategies framed to make job shadowing a success.

Table – 1 KMO and Bartlett's Test

Kaiser- Meyer-Olkin Measure of Sampling Adequacy		.765
Bartlett's Test of Sphericity	Approx. Chi Square	2326.507
	df	120
	Sig	.000

Table 2 - Rotated Component Matrix

	Component		
	1	2	3
Improved skills	.778		
Platform for identifying role models	.751		
Better Communication	.697		
Behavioural improvisations	.693		
Builds image and good will of the company	.520		
Builds image and good will of the company		.733	
Reduces the wastage associated with learning		.730	
Share best practices		.721	
Saves time		.629	
Active contribution in decision making		.615	
Implementing the strategies of reverse shadowing the company has been able to reduce the turnover		.586	
Faster learning and self-development			.715
Attitude and awareness change			.703
Attainable high targets			.677
Tool for breaking internal barriers			.554

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalisation
Rotation converged in 6 iterations.

The rotated component matrix shown in Table is a result of VARIMAX procedure of factor rotation. Interpretation is facilitated by identifying the variables that have large loadings on the same factor. Hence, those factors with high factor loadings in each component were selected. The selected factors were shown in the table.

Table 3 Clustering of inducing variables into Factors

Factor	Inducing Variable	Rotated Factor loadings
I 18.266 Behavioural changes	Faster learning and self-development X3	**0.715**
	Behavioural improvisations X6	**0.693**
	Better Communication X7	**0.697**
	Improved skills X8	**0.778**
	Platform for identifying role models X9	**0.751**
	Attitude and awareness change X2	**0.703**
II 36.447 Improved performance	Attainable high targets X1	**0.677**
	Active contribution in decision making X11	**0.615**
	Implementing the strategies of reverse shadowing the company has been able to reduce the turnover X12	**0.586**
	Reduces the wastage associated	**0.730**

	with learning X 13	
III 51.791 Better practices and policy changes	Saves time X14	**0.629**
	Builds image and good will of the company X15	**0.733**
	Tool for breaking internal barriers X 4	**0.554**
	Builds image and good will of the company X5	**0.519**
	Cater to the varied requirements X10	**0.722**
	Share best practices X16	**0.721**

In this table three factors were identified as being maximum percentage variance accounted. The variable X3, X6, X7, X8, X9 and X2 constitutes factor I and it accounts for 18.266 percent of total variance. The Variable X1, X11, X12 and X13 constitutes factor II and it accounts for 36.447 percent of the total variance. The variable X14, X15, X4, X5 and X16 constitutes factor III and it accounts for 51,791 percent of the total variance.

Ho: There is no positive influence over the position of employees in IT sector and the various strategies to make successful implementation of reverse job shadowing process.

Table 4 – Association between the position of employees in IT sector and the various strategies to make successful implementation of Reverse job shadowing process.

		Sum of Squares	**df**	**Mean Square**	**F**	**Sig**	**Result**
Behavioural Changes	Between Groups	6.944	2	3.472	.111	.005	S
	Within Groups	13091.235	417	31.394			
	Total	13098.17	419				
Improved Performance	Between Groups	39.199	2	19.600	2.170	.000	S
	Within Groups	3766.315	417	9.032			
	Total	3805.514	419				
Better practices and policy changes	Between Groups	203.267	2	101.633	6.0696	.002	S
	Within Groups	6951.924	417	16.671			
	Total	7155.190	419				

Source: Computed form primary data. Level of Significance: 5 percent.

Result: It is found from the table 4 that the hypothesis is rejected and there is positive influence of the position of employees in IT sector and the various strategies to make successful implementation of Reverse Job Shadowing process.

Employees holding lesser position find it easier to adapt to the job shadowing process of learning rather than employees who are at the higher level. Employees find it easier to build relationship with the peers and subordinates when they are posted in lesser positions and the mentors also find it convenient to interact when the peers and superiors are not holding positions at higher level. The communication process, methodologies used to explain and handling them is easier to fill in the skill deficits when accompanied with job shadowing.

Ho: There is no positive influence over the length of service and the problems faced in the implementation of reverse job shadowing process.

Table 5– Association between the length of service of employees in IT sector and the problems faced in the implementation of Reverse job shadowing process.

		Sum of Squares	df	Mean Square	F	Sig	Result
Behavioural Changes	Between Groups	56.580	2	28.290	.905	.000	S
	Within Groups	13041.599	417	31.275			
	Total	13098.179	419				
Improved Performance	Between Groups	78.101	2	39.050	4.369	.013	S
	Within Groups	3727.414	417	8.939			
	Total	3805.514	419				
Better practices and policy changes	Between Groups	28.342	2	14.171	.829	.004	S
	Within Groups	7126.849	417	17.091			
	Total	7155.190	419				

Source: Computed from primary data.
Level of Significance: 5 percent

Result: It is found from the table 5 that the hypothesis is rejected and it is concluded that there is significant influence of the length of the service of employees in IT sector and the problems faced by them in the implementation of the reverse job shadowing process. Employees having more service prefer not to choose this method of learning as they need to work with juniors to get the latest methods of working and they find it difficult to accept the knowledge shared by people who are little less in the hierarchy. However, the new entrants find it easier to adapt to the new methodologies and are free to work with superiors, peers and at times even the employees who have joined after them. So, the length of service of employees definitely indicates the success rate of this method of knowledge sharing. Mentor is mostly considered as a great asset to the newcomers as they feel at home and are able to improve quickly due to experience and knowledge of the mentor. Problems like stress, lack of comfort level with the mentor, inconsistencies with the methodology of sharing information, prior education of the mentor and mentee, distortions, non – involvement due to personal reasons , long pattern, deficiencies in identification of exact information required, Intrusions, work environment and mode of sharing can all cause hurdles in the proper execution of the jab shadowing process.

CONCLUSION

The current scenario is exposing the organisations to several changes and transformation which is impacting the economy due to not only regulatory modifications but with increasing customer awareness, employee expectations and more so the unstoppable progress in Information and communication sector has made the human talent a valuable resource. Organisations are frequently restructuring, redefining and reinventing their systems to face these challenges. It is evident that organisations which are not able to update themselves are slowly coming down in their performance and are existing in the fear of extinction. Business and performance is thriving on the human resources and it has become inevitable to treat the human capital as an asset. Managing the human resources is a hurculine task requiring strategic handling of the employee along with proper motivation to attain the goals of the organisation. When

one employee job-shadows another, the experience should allow for free exchange of questions, answers, and communication, whether the job is being performed or is an informal debriefing session afterwards. As Job shadowing is mainly for transfer of knowledge at various knowledge centres, it has to be continuous and has to happen when it needs replacement, when it becomes obsolete, so that the system is rejuvenated with current knowledge. The traditional outlook of managing people has been changed with job shadowing with broadening the organisational capabilities, managing relationships and also managing the learning and knowledge to achieve the goals of the organisation. The outcome of job shadowing should be to decide whether the employees love the job or decides that the job is not for him. He should maintain a positivity towards this thought and should always understand that the job shadowing is for learning the skills and experience of employees who have better knowledge than them. This would only enable the organisation to build the intellectual capital to leverage the human resources to conduct business to gain competitive advantage.

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SMART MEDICAL CARE MONITORING FRAMEWORK EXPLOITING INTERNET OF THINGS DURING COVID-19

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ABSTRACT

Social separating and isolating are presently standard practices which are executed worldwide since the episode of the novel (COVID-19) infection pandemic in 2019. Because of the full acknowledgment of the above control practices, successive clinic contact visits are being debilitate. Nonetheless, there are individuals whose physiological imperative necessities require routine checking for worked on solid living. Curiously, with the new mechanical headways in the space of Internet of Things (IoT) innovation. Internet of Things (IoT) based smart wellbeing checking framework is a patient observing framework wherein a patient can be observed 24 hours. In the current world, IoT is changing the framework of advancements. By working with easy association among different modules, IoT has empowered us to execute different complex frameworks like savvy home machines, shrewd traffic light frameworks, smart office frameworks, smart monitoring systems, brilliant vehicles, and smart temperature control frameworks, etc in very little space. Wellbeing checking frameworks are quite possibly the most remarkable uses of IoT. Many sorts of plans and examples have effectively been executed to screen a patient's ailment through IoT. In this paper aims to emphasize the common design and execution patterns of intelligent IoT based smart health moniotoring devices for patients.

Keywords- Framework, Infections, Internet of Things, Pandemic, Temperature.

INTRODUCTION

The term “Internet of Things” (IoT) was first coined in a presentation by Kevin Ashton about implementing radio-frequency identification (RFID) in the Procter and Gamble organization for supply chain management [1]. IoT is a trend setting innovation that can connect all smart objects together within a network with no human associations [2]. All the more basically, any item that can be associated with the internet for further monitoring or transferring information can be an IoT gadget [3]. Lately, IoT has acquired persuading research ground as a new research topic in a wide variety of academic and industrial disciplines, particularly in healthcare. The IoT revolution is reshaping modern healthcare systems, incorporating technological, economic, and social prospects. It is evolving healthcare systems from traditional to more customized healthcare systems through which patients can be analysed, treated, and checked all the more without any problem.

The Internet of Things (IoT) is envisioned as a network of billions of devices that can sense, communicate and share data which can then be analyzed to unlock a wealth of intelligence useful for planning, management and decision making [1]. IoT promises huge benefits for a variety of domains such as healthcare, manufacturing, agriculture, telecommunication and transportation. Despite the popularity of the IoT concept and its promised benefits, its adoption has been significantly slower than expected [2,3]. Some of the major reasons behind this include: (1) security, privacy, policy and trust issues [3–5]; (2) organisational inertia, long capital cycles and shortage of specialist workforce needed to successfully implement IoT [2,5]; and (3) lack of convincing use cases with clear return on investment (ROI) in some sectors. COVID-19 has impacted all walks of life so much that we may never return to the old normal. This pandemic is proving to be a catalyst for digital transformation because COVID-19 has created or expanded applications and use

cases of digital technologies [6–8]. It has also forced governments, organisations and individuals to change/adapt their priorities, their views on societal/ethical issues, and the way they operate. In many cases, this has addressed or mitigated many of the above-mentioned reasons behind the slower-than expected adoption of IoT across many verticals. The fight against COVID-19 has resulted in a less strict stance on privacy issues, higher trust in technology and fasttracked approval procedures. All devices are connected to one another with various smart technologies to create worldwide ubiquitous network called Internet of Things (IoT). We recorded the data of each sensor and uploaded the data into the server. We observed the data on many devices using internet with secured login and password.

SIGNIFICANT APPLICATIONS OF IOT DURING COVID-19 PANDEMIC

At present, it is a challenging task to detect and prevent the spreading of Corona Virus and help the medical practitioners, staff nurses and healthcare workers, etc to offer their treatments in a productive and effective manner to the patients This article investigates and presents the research activities that have been carried out using IoT to handle this pandemic in recent times The society faces many issues in this pandemic situation like maintaining social distance, availing the medical facilities, monitoring and tracking quarantined etc These issues can be addressed through IoT in an efficient manner and helps to serve the society timely and promisingly The various roles played by IoT during this pandemic are shown in Fig. 1 and include

- Timely location of the contamination and analysis the equivalent
- Deterrence of and controlling the spreading of disease
- Tracking the isolated patients
- Contact following of contaminated people
- Assisting medical services laborers
- Supply of meds and clinical types of gear and food things
- Remote observing of patients

Fig.1 Applications of IoT during Covid-19 pandemic.

ROLE OF IOT TECHNOLOGIES AND TOOLS IN COVID-19 PANDEMIC

Here, in this section, we present the attempts put through by the different research communities to tackle Coivd-19 crisis using IoT tools and technologies We also present commercially available IoT products to handle the crisis Covid-19 has an unprecedented impact on our society and economy The impact of this pandemic accelerated the adoption of many digital technologies nowadays Allied with other technologies like AI, Big data, Cloud etc, IoT, in particular, is of great use during this catastrophe The role of IoT in healthcare is unimaginable Let's review the articles which illustrated how IoT is being used to monitor the pandemic [11] cited that quality of service to human beings can be very well enhanced by IoT The authors quoted that IoT can very well handle the issues in drug delivery The use of IoT in drug delivery helps to mitigate the spreading of disease especially, during the purchase of drug and in turn, helps to save the physical and human resources The authors of [8] addressed the problems faced by orthopaedic patients in this pandemic such as availing the medical facilities, purchase of medicine etc Internet of Medical Things (IoMT) can resolve these issues and helps the orthopaedic patients living in remote

locations where it is difficult to extend the medical facilities [7] carried out a review of the technologies of Industrial IoT and their potential applications in the Covid-19 pandemic In addition, the authors also enumerated the significant technologies of Industry 40 namely IoT, AI, Big data, VR etc that help in Covid-19 crisis Telemedicine services to prevent and control the virus, prediction of outbreak and minimising or even stalling the spread of the virus, using drones for surveillance to ensure the execution of quarantine and mask-wearing etc are some of the issues that are mentioned in this attempt The main applications of IoT in Covid-19 crisis including Internet-connected hospital, tele-health consultation, rapid screening, smart tracking of infected persons, forecasting of virus etc are presented by[5] This work also summarised issues and challenges to be faced while implementing IoT for Covid-19 In the attempt [4], Cognitive Radio (CR) based IoT is utilized to mitigate the Covid-19 crisis This work helps to keep every person to be connected and monitored The various applications identified by [4] include real-time tracking, remote monitoring of the patients, instant diagnosis, contact tracing, screening and surveillance, prevention and control The security and privacy issues of using CR are also highlighted Chamola et al [3] highlighted the role of IoMT in monitoring patients from a remote location, tracking the order of medical items and usage of wearables to convey the health information to the officials concerned [6] focussed on wearable devices for monitoring the quarantined patients for various parameters like oxygen saturation, respiratory rate, lung sound rate etc , a sensing systems to detect the infection and monitor patients with mild symptoms and telehealth technologies for the remote monitoring and diagnosis of Covid-19. In Fig. 2 and 3 represented how IoT can take a part of health monitoring system during pandemic. The work by [9] described the role of IoT-based technologies in Covid-19 outbreak and reviewed the current IoT-based solutions for combating Covid-19 They segregated the IoT solutions in three main phases namely solutions for early diagnosis, quarantine time, and after recovery for each phase, IoT enabled devices such as IoT buttons, wearables, drones, robots and smart phone applications have also been depicted in Fig. 4.

Fig.2 Pulse meter

Fig.3. Communciation between devices

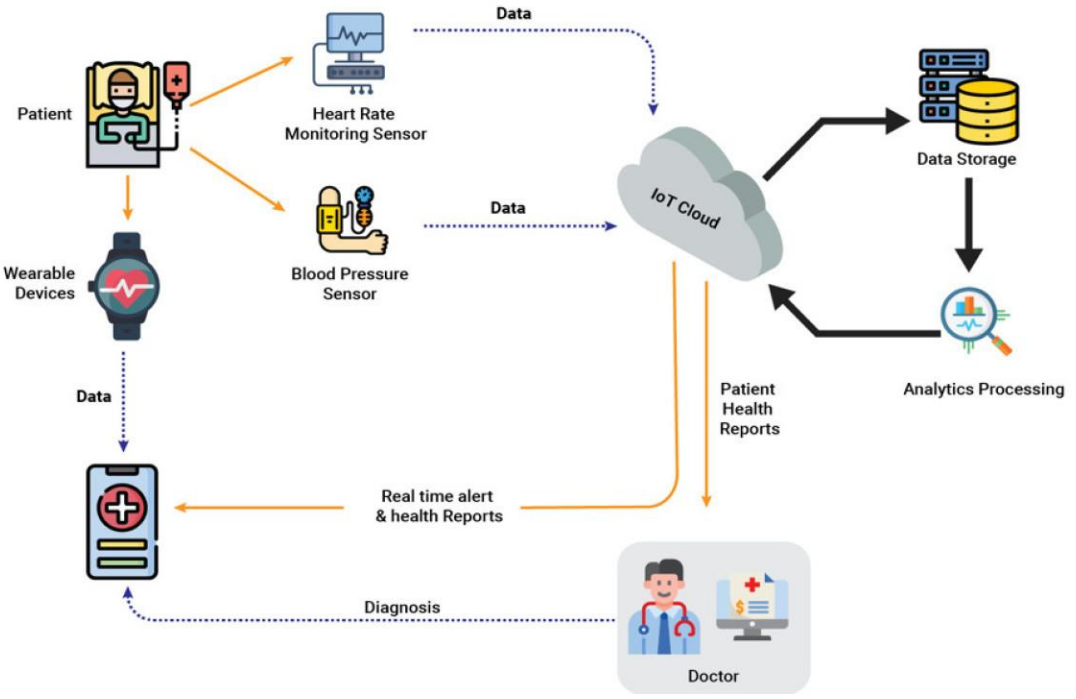

Fig.4. Monitoring Patient

CONCLUSION

Covid-19 is an irresistible illness and a worldwide pandemic. This destructive sickness has set off an unprecedented demand for IoT arrangements and has parted away successful solutions such as early detection of the infection and diagnosis of the infection, monitoring the treatment and quarantined persons, contact tracing, estimate of rate of cases and mortality, assisting the healthcare workers etc The applications of IoT to fight against this global pandemic can be extended to several sectors like healthcare, logistics etc which play a key role in reducing the risk of corona virus outbreak In this study, we have reviewed the articles that investigated the role of IoT in this crisis and presented how they helped.

Furthermore, we have additionally distinguished a couple of examination issues subsequent to checking on the new endeavors which incorporate guaranteeing exactness, security and pantomime and classification of the information created by IoT gadgets to sum up, while the world keeps on relying upon customary medical care measures for tending to the Covid-19 pandemic, however in 2021, there is currently an expansive scope of IoT instruments and advancements that can be utilized to further develop the current general wellbeing situation.

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A STUDY TO UNDERSTAND THE EFFECT OF DIGITAL RECRUITMENT IN IT SECTOR – REFERENCE TO CHENNAI

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ABSTRACT

Digitalization provides new techniques by means of digital technologies to change a business model. It helps in improving processes by maximum utilisation of digital technologies and digitised data. Every business today is in the process of implementing digitalisation in all departments. Considering the COVID-19 pandemic, digitalisation has taken a quantum leap in all businesses. This digital transformation helps the companies to stay competitive, relevant and successful. Recruiters have also adopted digitalisation in their process and are actually looking to hold on to the advantages of digital hiring process which has helped them to stay alive in the market during this pandemic. The objective of this paper is to understand the effect of digitalisation in Recruitment process in IT sector. The research was conducted on the basis of a structured questionnaire survey. The research sample included respondents who are HR professional from IT sector to examine the companies approach towards digitalisation and understand the advantages and disadvantages of digital recruitment.

Keywords: *COVID-19 Pandemic, Digitalization, IT sector, Recruitment, Technology*

INTRODUCTION

Recognizing recruitment as a strategic issue resulted in a rise in recruitment-related research at both the organisational and industry levels. For the purpose of attracting outstanding individuals, many companies have begun to adopt novel recruitment techniques. The development of the Indian IT industry relies heavily on human resources. With the fast changing economic environment, IT firms are hiring not just on the basis of technical skills, but also on the basis of personality traits. Companies demand professionals for recruitment. Attracting and retaining the appropriate people is a tough task for businesses. Online recruitment has surpassed more traditional methods. E-recruitment has become more quick and inexpensive, but does it ensure the uncommon combination of quality and quantity?

A. Digitisation and Digitalisation

"Clearly, the thing that's transforming is not the technology — it's the technology that is transforming you." — Jeanne W. Ross

We are living in a digital world and it is imperative for all businesses to accommodate new technologies to uphold its position in the market. What do you think when you first hear the term Digitalisation and Digitisation? Numbers, data, technology or coding. Many people misinterpret it as the absence of paper. While digitalisation and digital transformation is more than that in the business world and is closely linked to our daily lives, more than we think it is.

Digitisation is conversion of something into a digital design. Digitalisation is the use of digital technology to transform a particular business process. In simple words, digitize is nothing but information whereas digitalise means process. It is the translation of written and verbal communication to electronic messaging that is understood by everyone. And this transformation is achieved only through networking.

In business, digitization helps in manipulating and analysing the information by transforming the printed reports in to a digital format for easy reference. And all business processes involve people, it will be more accurate to say that digitalisation is the reformation of all business deeds around digital technologies that relies more on digital tools.

B. Recruitment

Recruitment is the process of identifying and employing the best-qualified person for a new or current position, both internally and externally. The recruiting process includes analysing a position's requirements, attracting candidates to that job, reviewing and choosing applications, hiring,

and integrating the new employee into the company. Recruitment is all about bringing in the right person to the right position. These individuals not only generate exceptional outcomes, but they also tend to stay with the company for a longer period of time. Even if an organisation has the most advanced technology and the best physical resources, it will struggle to carry out the desired results if it lacks the right people. This is true across the board in terms of business.

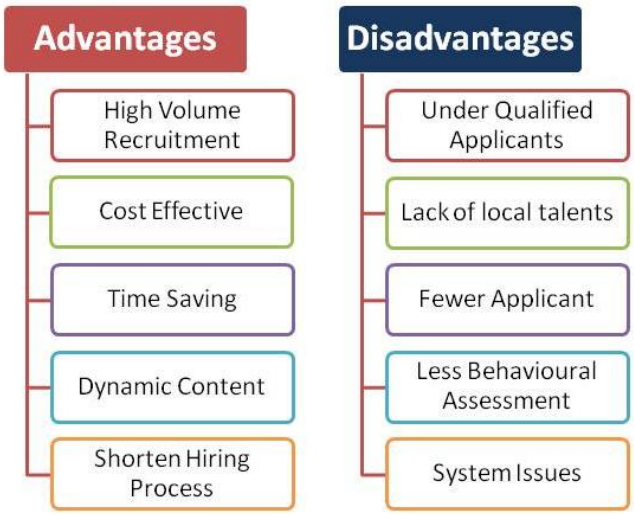
C. Recruitment during COVID-19 Pandemic

The economic impact of the government's shutdown due to coronavirus (COVID-19) pandemic has affected every industry, business and job position. The COVID-19 outbreak has had the most influence on the way we function from a business standpoint. Most recruitment initiatives were slowed or even stopped as a result of the change in how we work. The way the organization operates will continue to change as we adjust to our new reality, and most firms are rethinking how they work and what skills and expertise are required for organisational resilience. Every industry and company will react to the crisis by making decisions depending on their existing circumstances. Regardless of whether you're ready to hire right now or are preparing the next stages, your recruiting team must review their messaging strategy in order to preserve employer brand value (EVP) and engage prospects in the near future.

D. Digital Transformation

The use of dedicated technology to tackle a variety of recruitment difficulties, such as variable and changing hiring demands, increased number of candidates, inability to perform in-person meetings and interviews, and budget cuts, is referred to as digital transformation in recruitment. To do this effectively, being knowledgeable in digital tools and methods is no longer an option for a successful recruiter in today's industry. It's a requirement.

E. FigAdvantages and Disadvantages of Online Recruitment



LITERATURE REVIEW

This section focuses on the various theories that are relevant to our study. Galanaki (2002) did descriptive analysis involving.99 UK IT businesses whose shares were quoted on the London stock exchange in his study on the decision to hire online. A mail questionnaire was used to conduct the survey, which was followed by an interview with 34 companies. According to the author, online recruitment services provide the company with fewer but considerably superior applicants. Dave Bartram (2002) in his study on Internet Recruitment and Selection: Kissing frogs to find princess defines E-recruitment as the process of identifying, attracting, and influencing job candidates via the use of technology and human agents. A research conducted by Linda Barber (2006) on E-Recruitment Developments examined major components of the recruitment journey for those who are considering e-recruitment or who have already shifted their recruitment online. Sudheshna Bhukke and Prof B.Sudhir (2015) identified different practices of recruitment in IT industry. A study conducted by Anushya Yogarajan and Dr.S.N.Soundararajan (2017) on recruitment and selection process with the help of recruiting agency concluded that recruitment should not be lengthy and to find suitable applicants, a clear picture of the necessary candidate should be created to some extent. Danny Hinton and Debbie Stevens-Gill (2016) in their research on Online Psychometric Assessment identified

Psychometrics will continue to improve in the next years as the technology landscape evolves, allowing psychologists to measure the mind in ways that are hard to anticipate and overcoming the limitations of the past.

OBJECTIVES OF THE STUDY

1. To determine how businesses embrace digitalization in the hiring process.
2. To comprehend the benefits and drawbacks of using a digital solution in the recruitment process.
3. To determine whether it aids in determining the applicant's effectiveness.
4. To investigate the future implications and problems of using digitalisation in the recruitment process.

SCOPE OF THE STUDY

The intention of this study is to investigate the effect of digital recruitment in IT companies. The investigation reveals the companies approach towards digital recruitment, the advantages and disadvantages of digital recruitment and how effective is digital recruitment in assessing the behavioural aspect of the applicant?

RESEARCH DESIGN

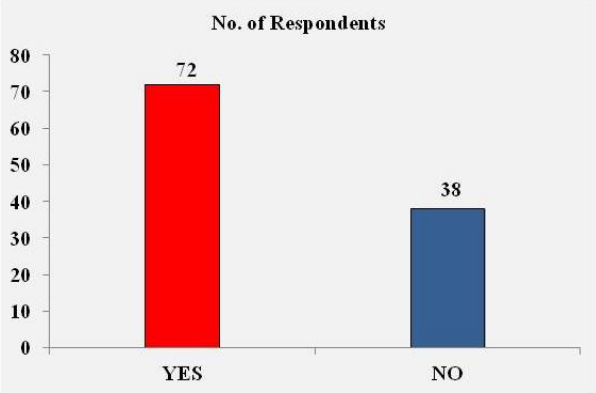
The specification of techniques and procedures for gathering the information needed is characterised as research design. It's a data gathering plan with an organisational framework. The data for the study is gathered from the HR professional of IT companies. Considering the COVID-19 pandemic, Questionnaires were created using Google Forms and distributed to IT company HR professionals. The sample size was 110 as the target audiences are only HR professionals.

DATA ANALYSIS

1. Analysis about the number of companies that has digitalized the recruitment process

TABLE I

PARTICULARS	NO. OF RESPONDENTS
YES	72
NO	38

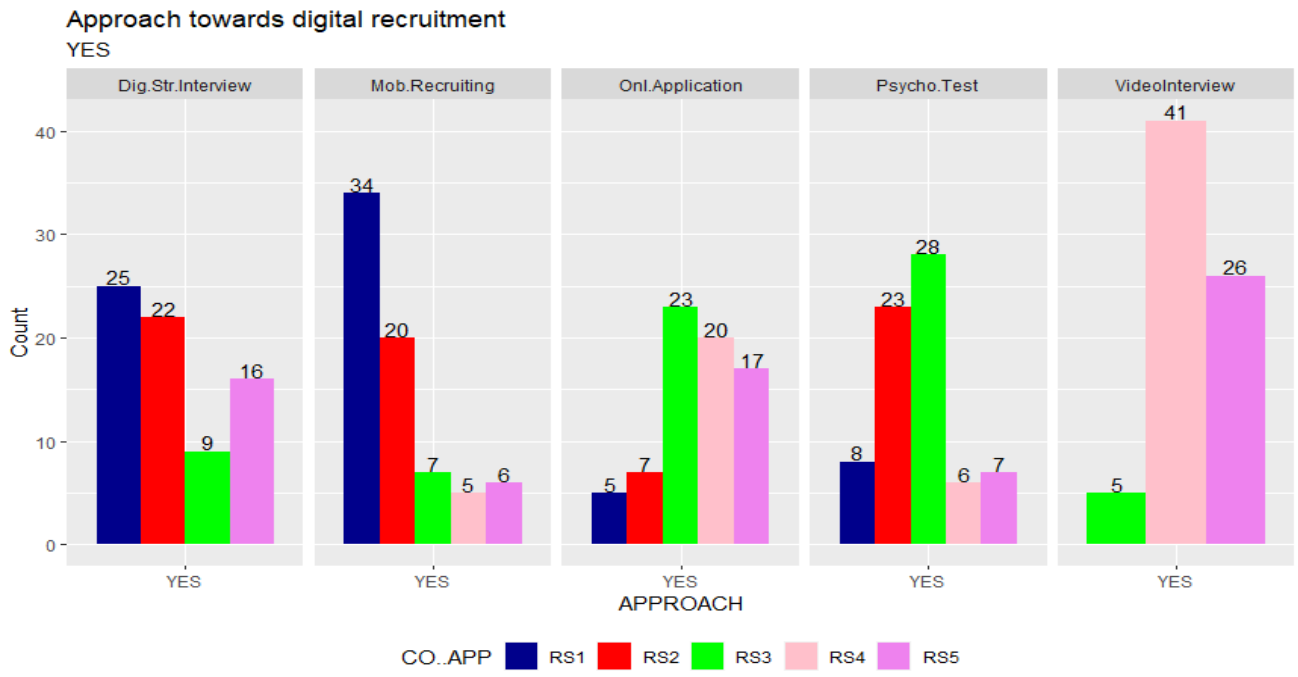


From the above table and graph it is observed that, 72 respondents have said that their company has adopted digitalization in recruitment and 38 respondents have said that their company has still not digitalized their recruitment process completely. Despite the fact that technology is not new to IT firms, a handful has not totally digitalized the recruiting process.

2. Analysis about how companies approach towards digital recruitment

TABLE II

RATING SCALE	ONLINE APPLICATION	PSYCHOMETRIC TEST	MOBILE RECRUITING	DIGITAL STRUCTURE INTERVIEWS	VIDEO INTERVIEWS
5	17	7	6	16	26
4	20	6	5	0	41
3	23	28	7	9	5
2	7	23	20	22	0
1	5	8	34	25	0

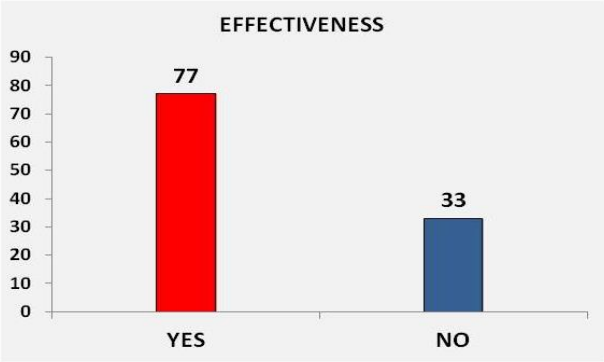


The parameters that I have chosen for analyzing this information are Online Application, Psychometric Test, Mobile Recruitment, Digital Structure Interview and Video Interview. From the above table and graph, it is observed that out of 72 respondents who have adopted digitalization in recruitment process, the most preferred method by the recruiters is Video Interview which is a job interview that takes place over the Internet and employs video technology as the primary mode of communication. And you can see that 26 respondents have rated Video Interview as the highly preferred approach. Next comes Online Application which is the first stage in the digital revolution of recruiting. And 17 respondents feel that it is the second most preferred approach in digital recruitment. 16 respondents prefer Digital Structure Interviews that helps in the storage of data using the technology and reduces the stress which in turn enhances the efficiency of the recruiters. 6 respondents prefer Psychometric Test. This is a tool that actually helps in assessing the aptitude and mental capabilities of a candidate. The most least preferred method of digital recruitment is Mobile Recruitment which is the process of recruiting and hiring people on the go utilising mobile technologies.

3. Analysis to understand the effectiveness of digital recruitment

TABLE III

PARTICULARS	**NO. OF RESPONDENTS**
YES	77
NO	33

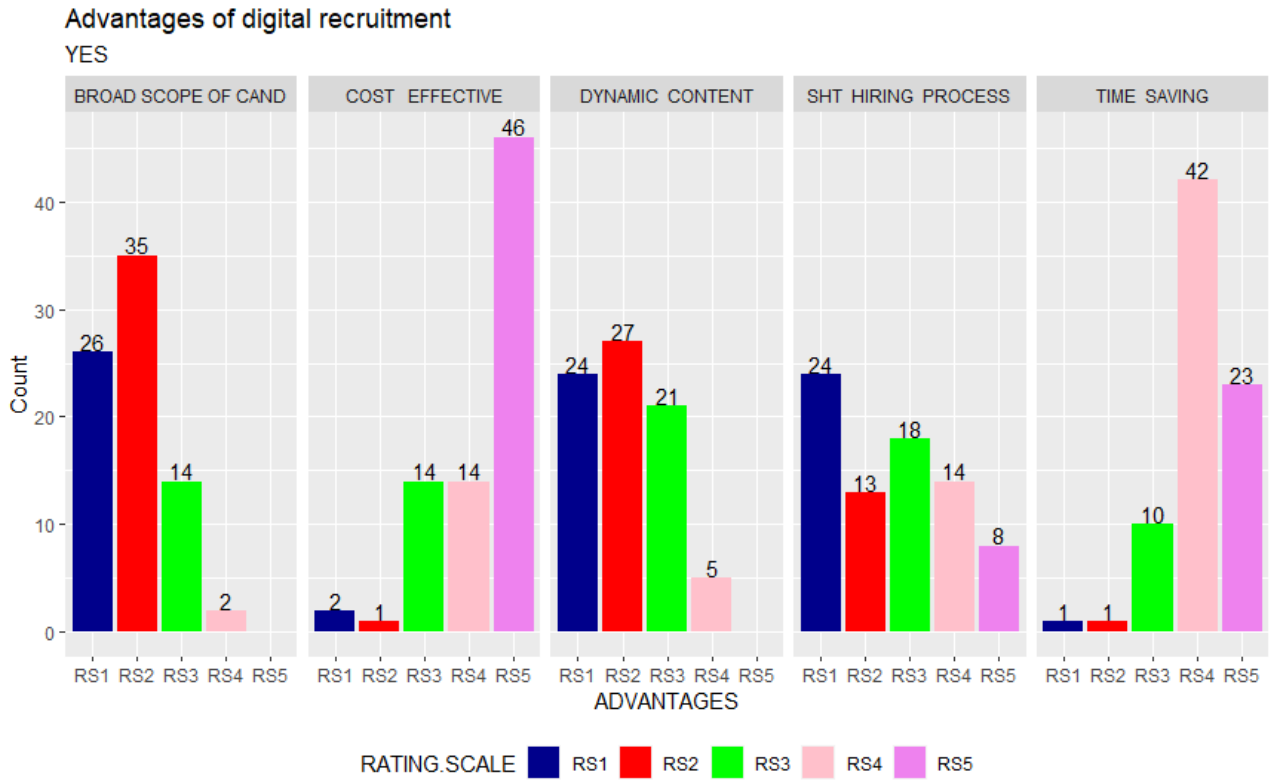


From the above table and graph, it is observed that 77 respondents have said that digital recruitment is effective and 33 respondents feel that it is ineffective. These 33 respondents are those who have not completely digitalised the recruitment process.

4. Analysis about the Advantages of digital recruitment

TABLE IV

Rating Scale	Cost Effective	Time Saving	Broader Scope	Dynamic Content	Shorten Hiring process
5	46	23	0	0	8
4	14	42	2	5	14
3	14	10	14	21	18
2	1	1	35	27	13
1	2	1	26	24	24



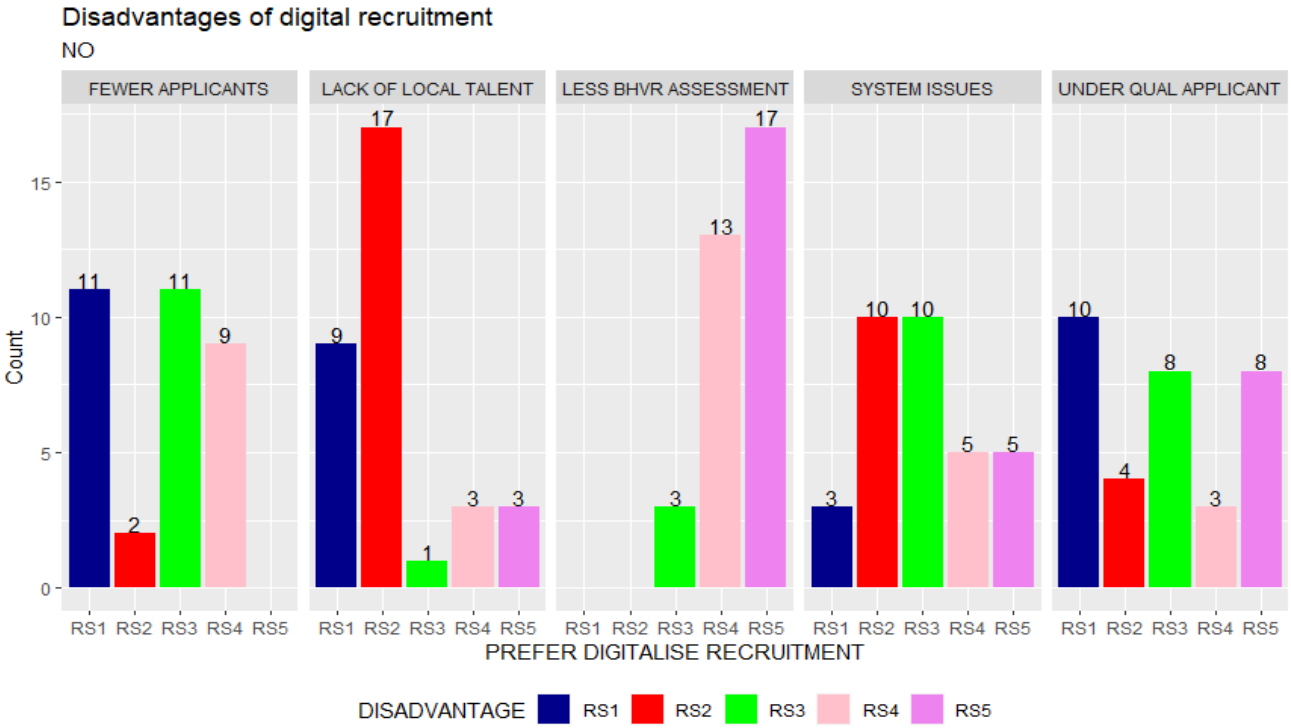
The parameters I have used to access the advantages of digital recruitment are Cost Effective, Time Saving, Dynamic Content, Broader Scope of candidates and Shorten hiring process. According to the table and graph above, 46 out of 77 respondents believe that the most advantageous element of digital recruiting is cost effectiveness as it is far less expensive than traditional methods of recruiting employees. Then there's Time Saving, which 23 out of 77 people believe is the most beneficial aspect of digital recruiting. With Internet access, you can post job openings from anywhere in the world. You don't have to spend time in paperwork and entering data manually. Hence it does saves a lot of time for the recruiters. Dynamic Content and a Broader scope of candidates are the parameters that are least beneficial as it depends upon the company on how they build up their brand to in attracting the top talents.

5. Analysis about the disadvantages of digital recruitment

TABLE V

Rating Scale	Fewer Applicant	Less Behavioural Assessment	Lack of Local Talent	System Issue	Under Qualified Applicant

5	0	16	4	5	8
4	9	13	3	5	3
3	11	3	1	10	8
2	2	0	17	10	4
1	11	0	9	3	10



The parameters I have used to assess the disadvantages of digital recruitment are Less Behavioural Assessment, Fewer applicants, Irrelevant under qualified applicants, System Issues and Lack of local talent. It is observed from the table and graph above that assessing the behavioural traits is a big failure in digital recruitment. 17 of the 33 respondents who felt that digital recruitment is ineffective, ranked the less behavioural assessment on the scale of 5 and 13 respondents have rated it on the scale of 4. As we can also see from TABLE II that Psychometric Test is a tool which actually is used to access the mental ability and aptitude of the applicant is least preferred or it says that not many companies actually use this tool in their recruitment process. Then comes Under Qualified Applicants wherein 8 respondents out of 33 have rated it on the scale of 5. As a result, it has been noted that recruiters are not receiving enough appropriate applications. 17 respondents have said that they have difficulty finding suitable employees in their area. The other parameters, such as fewer applicants and system issues, are seen to be the least detrimental.

FINDINGS

1. The COVID-19 pandemic has hastened the digital transformation of the recruitment function.
2. The fact that technology is not new to IT organisations, there are still few IT companies who have not completely digitalized the recruitment process.
3. Companies have a unique perspective on digital transformation and how to approach it.
4. Though many believe that digital recruiting offers a variety of benefits, such as cost effective, time saving and faster hiring process. Few HR experts still feel it is ineffective when it comes to analyzing behavioural traits.

CONCLUSION

The study is to investigate the effect of digital recruitment in IT sector. The purpose of the study is to look into the hiring processes of companies in the IT business using digital technologies. It's crucial to look at how far these companies have adopted and executed best practices mentioned in the literature. The survey discovered many recruitment strategies in the IT business. Across industries, the pandemic has expedited the digital transformation of the recruitment function. Some organisations in the volume hiring area have embraced digitalization to save money by using technology to help their employees function more efficiently rather than growing their HR workforce. Why is there a need for digital transformation in large-scale hiring? This change from one firm to the next. And it's certain that after experiencing the advantages of working from home and handling almost all of their problems and requests online, neither customers nor workers want to go back to the old ways of doing business. This is also true when it comes to recruitment However, we can observe that everyone has a distinct understanding and approach to digital transformation. For volume recruiting, some firms have begun to use resume-parsing software and pre-employment exams, and called it "digital transformation." Others stated they "went digital" by moving their interviews online and allowing their HR employees to work from home. As far as recruitment is concerned, digital transformation is a wide and nebulous term with no defined direction. The COVID-19 pandemic forced recruiters in the volume recruiting market to reassess their business models and digital transformation plans, emphasizing technology expenditures to alleviate recruitment bottlenecks. However, in many businesses, digitalization of hiring procedures runs the danger of getting stuck in the middle. To avoid this, businesses must rethink their recruiting tactics and allow technology to transform their hiring procedures from beginning to end, moving from “doing” digital to “being” a fully digital team capable of addressing not just the advantages but also the disadvantages.

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A STUDY ON SERVICE QUALITY PERCEPTION OF CUSTOMERS TOWARDS FOOD DELIVERY APP IN COIMBATORE CITY

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ABSTRACT

In a decade of advanced technological era, a greater number of people have used food delivery applications which have broken into the conventional practices and have offered a convenient solution to a problem of busy work schedule not letting people go out for getting a delicious food. The requirement of these apps increases day-by-day and largely driven by millennials. So, the research is necessary to examine the customers perception towards the services offered by the food delivery apps particularly in Coimbatore city. For this, the researchers have selected 140 customers who have used various food delivery apps at least minimum of 6 months. A structured questionnaire has been framed and collected the opinion of the customers through direct and through online by using google forms. The population is unknown and so the respondents could identify through food delivery people. The collected details were subdued into tables and graphs by using SPSS 22.0 and MS-Excel. For examining the relationship of the selected variables, a hypothesis has been framed and tested by using Anova analysis and correlation analysis. Also, percentage analysis and mean score analysis have been used. The research found that most of the respondents have experienced the better perception towards food delivery apps who belong to above 50 years age category, female customers, businessmen, using Swiggy App, using app for 1-3 times in a week and expensing Rs.3001-5000 monthly through food delivery app.

Keywords: *Service Quality Perception, Food Delivery App, Online Food Ordering, Online Ordering System.*

INTRODUCTION

The recent development of the internet in India, it has augmented the e-commerce industries. E-commerce development has made online food ordering services seamless for people who want to get food delivered at their doorstep. Although consumers continue to go out for the meals, consumers feel very convenient to order food online since it frees the customer from personally visiting the restaurants. In today's world service sector contributes 64.80% in GDP. Zomato, Swiggy, Ubar Eats, etc., are the most popular applications that provide services to the user to discover restaurants. The rise of digital technology is reshaping the industries. With the increased use of technology, the number of people engaging into the digital sector are rapidly increasing. Even Consumers are accustomed to shopping or even ordering online through apps or websites, with maximum convenience and transparency, expecting the same experience that they would get from the outlet itself. To match up with the consumer's expectations apps are providing increased facilities and services to the customers. This scenario doesn't exist only in one country but all across the globe. Being up to date with the customers' expectations helps firm retain customers to a greater extent.

REVIEW OF LITERATURE

In this research, the researchers are coated solely some relevant studies for reviewing the past literature.

According to Aditya Tribhuvan (2020) showed that a most of people use food apps as it's the best way to save time and convenient. Also, the most of participants preferred food app was Swiggy and cash on delivery was the safest and most secure form of payment. Moreover, the results obtained that all age and income groups used food apps and they were happy with the service quality, hygiene and packaging system, which made people order from food apps. The author Merry Borgohain (2019) indicated that the main influencing factors of highest respondent were found to be ease and convenience of using the food applications and ordering food sitting at home followed by the influencing factor to be time saving. In

addition, the most preferred mode of payment as Cash on delivery while the issues faced by the respondents while ordering food through applications was mostly regarding non-availability of food items/dishes they wish for. They confirmed that the overall satisfaction regarding services of the food application were responded as they were satisfied with the service provided followed by neutral responds too. Result from Gawande et al. (2019) explored that online food ordering system was new method and many of the users specifically above 40 years of age were not familiar with the ease of ordering food online. Further, mostly students preferred to order food online instead of going out for lunch and they felt ease of placing orders and time efficiency as main reason to prefer it. The study of Aparna Anib et al. (2019) divulged that there was significant relationship between usage and satisfaction of services of Swiggy, there was significant relationship between usage and preference over other food ordering apps. Also, there was no association between age and frequent usage of Swiggy app whereas there was no association between gender and convenience of Swiggy app.

The researcher Ardhana M Prabhash (2020) found in this attempt that most youngsters were well aware about online services on online food delivery system. Also, the most influencing factor was offers provided by online food apps and fast food was fancied by most respondents in their choice of cuisines. Moreover, the results indicated that a major proportion of respondents utilized Swiggy and least uses Potafo. In case of Jeganathan Gomathi Sankar and Naveenkumar (2020) noted that the main concerns of the customers were the safe food delivery and customer safety in this pandemic condition. Thus, factor affecting customer perception in online food delivery were delivery problem, preventive and secure, safety service. It was observed that safety service factors were major influenced the customer perception at the time of covid among the factors. The research from Mehathab sheriff and Shaik Mohamed (2019) assessed those youngsters were mostly poised to use online food ordering services and also price of the product, discounts and special Offers had the most influencing factor on online food ordering. Further, the second most influencing factor was the convenience, followed by On-time Delivery. Moreover, a major proportion of respondents used both Uber Eats and Swiggy to order their food online. The results obtained that there was significant relationship between monthly family income of the respondents and their level of satisfaction towards online food ordering services. It could be observed from Jeneefa and Rajalakshmy (2019) that perceived control and convenience were keys to customer use of online ordering which led to higher satisfaction. Also, young customers were more likely to use online, mobile or text ordering whereas young customers placed a greater value on convenience and speed than older users do. Besides, almost all users felt safe paying online and the Service rendered by the food ordering app was the major factor behind its success.

STATEMENT OF THE PROBLEM

The popularity of online food ordering and delivering services is steadily growing and the expectations of the users are also increasing. In this connection, the perception of the customers about Online Food Ordering and about the services of the Online Food Ordering companies gains significance. In this fast-changing tech landscape, when more and more diners are migrating online, restaurants have realized that if they fail to provide a robust, seamless and efficient online ordering platform, they will quickly be left out of the race. Now-a-days, the customers have faced number of problems while using food delivery apps like selection of restaurants, payment methods, delay in delivery, quality and quantity of food, packaging issues and unpleasant behaviour of delivery persons. Owing to these problems, the customers have faced numerous problems and frequently changed the food delivery app. So, all the food delivery apps companies have not able to maintain loyal customers. Based on the discussion, the researchers have raised a question that how the food delivery apps companies have given proper service to their customers and what extend the customers

have experienced the service quality of the food delivery apps in Coimbatore city. For finding the solution of the questions, the researchers have planned to conduct the study.

OBJECTIVES OF THE STUDY

- To identify the demographic profile and purchase behaviour of the customers of food delivery apps in Coimbatore city.
- To examine the service quality perception of customers towards services offered by the food delivery apps.
- To evaluate the degree of relationship of the service quality of food delivery apps with their customers.

HYPOTHESIS OF THE STUDY

- There is a significant mean difference in perception on service quality of food delivery app with regard to age of the customers.
- There is no significant mean difference in perception on service quality of food delivery app with regard to gender of the customers.
- There is no significant mean difference in perception on service quality of food delivery app with regard to using food delivery app of the customers.
- There is no significant mean difference in perception on service quality of food delivery app with regard to frequency of using food delivery app.
- There is no significant mean difference in perception on service quality of food delivery app with regard to monthly expenses through food delivery app.
- There is no significant mean difference in perception on service quality of food delivery app with regard to mode of payment.
- There is no significant mean difference in perception on service quality of food delivery app with regard to period of using.
- There is a positive association on service quality perception of food delivery app among the selected variables.

RESEARCH METHODOLOGY

In nature, this study is descriptive research design. The researcher has aimed to collect the necessary sample data or immediate survey regarding service quality perception of customers towards food delivery app in Coimbatore city. For this, the researchers have selected 140 customers who have used various food delivery apps at least minimum of 6 months. A structured questionnaire has been framed and collected the opinion of the customers through direct and through online by using google forms. The population is unknown and so the respondents could identify through food delivery people. The structured questionnaire has included customer profile and their service quality perception on food deliver app. This research has been performed in Coimbatore, Tamilnadu. For analysis of this study, the statistical techniques namely percentage analysis, mean score analysis, Standard deviation, Anova and Correlation analysis have been carried out. The details of analysis have been furnished in the following table.

RESULTS AND DISCUSSION

An online food delivery app enables a customer to order their food requirements from any preferred providers located locally through some mobile applications using the internet. The socio-economic profile of the participants has been evaluated in detail in this section and also analysis has been divided into two segments. Further, this section examined that the relationship between the variables viz. age, working department, designation, period of experience and dependent variable influence of transactional leadership on employee performance.

Table 1: Customers' Profile and their Opinion towards Service Quality Perception on Food Delivery App

S.No.	Variables	No. of Respondents	Percentage	Mean Score
	Age (Years)			
1	Below 30	33	23.6	3.84
2	30 – 40	41	29.3	3.86
3	41 – 50	49	35.0	3.52
4	Above 50	17	12.1	3.89
	Total	**140**	**100.0**	
	Gender			
1	Male	89	63.6	3.67
2	Female	51	36.4	3.86
	Total	**140**	**100.0**	
	Occupational Status			
1	Private Employee	28	20.0	3.67
2	Government Employee	41	29.3	3.82
3	Business	44	31.4	3.84
4	Professional	13	9.3	3.54
5	Others (Housewife, Student, Retired, etc.)	14	10.0	3.71
	Total	**140**	**100.0**	
	Using Food Delivery App			
1	Swiggy	7	5.0	3.97
2	Zomato	11	7.9	3.94
3	Ubar Eats	26	18.6	3.78
4	Foodpanda	14	10.0	3.73
5	Domino’s	18	12.9	3.44
6	Pizza Hut	24	17.1	3.87
7	JustEat	15	10.7	3.72
8	Faaso’s	5	3.6	3.30
9	Tasty Khana	12	8.5	3.88
10	Food Mingo	8	5.7	3.46
	Total	**140**	**100.0**	
	Frequency of Using Food Delivery App			
1	1-3 times in a week	42	30.0	3.82
2	1-5 times in a fortnight	57	40.7	3.79
3	1-10 times in a month	25	17.9	3.49
4	Occasionally	16	11.4	3.74
	Total	**140**	**100.0**	
	Monthly Expenses through Food Delivery App			
1	Upto Rs.1000	26	18.6	3.66
2	Rs.1001-3000	33	23.5	3.42
3	Rs.3001-5000	49	35.0	3.89
4	Above Rs.5000	32	22.9	3.90
	Total	**140**	**100.0**	
	Mode of Payment			
1	Credit Card	46	32.9	3.79
2	Debit Card	23	16.4	3.34

S.No.	Variables	No. of Respondents	Percentage	Mean Score
3	Cash on Delivery	15	10.7	3.98
4	Online Payment Channels	56	40.0	3.79
	Total	**140**	**100.0**	
	Period of Using the Food Delivery App			
1	Less than a Year	15	10.7	3.63
2	1-2 Years	35	25.0	3.89
3	2-3 Years	23	16.4	3.77
4	Above 3 Years	67	47.9	3.68
	Total	**140**	**100.0**	

- From the above analysis, it is indicated that 23.6% of the customers belong to below 30 years of age segment, 29.3% of the customers came into age group of 30-40 years, 35.0% of the customers belong to 41-50 years and 12.1% of the customers belong to above 50 years of age group.
- The analysis found that 63.6% of the customers are male and 36.4% of the customers are female.
- From the analysis, it is explored that 20.0% of the customers are private employees, 29.3% of the customers are government employees, 31.4% of the customers are businessmen, 9.3% of the customers are professional and 10.0% of the customers are belong to others like housewives, students, retired persons, etc.
- From the analysis, it is assessed that 5.0% of the customers are using Swiggyapp for food delivery, 7.9% of the customers are utilizing Zomato, 18.6% of the customers as Ubar Eats, 10.0% of the customers as Foodpanda, 12.9% of the customers as Domino's, 17.1% of the customers as Pizza Hut, 10.7% of the customers as JustEat, 3.6% of the customers as Faaso's, 8.5% of the customers as TastyKhana and 5.7% of the customers are utilizing FoodMingo for food deliver.
- It is determined that 30.0% of the customers are using food delivery app for 1-3 times in a week, 40.7% of the customers are utilizing for 1-5 times in a fornight, 17.9% of the customers as 1-10 times in a month and 11.4% of the customers are using food delivery app occasionally.
- It is explored that 18.6% of the customers are expensing upto Rs.1000 monthly through food delivery app, 23.5% of the customers are spending Rs.1001-3000 for food delivery, 35.0% of the customers are expensing Rs.3001-5000 and 22.9% of the customers are spending above Rs.5000 monthly.
- It is surmised that 32.9% of the customers are using credit card for payment of food delivery app, 16.4% of the customers are utilizing debit card, 10.7% of the customers are making payment as cash on delivery and 40.0% of the customers performing online payment channels for payment of food delivery app.

Service Quality Perception of Customers towards Food Delivery App

There are several food delivery apps in India that one can download on customers' smart phone to deliver food services on the go and from the comfort of homes. For this study objective, the researcher has developed ten statements with the help of 5 points Likert's scaling method for collecting the service quality perception of customers towards food delivery app in the study area. The following table has given the mean score and SD of the statements are given.

Table 2: Service Quality Perception of Customers towards Food Delivery App

No.	Statement	Mean	SD

1	The app is user friendly	3.89	1.13
2	Prices of goods are updated	3.78	1.29
3	Prompt acknowledgement to customer's transactions	3.78	1.16
4	App respond to the customer's requests is quick	3.84	1.22
5	It has appropriate design	3.59	1.25
6	It is understood by all types of customers	3.75	1.13
7	The app makescustomers' feel safe and secured	3.39	1.41
8	The information displayed in the app are trust worthy	4.02	1.27
9	The app gets personal attention to their customers	3.83	1.22
10	The app is able to communicate effectively with customers	3.53	1.19

It is indicated from the analysis that the employees opined that the information displayed in the app are trust worthy with the mean score and standard deviation of 4.02 and 1.27 respectively following by the food deliver app is user friendly with the mean score and standard deviation of 3.89 and 1.13 respectively amongst the ten categories of service quality perception.

Relationship between Age and Service Quality Perception on Food Delivery App

H_0 : There is no significant mean difference in perception on service quality of food delivery app with regard to age of the customers.

Table 3: Age and Service Quality Perception on Food Delivery App

	Sum of Squares	df	Mean Square	F	'p' value
Between Groups	3.539	3	1.180	4.120	0.008*
Within Groups	38.937	136	0.286		
Total	42.476	139			

Note: * - Significant at 1% level

It is observed from the table that the null hypothesis is rejected since the 'p' value is lesser than 0.05. Hence, there is a significant mean difference in perception on service quality of food delivery app with regard to age of the customers.

Relationship between Gender and Service Quality Perception on Food Delivery App

H_0 : There is no significant mean difference in perception on service quality of food delivery app with regard to gender of the customers.

Table 4: Gender and Service Quality Perception on Food Delivery App

	Sum of Squares	df	Mean Square	F	'p' value
Between Groups	1.170	1	1.170	3.910	0.050**
Within Groups	41.306	138	0.299		
Total	42.476	139			

Note: * - Significant at 1% level

It is assessed from the table that the null hypothesis is rejected since the 'p' value is lesser than 0.05. Consequently, there is a significant mean difference in perception on service quality of food delivery app with regard to gender of the customers.

Relationship between Using Food Delivery Appand its Service Quality Perception

H_0 : There is no significant mean difference in perception on service quality of food delivery app with regard to using food delivery app of the customers.

Table 5: Using Food Delivery App and its

Service Quality Perception

	Sum of Squares	Df	Mean Square	F	'p' value
Between Groups	4.675	9	0.519	1.786	0.077 NS
Within Groups	37.801	130	0.291		
Total	42.476	139			

Note: * - Significant at 1% level

It is measured from the table that the null hypothesis is accepted since the 'p' value is greater than 0.05. Hence, there is no significant mean difference in perception on service quality of food delivery app with regard to using food delivery app of the customers.

Relationship between Frequency of Using Food Delivery App and its Service Quality Perception

H_0 : There is no significant mean difference in perception on service quality of food delivery app with regard to frequency of using food delivery app.

Table 6: Frequency of Using Food Delivery App and its Service Quality Perception

	Sum of Squares	df	Mean Square	F	'p' value
Between Groups	1.956	3	0.652	2.188	0.092 NS
Within Groups	40.520	136	0.298		
Total	42.476	139			

Note:NS - Not Significant

It is noted from the table that the null hypothesis is accepted because the 'p' value is greater than 0.05. Therefore, there is no significant mean difference in perception on service quality of food delivery app with regard to frequency of using food delivery app by the customers.

Relationship between Monthly Expenses through Food Delivery App and its Service Quality Perception

H_0 : There is no significant mean difference in perception on service quality of food delivery app with regard to monthly expenses through food delivery app.

Table 7: Monthly Expenses through Food Delivery App and its Service Quality Perception

	Sum of Squares	df	Mean Square	F	'p' value
Between Groups	5.372	3	1.791	6.563	0.000 *
Within Groups	37.104	136	0.273		
Total	42.476	139			

Note: * - Significant at 1% level

It is confirmed from the table that the null hypothesis is rejected since the 'p' value is lesser than 0.05. Hence, there is a significant mean difference in perception on service quality of food delivery app with regard to monthly expenses for online food delivery of the customers.

Relationship between Mode of Payment and Service Quality Perception on Food Delivery App

H_0 : There is no significant mean difference in perception on service quality of food delivery app with regard to mode of payment.

Table 8: Mode of Payment and Service Quality Perception on Food Delivery App

	Sum of Squar	df	Mean Square	F	'p' value

	es				
Between Groups	1.261	3	0.420	1.387	0.249 NS
Within Groups	41.215	136	0.303		
Total	42.476	139			

Note: * - Significant at 1% level

It is examined from the table that the null hypothesis is accepted as the 'p' value is greater than 0.05. So, there is no significant mean difference in perception on service quality of food delivery app with regard to mode of payment of the customers.

Relationship between Period of Using the Food Delivery App and Its Service Quality Perception

H_0 : There is no significant mean difference in perception on service quality of food delivery app with regard to period of using.

Table 9: Period of Using the Food Delivery App and Its Service Quality Perception

	Sum of Squares	df	Mean Square	F	'p' value
Between Groups	4.779	3	1.593	5.747	0.001 *
Within Groups	37.697	136	0.277		
Total	42.476	139			

Note: * - Significant at 1% level

From the analysis, it is found that the null hypothesis is rejected since the 'p' value is lesser than 0.05. Consequently, there is no significant mean difference in perception on service quality of food delivery app with regard to period of usingfood delivery app by the customers.

Degree of Relationship between selected variables and Service Quality Perception on Food Delivery App

To examine the relationship between the selected variables and the dependent variable service quality perception on food delivery app with the help of null hypothesis, Correlation analysis has been employed in the following table. For this objective, the variables have been selected namely age, frequency of using food delivery app, monthly expenses through food delivery app and period of using food delivery app.

H_0 : There is a positive association on service quality perception of food delivery app among the selected variables.

Table 10: Degree of Relationship between selected variables and Service Quality Perception on Food Delivery App

No.	Independent Variables	'r' value	'p' value
1	Age	0.413	0.000*
2	Frequency of Using Food Delivery App	-0.131	0.123^{NS}
3	Monthly Expenses through Food Delivery App	0.248	0.003*
4	Period of using Food Delivery App	0.377	0.000*

Note: * - Significant at 1% level; NS - Not Significant

It is revealed from correlation analysis that among the four selected variables, three variables like age, monthly expenses through food delivery app and period of using food delivery app are having positive correlation with the service quality perception on food delivery app. On the other hand, the variable frequency of using food delivery app is not associated with service quality perception on food delivery app in the study area. The analysis concluded that whenever age, monthly expenses through food delivery app and period of using food delivery app increases their service quality perception on food delivery app also positively increases.

FINDINGS

- It observed from the analysis that majority of the customers are belong to age group of 41-50 years. In addition, high level of service quality perception on food delivery app is perceived by the customers came into above 50 years age category.
- It is showed from the analysis that most of the respondents are male customers. Also, maximum level of service quality perception on food delivery app is perceived by female customers.
- From the analysis, it is determined that most of the customers are businessmen. Moreover, maximum level of service quality perception on food delivery app is perceived by businessmen.
- It is inferred that most of the customers are using Ubar Eats app for food deliver. Further, high level of service quality perception on food delivery app is perceived by customers using Swiggy.
- The analysis found that majority of the customers are utilizing food delivery app for 1-5 times in a fortnight. Also, maximum level of service quality perception on food delivery app is perceived by customers who utilizing food delivery app for 1-3 times in a week.
- From the analysis, it is divulged that most of the customers are spending Rs.3001-5000 monthly through food delivery app. Further, high level of service quality perception on food delivery app is perceived by customers who expensing Rs.3001-5000 monthly for food delivery.
- From the analysis, it is found that most of the customers are using online payment channels for online food delivery. In addition, high level of service quality perception on food delivery app is perceived by customers who making payment as cash on delivery for food delivery.
- It is examined from the mean score analysis that the employees opined that the information displayed in the app are trust worthy with the mean score of 4.02 followed by the food deliver app is user friendly with the mean score of 3.89.
- It is found from Anova that there is a significant mean difference in perception on service quality of food delivery app with regard to age of the customers.
- The Anova analysis observed that there is a significant mean difference in perception on service quality of food delivery app with regard to gender of the customers.
- From the Anova, it is explored that there is no significant mean difference in perception on service quality of food delivery app with regard to using food delivery app of the customers.
- It is divulged from Anova that there is no significant mean difference in perception on service quality of food delivery app with regard to frequency of using food delivery app by the customers.
- The result from Anova that there is a significant mean difference in perception on service quality of food delivery app with regard to monthly expenses through food delivery app of the customers.
- The Anova test showed that there is no significant mean difference in perception on service quality of food delivery app with regard to mode of payment of the customers.
- It is identified from Anova that there is no significant mean difference in perception on service quality of food delivery app with regard to period of using food delivery app by the customers.
- It is confirmed from Correlation analysis that whenever age, monthly expenses through food delivery app and period of using food delivery app increases their service quality perception on food delivery app also positively increases.

SUGGESTIONS

- It could be noted that high level of service quality perception on food delivery app is perceived by the customers came into above 50 years age category. So, the restaurant should

perform more efficient service personnel to look into the problem of delay in delivery.

- From the study, it is indicated that maximum level of service quality perception on food delivery app is perceived by businessmen. Hence, the food delivery apps should discover the not available locations as even today there are many places that do not have sufficient access to food deliver services.
- This study revealed that high level of service quality perception on food delivery app is perceived by customers using Swiggy because their quality of servicing food in time. So, all online food suppliers should come forward to provide good service but quality & quantity services should be maintained correctly.
- The findings showed that maximum level of service quality perception on food delivery app is perceived by customers who expensing Rs.3001-5000 through food delivery app due to they spend more monthly. Hence, the restaurant should consider the cost of food because reasonable price or low price of food supplied by app will be convenient for all customers to increase the service quality perception.
- The food suppliers though app build a customer helpdesk and service follow up to resolve any issue on side of the customers' service quality perception.

CONCLUSION

This study has aimed to explore the service quality perception of customers towards food delivery app in Coimbatore city. Approach of food delivery has its impact with a wave among the youngers and tremendously increase has been seen in restaurant business with various strategies. From the results, it is confirmed that majority of customers use food delivery apps as it's the best way to save time and is convenient whereas reflect as an essential operation. Among the selected customers, although the most using food deliver app is Ubar Eats app, high level of service quality perception on food delivery is perceived through Swiggy because safest and delivery of food in time. This study focused has given an overview of the consumer service quality perception on the food delivery app which has quite positive output. Hence, it is stated that restaurants should focus on giving their customers the best quality and various options on choosing the variety of food stuff more and more customers should be encouraged to order food online through food deliver app.

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DOUBLY ISOLATE ECCENTRIC DOMINATION IN GRAPHS

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ABSTRACT

A subset D of the vertex set V(G) of a graph G is said to be a dominating set if every vertex not in D is adjacent to at least one vertex in D. A dominating set D is said to be an eccentric dominating set if for every $v \in V - D$, there exists at least one eccentric vertex of v in D. The minimum cardinality of an eccentric dominating set is called the eccentric domination number and is denoted by $\gamma_{ed}(G)$. An eccentric dominating set S of G is an isolate eccentric dominating set if the induced subgraph $\langle S \rangle$ has atleast one isolated vertex. The minimum of the cardinality of the isolate eccentric dominating set of G is called the isolate eccentric domination number $\gamma_{oed}(G)$. An isolate eccentric dominating set S is said to be a doubly isolate eccentric dominating set of G if the subgraph $\langle V(G) - S \rangle$ induced by $V(G) - S$ has an isolated vertex. The minimum cardinality of a doubly isolate eccentric domination number is denoted by $\gamma_{ooed}(G)$. In this paper, we initiate the study of doubly isolate eccentric domination number; obtain some bounds for $\gamma_{ooed}(G)$ and exact values of $\gamma_{ooed}(G)$ for some particular classes of graphs. Also, we characterize graphs for which $\gamma_{ooed}(G) = 1, 2$ and $p - 1$.

Keywords: *Domination, Eccentric domination, Isolate Eccentric Domination, Doubly Isolate Eccentric Domination.*
Mathematics Subject Classification: 05C12, 05C69.

Introduction

Let G be a finite, simple, connected and undirected (p, q) graph with vertex set V(G) and edge set E(G). For graph theoretic terminology refer to Harary [13], Buckley and Harary [11]. The concept of domination in graphs was introduced by Ore [16].

The concept of domination in graphs is originated from the chess games theory and that paved the way to the development of the study of various domination parameters and its relation to various other graph parameters. A set $D \subseteq V$ is said to be a dominating set in G if every vertex in $V - D$ is adjacent to some vertex in D. The minimum cardinality of a dominating set is called the domination number and is denoted by $\gamma(G)$. For details on domination theory, refer to Haynes, Hedetniemi, and Slater [14].

Janakiraman, Bhanumathi and Muthammai [15] introduced Eccentric domination in Graphs. Bhanumathi and Muthammai studied some bounds of eccentric domination number and eccentric domination in trees in [3, 4] and Bhanumathi initiated the study of connected eccentric domination in graphs in [2]. Bhanumathi, John Flavia and Kavitha [5] studied the concept of Restrained Eccentric domination in graphs. Bhanumathi and John Flavia studied the concept of Total Eccentric domination in graphs and some results on Eccentric domination in graphs [6, 8]. Bhanumathi and Sudhasenthil [7] studied the concept of the split and Nonsplit Eccentric domination in graphs. Sahul Hamid and Balamurugan [17] studied the concept of Isolate domination in graphs. Benjir H. Arriola [1] studied the concept of doubly isolate domination in graphs. Bhanumathi and Niroja [9] studied the concept of Isolate Eccentric Domination in Graphs. Bhanumathi and Meenal Abirami [10] studied the concept of Upper Eccentric Domination in Graphs.

Definition 1.1: Let G be a graph, and let V be a sub graph of G. For any vertex v in G, the distance d(u, v) from u to v is the shortest distance from u to a vertex v in V.

Definition 1.2: Let G be a connected graph and v be a vertex of G. The eccentricity e(v) of v is the distance to a vertex farthest from v. Thus, $e(v) = \max\{d(u, v) : u \in V\}$. The radius r(G) is the minimum eccentricity of the vertices, whereas the diameter diam(G) = d(G) is the maximum eccentricity. For any connected graph G, $r(G) \leq diam(G) \leq 2r(G)$. The vertex v is a central vertex if e(v) = r(G). The center C(G) is the set of all central vertices. For a vertex v, each vertex at a distance e(v) from v is an eccentric vertex of v. Eccentric set of a

vertex v is defined as $E(v) = \{u \in V(G) / d(u, v) = e(v)\}$.

Definition 1.3 [12, 14]: A set $D \subseteq V$ is said to be a dominating set in G if every vertex in $V - D$ is adjacent to some vertex in D. The minimum cardinality of a dominating set is called the domination number and is denoted by $\gamma(G)$.

Definition 1.4 [17]: A subset $S \subseteq V(G)$ is called an isolate set if the subgraph induced by S has an isolated vertex. This set S is an isolate dominating set if it is both isolate and dominating. The minimum cardinality of an isolate dominating set is called the isolate domination number and is denoted by $\gamma_o(G)$.

Definition 1.5 [15]: A set $D \subseteq V(G)$ is an eccentric dominating set if D is a dominating set of G and for every $v \in V - D$, there exists at least one eccentric vertex of v in D. The minimum cardinality of an eccentric dominating set is called the eccentric domination number and is denoted by $\gamma_{ed}(G)$.

Definition 1.6 [9]: A set $S \subseteq V(G)$ is an isolate eccentric dominating set if S is an eccentric dominating set and also the induced sub graph $\langle S \rangle$ has atleast one isolated vertex. The minimum of the cardinality of the isolate eccentric dominating set of G is called the isolate eccentric domination number $\gamma_{oed}(G)$.

Theorem 1.1 [12]: For any graph G, $\lceil p/(1 + \Delta(G)) \rceil \leq \gamma(G) \leq p - \Delta(G)$.

Theorem 1.2 [15]: (i) $\gamma_{ed}(G) = 1$ if and only if $G = K_p$.

(ii) $\gamma_{ed}(P_p) = \lceil p/3 \rceil$ if $p = 3k + 1$

$\gamma_{ed}(P_p) = \lceil p/3 \rceil + 1$ if $p = 3k$ or $3k + 2$

(iii) $\gamma_{ed}(C_p) = p/2$ if p is even.

$\gamma_{ed}(C_p) = \lceil p/3 \rceil$ or $\lceil p/3 \rceil + 1$ if p is odd.

(iv) If G is a two self-centered graph, then $\gamma_{ed}(G) = 2$ if and only if G has a dominating edge which is not in a triangle.

(v) If G is a graph with radius two and diameter three then $\gamma_{ed}(G) = 2$ if and only if G has a γ-set $D = \{u, v\}$ of cardinality two with $d\{u, v\} = 3$ and for any u-v path uxyv in G, $e(u) = e(v) = 3$ and $e(x) = e(y) = 2$.

Theorem 1.3 [17]: (i) $\gamma_o(P_p) = \lceil p/3 \rceil$.

(ii) $\gamma_o(C_p) = \lceil p/3 \rceil$.

Theorem 1.4 [9]: (i) $\gamma_{oed}(K_p) = 1$.

(ii) $\gamma_{oed}(K_{1,p}) = p$.

(iii) $\gamma_{oed}(P_p) = \lceil p/3 \rceil$ if $p = 3k + 1$.

$\gamma_{oed}(P_p) = \lceil p/3 \rceil + 1$ if $p = 3k$ or $3k + 2$.

(iv) $\gamma_{oed}(C_p) = p/2$ if p is even.

$\gamma_{oed}(C_p) = \lceil p/3 \rceil$ or $\lceil p/3 \rceil + 1$ if p is odd.

(v) $\gamma_{oed}(P_p \circ K_1) = p$.

(vi) $\gamma_{oed}(C_p \circ K_1) = p$.

Doubly Isolate Eccentric Domination in Graphs

Now, we define doubly isolate eccentric dominating set of a connected graph as follows:

An isolate eccentric dominating set S is said to be a doubly isolate eccentric dominating set of G if S is an isolate eccentric dominating set and also the subgraph $\langle V(G) - S \rangle$ induced by $V(G) - S$ has an isolated vertex. The minimum cardinality of a doubly isolate eccentric domination number is denoted by $\gamma_{ooed}(G)$.

Obviously, $\gamma(G) \leq \gamma_o(G) \leq \gamma_{oed}(G) \leq \gamma_{ooed}(G)$ and $\gamma_{ed}(G) \leq \gamma_{ooed}(G)$.

Also, $1 \leq \gamma_{ooed}(G) \leq p - 1$, when G is connected. The bounds are sharp, since $\gamma_{ooed}(G) = 1$ for $G = K_2$, $\gamma_{ooed}(G) = p - 1$ for $G = P_4$ or G is a unicentral graph of diameter two with a pendant vertex.

Example 2.1:

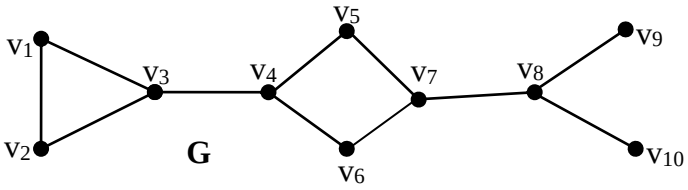

Figure 2.1

In Figure 2.1, $S_1 = \{v_3, v_7, v_8\}$ is a minimum dominating set of G. It is also a minimum isolate dominating set of G. $\gamma(G) = \gamma_o(G) = 3$. $S_2 = \{v_1, v_4, v_8, v_9\}$ is a minimum eccentric dominating set of G and is a minimum isolate eccentric dominating set of G. It is also a minimum doubly isolate eccentric dominating set of G. $\gamma_{ed}(G) = \gamma_{oed}(G) = \gamma_{ooed}(G) = 4$.

Example 2.2:

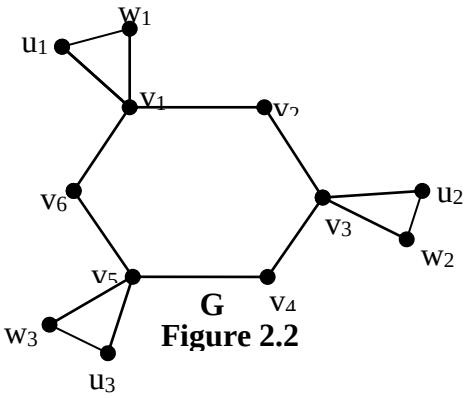

Figure 2.2

In Figure 2.2, $S_1 = \{v_1, v_3, v_5\}$ is a minimum

dominating set of G. It is also a minimum isolate dominating set of G. $\gamma(G) = \gamma_o(G) = 3$.
$S_2 = \{u_1, u_2, u_3, v_2, v_4, v_6\}$ is a minimum eccentric dominating set of G and is a minimum isolate eccentric dominating set of G. $\gamma_{ed}(G) = \gamma_{oed}(G) = 6$.
$S_3 = \{u_1, u_2, u_3, v_2, v_4, v_6, w_1\}$ is a minimum doubly isolate eccentric dominating set of G and $\gamma_{ooed}(G) = 7$.

Remark 2.1: Let G be a connected graph with $p \geq 3$. The doubly isolate eccentric dominating set does not exist for the following graphs.

(i) Complete graph.
(ii) Complete bi-partite graph.
(iii) Wheel graph.
(iv) Fan graph.
(v) r(G) = 1 and diam(G) = 2 with more than one central vertex.

Remark 2.2: $\gamma_{ooed}(G) = 1$ if and only if $G = K_2$.

Theorem 2.1: If a graph G has a pendant vertex then G has a doubly isolate eccentric dominating set.

Proof: Let u be a pendant vertex and w be a support vertex of u in G. Then D = V(G) – {w} is a doubly isolate eccentric dominating set of G.

Remark 2.3: The converse of Theorem 2.1 need not be true.

Example 2.3:

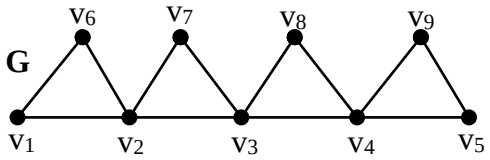

Figure 2.3

In Figure 2.3, S = $\{v_1, v_2, v_3, v_5\}$ is a minimum doubly isolate eccentric dominating set of G, and $\gamma_{ooed}(G) = 4$. G has a doubly isolate eccentric dominating set. But G has no pendant vertices.

Theorem 2.2: Let G be a graph with radius one and diameter two. Then G has a doubly isolate eccentric dominating set if and only if G has a unique central vertex and a pendant vertex.

Proof: Let D be a doubly isolate eccentric dominating set of G. Then $\langle D \rangle$ and $\langle V - D \rangle$ contain isolated vertices and D is an eccentric dominating set of G. Let $u \in D$ be isolated in $\langle D \rangle$ and $v \in V - D$ be isolated in $\langle V - D \rangle$. D contains an isolated vertex, which implies that D has no central vertex. This implies that central vertices are in V – D. Hence, if V – D has more than one central vertex then $\langle V - D \rangle$ has no isolated vertex. Thus V – D must contain exactly one vertex which is a central vertex. Therefore, G has a unique central vertex v.

Now, u in D is isolated in $\langle D \rangle$ implies that u is adjacent to v and u is not adjacent to any other vertex of eccentricity two, V – D = {v} and D = V – {v}. Thus, u must be a pendant vertex in G.

On the other hand, let u be the central vertex and w be the pendant vertex of G. Then S = V(G) – {u} is a doubly isolate eccentric dominating set of G.

Example 2.4:

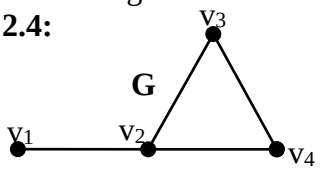

Figure 2.4

In Figure 2.4, S = $\{v_1, v_3, v_4\}$ is a minimum doubly isolate eccentric dominating set of G. $\gamma_{ooed}(G) = 3$.

Corollary 2.1: Let G be a graph with radius one and diameter two having a doubly isolate eccentric dominating set. Then $\gamma_{ooed}(G) = p - 1$.

Theorem 2.3: Let G be a two self-centered graph. Then G has a doubly isolate eccentric dominating set if and only if there exists $w \in V(G)$ such that $\langle N_1(w) \rangle$ has an isolated vertex and every vertex in $N_1(w) = N(w)$ has atleast one non-adjacent vertex in $N_2(w)$.

Proof: Let $w \in V(G)$ such that every vertex in $N_1(w)$ has atleast one non-adjacent vertex in $N_2(w)$. The vertex w and $N_2(w)$ dominate all other vertices of G. In this case, $D = N_2(w) \cup \{w\}$ is a doubly isolate eccentric dominating set, since every vertex in N(w) has eccentric vertex in $N_2(w)$, w is isolated in D and by the given condition $\langle N_1(w) \rangle$ has an isolated vertex.

In this case, $N_2(w) \cup \{w\}$ is a doubly isolate

eccentric dominating set and $\gamma_{ooed}(G) \leq p - \delta(G) + 1$.

On the other hand, clearly, $D = N_2(w) \cup \{w\}$ is an isolate dominating set of G. D is doubly isolate only when $N_1(w)$ has an isolated vertex. Suppose D is an eccentric dominating set of G. In this case, elements of $N_1(w)$ has eccentric vertices in $N_2(w)$ only. Since, G is two self-centered, this implies that every $v \in N_1(w)$ has atleast one non-adjacent vertex in $N_2(w)$.

This proves the theorem.

Example 2.5:

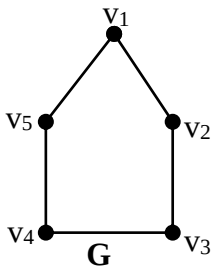

Figure 2.5

In Figure 2.5, $S = \{v_1, v_3, v_4\}$ is a minimum doubly isolate eccentric dominating set of G. $\gamma_{ooed}(G) = 3$.

Example 2.6:

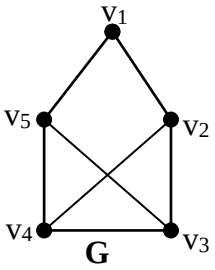

Figure 2.6

In Figure 2.6, $D = N_2(v_1) \cup \{v_1\}$ is a doubly isolate dominating set. But D is not an eccentric dominating set. G has no doubly isolate eccentric dominating set.

Theorem 2.4: If G is a graph with radius two and diameter three and if G has a pendant vertex v of eccentricity three then $\gamma_{ooed}(G) \leq \deg w + 1$, where w is the support of v.

Proof: If G has a pendant vertex v of eccentricity three then its support vertex w is of eccentricity two. Consider N(w). N(w) dominates all the vertices of G and all the vertices of $N_2(w)$ are eccentric to v. The vertex v is eccentric to vertices of $N_2(w)$. Now, $D = N(w) \cup \{v\} \cup \{u\} = N(w) \cup \{u\}$ is a doubly isolate eccentric dominating set, since v is an isolated vertex of $\langle D \rangle$ and w is an isolated vertex of $\langle V - D \rangle$ and the vertex $u \in N_2(w)$ is eccentric to w.

Thus, $\gamma_{ooed}(G) \leq \deg w + 1$.

Example 2.6:

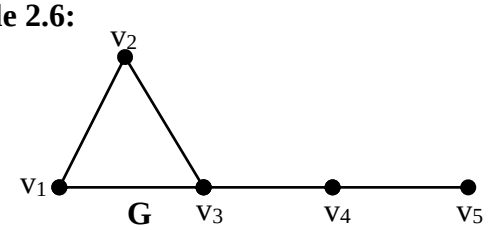

Figure 2.6

In Figure 2.6, $S = \{v_1, v_3, v_5\}$ is a minimum doubly isolate eccentric dominating set of G. $\gamma_{ooed}(G) = 3$.

Theorem 2.5: If G is of radius two with a unique central vertex v such that $\langle N(v) \rangle$ has an isolated vertex, then $\gamma_{ooed}(G) \leq p - \deg v$.

Proof: If G is a graph of radius two with a unique central vertex v then v dominates N[v] and the vertices in V – N[v] dominate themselves and each vertex in N[v] has eccentric vertices in V – N[v] only. Hence, $S = V - N(v)$ is a doubly isolate eccentric dominating set, since v is an isolated vertex of $\langle S \rangle$, $V - S = N(v)$ and by the given condition $\langle N(v) \rangle$ has an isolated vertex.

Thus, $\gamma_{ooed}(G) \leq |V - N(v)|$

$\leq p - \deg v$.

Example 2.7:

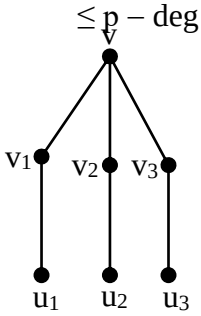

Figure 2.7

In Figure 2.7, $S = \{v_1, u_2, u_3\}$ is a minimum doubly isolate eccentric dominating set of G. $\gamma_{ooed}(G) = 3$.

Corollary 2.2: If T is a unicentral tree of radius two, then $\gamma_{ooed}(G) \leq p - \deg v$, where v is a central vertex.

Corollary 2.3: If G is a graph with radius two and G has a vertex v of eccentricity two such that $\langle N(v) \rangle$ has an isolated vertex then $\gamma_{ooed}(G) \leq p - \deg v$.

Theorem 2.6: If G is a graph of radius greater than two and there exists a vertex v with ⟨N(v)⟩ contains an isolated vertex, then $\gamma_{ooed}(G) \leq p - \deg v$.

Proof: Let v be a vertex of maximum degree k. Then v dominates N[v] and the vertices in S = V – N(v) dominate themselves. Also, since diameter of G is greater than two, each vertex in N(v) has eccentric vertices in V – N(v) only. Hence, S = V – N(v) is an isolate eccentric dominating set, since v is an isolated vertex in⟨S⟩. By the given condition ⟨N(v)⟩ = ⟨V – S⟩ has an isolated vertex.

Thus, $\gamma_{ooed}(G) \leq |S| = |V - N(v)|$
$\leq p - \deg v$.

Example 2.8:

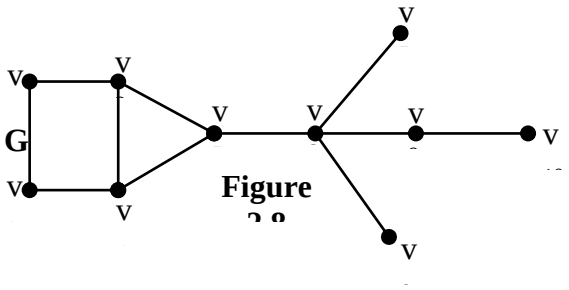

Figure 2.8

In Figure 2.8, S = {v_1, v_2, v_6, v_{10}} is a minimum doubly isolate eccentric dominating set of G. $\gamma_{ooed}(G) = 4$.

For the following results, consider the graphs G for which $\gamma_{ooed}(G)$ exists.

Lemma 2.1: Let G be a graph with radius one and diameter two. Then $\gamma_{ooed}(G) = 2$ if and only if $G = K_{1,2}$.

Proof: By Theorem 2.2, G has unique central vertex and G has a pendant vertex. Let D be a $\gamma_{ooed}(G)$ set with $|D| = 2$. Then $|V - D| = 1$ as in Theorem 2.3 and V – D contains only the central vertex. Hence, $|D| = 2$, D contains an isolated vertex implies that both the vertices of D are isolated and are adjacent to the central vertex. Thus, $G = K_{1,2}$ only.

Lemma 2.2: Let G be a two self-centered graph. Then $\gamma_{ooed}(G) \neq 2$.

Proof: Suppose, $\gamma_{ooed}(G) = 2$. Then $\gamma(G) = \gamma_{ed}(G) = \gamma_{ooed}(G) = 2$, since $\gamma_{ed}(G) \neq 1$ and $\gamma(G) \neq 1$ for G. $\gamma_{ed}(G) = 2$ implies that there is a γ_{ed}-set D = {u, v} such that e = uv is a dominating edge of G which is not in a triangle by Theorem 1.2. But D is doubly isolate implies that u and v are not adjacent in G. Hence, $\gamma_{ooed}(G)$ cannot be two.

Lemma 2.3: Let G be a graph with radius two and diameter three. Then $\gamma_{ooed}(G) \neq 2$.

Proof: Suppose, $\gamma_{ooed}(G) = 2$. Then $\gamma(G) = \gamma_{ed}(G) = \gamma_{ooed}(G) = 2$, since $\gamma_{ed}(G) \neq 1$ and $\gamma(G) \neq 1$ for G. $\gamma_{ed}(G) = 2$ implies that there is a γ_{ed}-set D = {x, y} which is not connected and d(x, y) = 3 by Theorem 1.2. So D contains isolated vertices. But if V – D contains an isolated vertex v then it is adjacent to any one of x or y and is not adjacent to any other vertices. Hence, v is pendant. Let v be adjacent to x. Then e(x) = 3 implies that eccentricity of v is four, which is a contradiction. Hence, $\gamma_{ooed}(G)$ cannot be two.

Lemma 2.4: Let G be a graph of radius greater than two. Then $\gamma_{ooed}(G) \neq 2$.

Proof: It can be proved as in Lemma 2.3.

Theorem 2.7: $\gamma_{ooed}(G) = 2$ if and only if $G = K_{1,2}$.

Proof: Follows from Lemmas 2.1, 2.2, 2.3 and 2.4.

Now, we characterize graphs G for which $\gamma_{ooed}(G) = p - 1$.

Lemma 2.5: Let G be a graph of radius one and diameter two. Then $\gamma_{ooed}(G) = p - 1$ if and only if G has a unique central vertex and a pendant vertex.

Proof: Let D be a doubly isolate eccentric dominating set of G. By Theorem 2.2, G is unicentral and has a pendant vertex. D has an isolate implies that D has no central vertex and ⟨V – D⟩ has isolate vertices. D = E_2, set of all non-central vertices = V – {u}, is a doubly isolate eccentric dominating set

Also, S = D – {x}, where $x \in E_2$, cannot be a doubly isolate dominating set. Since V – S has no isolated vertices. Thus, $\gamma_{ooed}(G) = p - 1$.

Lemma 2.6: Let G be a graph with radius two and diameter three. Then $\gamma_{ooed}(G) = p - 1$ if and only if $G = P_4$.

Proof: Let D be $\gamma_{ooed}(G)$-set of G with $|D| = p - 1$. Let $D = V - \{v\}$. The vertex $v \in V - D$ and is isolated. D is a $\gamma_{ooed}(G)$-set implies that there exists $x \in D$ such that x is isolated in $\langle D \rangle$. Hence x has no neighbour in D. Thus x in G is adjacent to v only. Therefore, deg x = 1 in G. Now, r(G) = 2, diam(G) = 3 and x is a pendant vertex implies that e(x) = 3 and e(v) = 2 in G. The vertex $v \in V - D$, hence, there exists $y \in D$ such that e(y) = 3 and y is eccentric to x and v, xvwy is a path of length three. If there exists a vertex z with e(z) = 3 which is adjacent to w, then w dominates z and x is eccentric to z. Hence, D is not minimal. If e(z) = 2, then w is adjacent to z and x is eccentric to z. Hence, again D is not minimal. If there exists $z \in V$ such that z is adjacent to v and $z \in D$, then $S = V - \{w, z\}$ is a minimum doubly isolate eccentric dominating set. If there exists $z \in V$ such that z is adjacent to both v and w, then also D is not minimum. Hence, $\gamma_{ooed}(G) = p - 1$ only when $G = P_4$.

Lemma 2.7: Let G be a self-centered graph of radius two. Then $\gamma_{ooed}(G)$ cannot be $p - 1$.
Proof: Let G be a 2 self-centered graph. Suppose $\gamma_{ooed}(G) = p - 1$, there exists $D \subseteq V(G)$ such that $D = V - \{v\}$ and D is a γ_{ooed}-set. Now, D is a γ_{ooed}-set implies that there exists $x \in D$ such that x is isolated in $\langle D \rangle$. Hence, x has no neighbour in D. So it is adjacent to v only. This implies that deg x = 1, which is a contradiction to G is self-centered.
Remark 2.4: If G is a connected graph with $\delta(G) \geq 2$, then $\gamma_{ooed}(G) \neq p - 1$.

Lemma 2.8: Let G be a graph with radius > 2, then $\gamma_{ooed}(G) \neq p - 1$.
Proof: Let $D \subseteq V$ be a $\gamma_{ooed}(G)$-set. Suppose there exists a γ_{ooed}-set D such that $|D| = p - 1$. Let $V - D = \{v\}$, vertex v is isolated in $V - D$ and there exists $x \in D$, which is isolated in D implies that v is adjacent to x and x is pendant in G. D contains all vertices except v. Hence, D contains eccentric vertex y of v. Thus, there exists a path of length atleast four. Let xvuwy be such a path. Then we can form a $\gamma_{ooed}(G)$-set leaving u or w also. Hence, $\gamma_{ooed}(G) \neq p - 1$.

Theorem 2.8: If G is a connected graph then $\gamma_{ooed}(G) = p - 1$ if and only if $G = P_4$ or G is a unicentral graph of diameter two with a pendant vertex.
Proof: Follows from Lemmas 2.2 and 2.3.

Theorem 2.9: If $G \neq P_4$ is a connected graph with radius greater than one, then $3 \leq \gamma_{ooed}(G) \leq p - 2$.
Proof: Follows from Theorems 2.7 and 2.8**.**

Doubly Isolate Eccentric Domination in some particular classes of Graphs

The doubly isolate eccentric domination number of some classes of graphs is given in the following theorems.
Theorem 3.1: If G is a wounded spider (not a path), then $\gamma_{ooed}(G) = u + 1$, where u is the number of non-wounded legs.
Proof: Let G be a wounded spider. Let w be a vertex of maximum degree $\Delta(G)$ and U be the set of pendant vertices which are adjacent to vertices of degree two. The set $U \cup \{w\}$ form a minimum doubly isolate eccentric dominating set, where $(V(G) - (U \cup \{w\}))$ has an isolated vertex. Hence, $\gamma_{ooed}(G) = u + 1$, where $|U| = u$.

Theorem 3.2: $\gamma_{ooed}(P_p) = \lceil p/3 \rceil + 1$ if $p > 5$.
Proof: Let $v_1, v_2, v_3, \ldots, v_p$ represent the path P_p.
Case(i): p = 3k, k ≥ 2.

$S = \{v_1, v_4, v_7, \ldots, v_{3k-5}, v_{3k-2}, v_{3k}\}$ is the minimum isolate eccentric dominating set in P_p. $\langle V - S \rangle$ contains isolated vertices. Hence, it is also a doubly isolate eccentric dominating set. Therefore, $\gamma_{ooed}(P_p) \leq \lceil p/3 \rceil + 1$. We have $\gamma_{oed}(G) \leq \gamma_{ooed}(G)$ and hence by Theorem 1.4, $\lceil p/3 \rceil + 1 \leq \gamma_{ooed}(P_p)$.

Thus, $\gamma_{ooed}(P_p) = \gamma_{oed}(P_p) = \lceil p/3 \rceil + 1$.
Case(ii): p = 3k + 1, k ≥ 2.

$S = \{v_1, v_4, v_7, \ldots, v_{3k-2}, v_{3k+1}\}$ is the γ_{oed}-set of P_p. S is not a doubly isolate eccentric dominating set.

$S' = \{v_1, v_4, v_7, \ldots, v_{3k-2}, v_{3k}, v_{3k+1}\} = S \cup \{v_{3k}\}$ or $S \cup \{x\}$ where $x \in V - S$ is a doubly isolate eccentric dominating set. Therefore, $\gamma_{ooed}(P_p) \leq \lceil p/3 \rceil + 1$.

We have $\gamma_{oed}(G) \leq \gamma_{ooed}(G)$ and hence by Theorem 1.4, $\lceil p/3 \rceil \leq \gamma_{ooed}(P_p)$ and there exists no doubly isolate eccentric dominating set with cardinality $\lceil p/3 \rceil$.

Hence, $\gamma_{ooed}(P_p) = \gamma_{oed}(P_p) + 1 = \lceil p/3 \rceil + 1$.

Case(iii): p = 3k + 2, k ≥ 2.

$S = \{v_1, v_4, v_7, \ldots, v_{3k-2}, v_{3k}, v_{3k+2}\}$ is the γ_{oed}-set of P_p. $\langle V - S \rangle$ contains isolated vertices. Hence, it is also a doubly isolate eccentric dominating set. Therefore, $\gamma_{ooed}(P_p) \leq \lceil p/3 \rceil + 1$. We have $\gamma_{oed}(G) \leq \gamma_{ooed}(G)$ and hence by Theorem 1.4, $\lceil p/3 \rceil + 1 \leq \gamma_{ooed}(P_p)$.

Thus, $\gamma_{ooed}(P_p) = \gamma_{oed}(P_p) = \lceil p/3 \rceil + 1$.

Remark 3.1: $\gamma_{ooed}(P_2) = 1$, $\gamma_{ooed}(P_3) = 2$, $\gamma_{ooed}(P_4) = 3$ and $\gamma_{ooed}(P_5) = 3$.

Theorem 3.3: (i) $\gamma_{ooed}(C_p) = p/2$ if p is even.
(ii) $\gamma_{ooed}(C_p) = \lceil p/3 \rceil$ (or) $\lceil p/3 \rceil + 1$ if p is odd.

Proof of (i): If p = 3, any one vertex of C_3 is an isolate eccentric dominating set but does not exists doubly isolate eccentric dominating set.

If p = 4, any two adjacent vertices of C_4 is an eccentric dominating set of C_4 but does not exists an isolate eccentric dominating set in C_4. Hence, does not exists doubly isolate eccentric dominating set in C_4.

Let p = 2k and k > 2.

Let the cycle C_p be $v_1v_2v_3\ldots v_{2k}v_1$. Each vertex of C_p has exactly one eccentric vertex (that is C_p is unique eccentric vertex graph).

Hence, $\gamma_{ooed}(C_p) \geq \gamma_{oed}(C_p) \geq \gamma_{ed}(C_p) \geq p/2$. (1)

Case(i): k-odd.

$S = \{v_1, v_3, \ldots, v_k, v_{k+2}, \ldots, v_{2k-1}\}$ is the γ_{oed}-set of C_p. $\langle V - S \rangle$ contains isolated vertices. Hence, S is also a doubly isolate eccentric dominating set.

Therefore, $\gamma_{ooed}(C_p) \leq p/2$ (2)

From (1) and (2), $\gamma_{ooed}(C_p) = p/2$.

Case(ii): k-even.

$S = \{v_1, v_3, \ldots, v_{k-1}, v_{k+2}, \ldots, v_{2k}\}$ is the γ_{oed}-set of C_p. $\langle V - S \rangle$ contains isolated vertices. Hence, S is also a doubly isolate eccentric dominating set.

Therefore, $\gamma_{ooed}(C_p) \leq p/2$. (3)

From (1) and (3), $\gamma_{ooed}(C_p) = p/2$.

Proof of (ii):

When p is odd, each vertex of C_p has exactly two eccentric vertices. If p = 2k + 1, $v_i \in V(G)$ has v_{i+l}, v_{i+k+1} as eccentric vertices.

Case(i): p = 6m + 1, m ≥ 1.

Also 6m = 2k ⇒ k is a multiple of 6.

$S = \{v_1, v_4, \ldots, v_{k+1}, v_{k+3}, \ldots, v_{2k-1}, v_{2k}\}$ is the γ_{oed}-set of C_p. $\langle V - S \rangle$ contains isolated vertices. Hence, S is also a doubly isolate eccentric dominating set.

Therefore, $\gamma_{ooed}(C_p) \leq \lceil p/3 \rceil$. (4)

By Theorem 1.4, $\lceil p/3 \rceil \leq \gamma_{ooed}(C_p)$. (5)

From (4) and (5), $\gamma_{ooed}(C_p) = \lceil p/3 \rceil$.

Case(ii): p = 6m + 3, m ≥ 1.

p = 6m + 3 = 2k + 1 ⇒ 2k even and 2k = 6m + 2.

$S = \{v_1, v_4, \ldots, v_k, v_{k+3}, \ldots, v_{2k-1}, v_{2k+1}\}$ is the γ_{oed}-set of C_p. $\langle V - S \rangle$ contains isolated vertices. Hence, S is also a doubly isolate eccentric dominating set.

Therefore, $\gamma_{ooed}(C_p) \leq \lceil p/3 \rceil + 1$. (6)

By Theorem 1.4, $\lceil p/3 \rceil + 1 \leq \gamma_{ooed}(C_p)$. (7)

From (6) and (7), $\gamma_{ooed}(C_p) = \lceil p/3 \rceil + 1$.

Case(iii): p = 6m + 5, m ≥ 1.

p = 6m + 5 = 2k + 1 ⇒ 2k even and 2k = 6m + 4.

$S = \{v_1, v_4, \ldots, v_{k-1}, v_k, v_{k+3}, \ldots, v_{2k-2}, v_{2k+1}\}$ is the γ_{oed}-set of C_p. $\langle V - S \rangle$ contains isolated vertices. Hence, S is also a doubly isolate eccentric dominating set.

Therefore, $\gamma_{ooed}(C_p) \leq \lceil p/3 \rceil + 1$. (8)

By Theorem 1.4, $\lceil p/3 \rceil + 1 \leq \gamma_{ooed}(C_p)$. (9)

From (8) and (9), $\gamma_{ooed}(C_p) = \lceil p/3 \rceil + 1$.

Remark 3.2: $\gamma_{ooed}(C_5) = 3$.

Theorem 3.4: If $P_n \circ K_1$ is a path corona, then $\gamma_{ooed}(P_n \circ K_1) = n$, where 2n = p.

Proof: Let $A = \{v_1, v_2, v_3, \ldots, v_n\}$ be the set of vertices of P_n and $B = \{w_1, w_2, w_3, \ldots, w_n\}$be the set of pendant vertices attached at v_1, v_2, v_3, …, v_n respectively.

$S = \{w_1, v_2, v_3, \ldots, v_{n-1}, w_n\}$is the minimum isolate eccentric dominating set of $P_n \circ K_1$. $\langle V - S \rangle$ contains isolated vertices. Hence, S is also a doubly isolate eccentric dominating set.

Therefore, $\gamma_{ooed}(P_n \circ K_1) = n$, where $2n = p$.

Remark 3.3: $\gamma_{ooed}(P_2 \circ K_1) = 3$.

Theorem 3.5: If $C_n \circ K_1$ is a cycle corona, then $\gamma_{ooed}(C_n \circ K_1) = n$, where $2n = p$.

Proof: Let $A = \{v_1, v_2, v_3, \ldots, v_n\}$ be the set of vertices of C_n and $B = \{w_1, w_2, w_3, \ldots, w_n\}$be the set of pendant vertices attached at $v_1, v_2, v_3, \ldots, v_n$ respectively. $S = \{w_1, w_2, w_3, \ldots, w_{n-1}, v_n\}$is the minimum isolate eccentric dominating set of $C_n \circ K_1$. $\langle V - S \rangle$ contains isolated vertices. Hence, S is also a doubly isolate eccentric dominating set.

Therefore, $\gamma_{ooed}(C_n \circ K_1) = n$, where $2n = p$.

Conclusion

Here, we have initiated the study of doubly isolate eccentric domination in graphs. We have studied existence of doubly isolate eccentric domination in graphs, doubly isolate eccentric domination number in some families of graphs and also found out some bounds for doubly isolate eccentric domination number of a graph. Also, we have characterized graphs for which $\gamma_{ooed}(G) = 1, 2$ and $p - 1$.

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ECCENTRICITY T-INDEX OF SOME POLYHEX NANOTUBES

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ABSTRACT

In this paper, we define two new topological indices namely eccentric connectivity T-indices and multiplicative eccentric connectivity T-indices; compute Eccentricity T-Indices and eccentric connectivity T-indices of Armchair polyhex nanotubes and Zigzag polyhex nanotubes.

Keyword: *Eccentricity T-Indices, Total graph, polyhex nanotubes.*

Introduction

Let G be a simple, finite graph with n vertices and m edges with vertex set V(G) and edge set E(G). The edge connecting the vertices u and v ∈ V(G) is denoted by e = uv. The vertices and edges of a graph are called elements of G. For graph theoretic terminology refer to Harary[3].

Let G be a connected graph and v be a vertex of G. The distance d(u, v) between two vertices u and v in G is the minimum length of a path joining them if any; otherwise d(u, v) = ∞. The eccentricity e(v) of v is the distance to a vertex farthest from v. Thus, e(v) = max{d(u, v); u ∈ V}. The radius r(G) is the minimum eccentricity of the vertices, whereas the diameter diam(G) is the maximum eccentricity.

The Total graph T(G) of G is the graph whose vertex set is V = V(G) ∪ E(G) where two elements are adjacent if and only if they are adjacent vertices of G or they are adjacent edges of G or one is a vertex of G and another is an edge of G incident with it. Elements of V which are in V(G) are known as point vertices and are in E(G) are known as line vertices. Let $e_{T(G)}(u) = e_T(u)$ and $e_{T(G)}(e) = e_T(e)$ denote the eccentricity of point vertex u and line vertex e in T(G) respectively.

In chemical graph theory, various topological indices were introduced to study the properties of chemical structures. The topological indices are one of the mathematical models that can be defined by assigning a real number to the chemical molecule and used as a descriptor of the molecule under study. The physical-chemical characteristics of molecules can be analyzed by taking benefit from the topological indices.

In 2020, Bhanumathi and Thusleem Furjana, introduced the first, second and third eccentricity T-indices [2] and they were defined as

$$ET_1(G) = \sum_{v\in V(G)} e_T(v)$$

$$ET_2(G) = \sum_{(u,v)\in E(G)} e_T(u)e_T(v)$$

$$ET_3(G) = \sum_{(u,v)\in E(G)} \left(e_T(u) + e_T(v)\right)$$

Similarly, they have defined the multiplicative eccentricity T-indices as

$$ET\Pi_1(G) = \prod_{v\in V(G)} e_T(v)$$

$$ET\Pi_2(G) = \prod_{(u,v)\in E(G)} e_T(u)e_T(v)$$

$$ET\Pi_3(G) = \prod_{(u,v)\in E(G)} \left(e_T(u) + e_T(v)\right)$$

Now, we define the Eccentric connectivity T-index and Multiplicative Eccentric connectivity T-index as follows:

$$ET^c(G) = \sum_{u\in V(G)} d_T(u)e_T(u)$$

$$ET^c(G) = \prod_{u\in V(G} d_T(u)e_T(u)$$

where $d_T(u)$ denote degree of point vertex u in Total graph T(G) of G and $e_T(u)$ denote the eccentricity of point vertex u in Total graph T(G) of G.

Eccentricity T-index of Armchair Polyhex nanotube $TUAC_6(p, q)$

Let $H = TUAC_6(p, q)$ be a armchair polyhex nanotube, where p is the number of hexagons in each row and q is the number of rows in the molecular graph H. The graph

Sl.No	Number of vertices v in H	Eccentricity of point vertices v in T(H), $e_T(v)$	Degree of the point vertices in T(H) $d_T(v)$
1	2p	p + 2q – 1	4
2	2p	p + 2q – 2	6
3	2p	p + 2q – 3	6
----------	--------	----------	-----
q – 1	2p	p + q + 1	6
q	2p	p + q	6
q + 1	2p	p + q	6
q + 2	2p	p + q +1	6
----------	----------	----------	-----
q + 1 + q – 2	2p	p + 2q – 2	6
q + 1 + q – 1 = 2q	2p	p + 2q – 1	4

$TUAC_6(p, q)$ has 4pq vertices and 6pq – 2q edges.

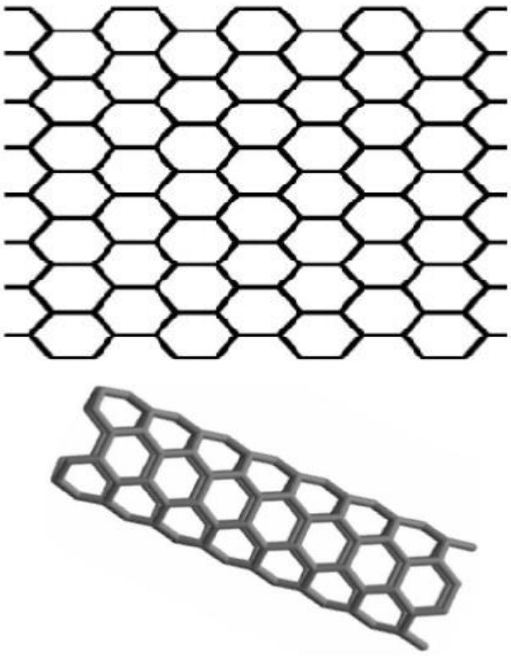
First, we evaluate the number of edges e = uv in H = $TUAC_6(p, q)$ with eccentricity of end vertices u, v in T(H), that is $e_T(u)$, $e_T(v)$ where $e_T(u)$ denotes the eccentricity of point vertex u and $e_T(v)$ denotes the eccentricity of point vertex v in T(H). The values are given in the Table 2.1 and the number of vertices u ∈V(G) and eccentricity of vertices u in T(H) are given in Table 2.2.

Sl.No	Number of edges uv in H	Eccentricity of the end point vertices u, v in T(H) $(e_T(u), e_T(v))$
1	p 2p	(p + 2q – 1, p + 2q – 1) (p + 2q – 1, p + 2q – 2)
2	p 2p	(p + 2q – 2, p + 2q – 2) (p + 2q – 2, p + 2q – 3)
3	p 2p	(p + 2q – 3, p + 2q – 3) (p + 2q – 3, p + 2q – 4)
-----	----------	----------
q	p 2p	(p + q, p + q) (p + q, p + q)
q + 1	p 2p	(p + q, p + q) (p + q, p + q + 1)
------	---------	----------
2q – 1	p 2p	(p + 2q – 2, p + 2q – 2) (p + 2q – 2, p + 2q – 1)
2q	p	(p + 2q – 1, p + 2q – 1)

Table 2.1

Table 2.2

Example: Let H = $TUAC_6(4, 8)$. The graph $TUAC_6(4, 8)$ has 128 vertices and 184 edges. The number of edges and eccentricity of end vertices in T(H) are given in Table 2.3 and the number of vertices and eccentricity of vertices in T(H) are given in Table 2.4.



(a)

(b)

(a) The 2-dimensional lattice

(b)

$TUAC_6(4, 8)$ nanotube

Sl.No	Number of edges uv in H	Eccentricity of the end vertices in T(H) $(e_T(u), e_T(v))$	Sl.No	Number of edges	Eccentricity of the end vertices in T(H) $(e_T(u), e_T(v))$
1	4 8	(19, 19) (19, 18)	9	4 8	(12, 12) (12, 13)
2	4 8	(18, 18) (18, 17)	10	4 8	(13, 13) (13, 14)

3	4 8	(17,17) (17,16)	11	4 8	(14, 14) (14, 15)
4	4 8	(16, 16) (16, 15)	12	4 8	(15, 15) (15, 16)
5	4 8	(15, 15) (15,14)	13	4 8	(16, 16) (16, 17)
6	4 8	(14, 14) (14, 13)	14	4 8	(17, 17) (17, 18)
7	4 8	(13, 13) (13,12)	15	4 8	(18, 18) (18, 19)
8	4 8	(12,12) (12, 12)	16	4	(19, 19)

Table 2.3

Sl.No	Number of vertices	Eccentricity of vertices in T(H), $e_T(u)$	Degree of the vertices in T(H),$d_T(u)$	Sl.No	Number of vertices	Eccentricity of vertices in T(H), $e_T(u)$	Degree of the vertices in T(H), $d_T(u)$
1	8	19	4	9	8	12	4
2	8	18	6	10	8	13	6
3	8	17	6	11	8	14	6
4	8	16	6	12	8	15	6
5	8	15	6	13	8	16	6
6	8	14	6	14	8	17	6
7	8	13	6	15	8	18	6
8	8	12	6	16	8	19	4

Table 2.4

(i)$ET_1(H) = \sum_{v \in E(H)} e_T(v)$

= 2{8(19)+ 8(18) + 8(17) + 8(16) + 8(15) + 8(14) + 8(13) + 8(12) } = 2{152 + 144 + 136 +128 + 120 + 112 + 104 + 96} = 2(992) = 1984

Similarly, we can find out that,

(ii) $ET_2(H) = 44192$ (iii) $ET_3(H) = 5648$ (iv) $ET\Pi_1(H) = (5.112799936 \times 10^{16})^2$

(v) $ET\Pi_2(H) = (5.199129144 \times 10^{46})^2(1152)$

(vi) $ET\Pi_3(H) = (2.780583113 \times 10^{33})^2(192)$

(vii) $ET^c(H) = 11296$ (viii) $ET\Pi^c(H) = (5.725027052 \times 10^{22})^2$

Theorem 2.1(i): First eccentricity T-index of H = $TUAC_6(p, q)$ is $ET_1(H) = 2\sum_{k=0}^{q-1} 2p(p+q+k)$

(ii): Second eccentricity T-index of H = $TUAC_6(p, q)$ is $ET_2(H) = 2\sum_{k=0}^{q-1} p(p+q+k)^2 + 2\sum_{k=1}^{q-1} 2p[(p+q+k)(p+q+(k-1))] + 2p(p+q)^2$

(iii): Third eccentricity T-index of H = $TUAC_6(p, q)$ is $ET_3(H) = 2\sum_{k=0}^{q-1} 2p(p+q+k) + 2\sum_{k=1}^{q-1} 2p[(p+q+k)+(p+q+(k-1))] + 4p(p+q)$

Proof(i): $ET_1(H) = \sum_{v \in E(H)} e_T(v)$

= 2p(p + 2q – 1) + 2p(p + 2q – 2) + 2p(p + 2q – 3) +…+ 2p(p + q)+2p(p + q) + 2p(p + q + 1) +…+ 2p(p + 2q – 2) +2p(p + 2q – 1)

$= 2\sum_{k=0}^{q-1} 2p(p+q+k)$

Proof(ii): $ET_2(H) = \sum_{(u,v) \in E(H)} e_T(u)e_T(v)$

={p(p + 2q – 1)(p + 2q – 1)} + {2p(p + 2q – 1)(p + 2q – 2)} + {p(p + 2q – 2)

(p + 2q – 2)} +{2p{(p + 2q – 2)(p + 2q – 3)} …+ {p(p + q)(p + q)} + {2p(p + q)

(p + q + 1)} +…+ {p(p + 2q – 2)(p + 2q – 2)} + {2p(p + 2q – 2)(p + 2q – 1)} +

{p(p + 2q – 1)(p + 2q – 1)}

$$= 2\sum_{k=0}^{q-1} p(p+q+k)^2 +$$

$$2\sum_{k=1}^{q-1} 2p[(p+q+k)(p+q+(k-1))] +$$

$2p(p+q)^2$

Proof(iii): $ET_3(H) = \sum_{(u,v)\in E(H)} e_T(u) + e_T(v)$

={p[(p + 2q – 1) + (p + 2q – 1)]} + {2p[(p + 2q – 1) + (p + 2q – 2)]} + {p[(p + 2q –2) + (p + 2q – 2)]} + {2p[(p + 2q – 2) + (p + 2q – 3)]} …+{p[(p + q) +(p + q)]}+ {2p[(p + q) + (p + q + 1)]} +…+ {p[(p + 2q – 2) + (p + 2q – 2)]} + {2p[(p + 2q – 2) + (p + 2q – 1)]} + {p[(p + 2q – 1) + (p + 2q – 1)]}

$$= 2\sum_{k=0}^{q-1} 2p(p+q+k) +$$

$$2\sum_{k=1}^{q-1} 2p[(p+q+k)+(p+q+(k-1))] +$$

$4p(p+q)$

Theorem 2.2: Eccentric connectivity T-index of H = $TUAC_6(p, q)$ is $ET^c(H) = 2\sum_{k=0}^{q-2} 12p(p+q-k) + 16p(p + 2q - 1)$

Proof: $ET^c(H) = \sum_{u\in V(H)} d_T(u)e_T(u)$

= 2p4(p + 2q – 1) + 2p6(p + 2q – 2) + 2p6(p + 2q – 3)+…+2p6(p+q) + 2p6(p +q) + 2p6(p+q + 1) + 2p6(p +q +1) +…+2p6(p + 2q – 2) + 2p4(p + 2q – 1)

$$= 2\sum_{k=0}^{q-2} 12p(p+q-k) + 16p(p + 2q - 1)$$

Theorem 2.3(i): First Multiplicative eccentricity T-index of H = $TUAC_6(p, q)$ is

$$ET\Pi_1(H) = \prod_{k=0}^{q-1} \left(2p[(p+q+k)]\right)^2$$

(ii): Second Multiplicative eccentricity T-index of H = $TUAC_6(p, q)$ is

$$ET\Pi_2(H) = \prod_{k=0}^{q-1} \left(p(p+q+k)^2\right)^2$$

$$\prod_{k=1}^{q-1} \left(2p[(p+q+k)(p+q+(k-1))]\right)^2 \; 2p(p+q)^2$$

(iii): Third Multiplicative eccentricity T-index of H = $TUAC_6(p, q)$ is

$$ET\Pi_3(H) = \prod_{k=0}^{q-1} \left(2p(p+q+k)\right)^2$$

$$\prod_{k=1}^{q-1} \left(2p[(p+q+k)+(p+q+(k-1))]\right)^2 \; 4p(p+q)$$

Proof(i): $ET\Pi_1(H) = \prod_{v\in E(H)} e_T(v)$

= {2p(p + 2q – 1)}{2p(p + 2q – 2)}{2p(p + 2q – 3)} … {2p(p + q)}{2p(p + q)}{2p(p + q + 1)} …{2p(p + 2q – 2)}{2p(p + 2q – 1)}

$$= \prod_{k=0}^{q-1} \left(2p[(p+q+k)]\right)^2$$

Proof(ii): $ET\Pi_2(H) = \prod_{(u,v)\in E(H)} e_T(u)e_T(v)$

={p(p + 2q – 1)(p + 2q – 1)} {2p(p + 2q – 1)(p + 2q – 2)} {p(p + 2q – 2)

(p + 2q – 2)} {2p(p + 2q – 2)(p + 2q – 3)}… {p(p + q)(p + q)} {2p{(p + q)(p + q + 1)}… {p(p + 2q – 2)(p + 2q – 2)} {2p(p + 2q – 2)(p + 2q – 1)} {p(p + 2q – 1)

(p + 2q – 1)}

$$= \prod_{k=0}^{q-1} \left(p(p+q+k)^2\right)^2$$

$$\prod_{k=1}^{q-1} \left(2p[(p+q+k)(p+q+(k-1))]\right)^2 \; 2p(p+q)^2$$

Proof(iii): $ET\Pi_3(H) = \prod_{(u,v)\in E(H)} e_T(u) + e_T(v)$

=p{(p + 2q – 1) + (p + 2q – 1)} 2p{(p + 2q – 1) + (p + 2q – 2)} p{(p + 2q – 2) +

(p + 2q – 2)} 2p{(p + 2q – 2) + (p + 2q – 3)} … p{(p + q) +(p + q)} 2p{(p + q) +

(p + q)} … p{(p + 2q – 2) + (p + 2q – 2)} 2p{(p + 2q – 2) + (p + 2q – 1)}

p{(p + 2q – 1) + (p + 2q – 1)}

$$= \prod_{k=0}^{q-1} \left(2p(p+q+k)\right)^2$$

$$\prod_{k=1}^{q-1}(2p[(p+q+k)+(p+q+(k-1))])^2$$

4p(p+q)

Theorem 2.4: Multiplicative Eccentric connectivity T-index of H = $TUAC_6(p, q)$ is

$ET\Pi^c(H) = \prod_{k=0}^{q-2}(12p(p+q+k))^2$ [8p(p+ 2q – 1)]^2

Proof: $ET\Pi^c(H) = \prod_{u\in V(H)} d_T(u)e_T(u)$

= **2**p4(p + 2q – 1) 2p6(p + 2q – 2) 2p6(p + 2q – 3) …2p6(p+q) 2p6(p +q) 2p6(p +q + 1) …2p6(p + 2q – 2) 2p4(p + 2q – 1)

$= \prod_{k=0}^{q-2}(12p(p+q+k))^2$

[8p(p+2q – 1)]^2

Eccentricity T-index of Zigzag polyhex nanotubes $TUZC_6(p, q)$

Let H = $TUZC_6(p, q)$ be a zigzag polyhex nanotube, where p is the number of hexagons in each row and q is the number of zigzag lines in the column of molecular graph of H. The graph $TUZC_6(p, q)$ has 2pq vertices and 3pq – p edges.

First, we evaluate the number of edges e = uv in H = $TUZC_6(p, q)$ with eccentricity of end vertices $e_T(u)$, $e_T(v)$ where $e_T(u)$ denote the eccentricity of point vertex u and eccentricity of the point vertex v in T(H). The values are given in the Table 3.1 and the number of vertices and eccentricity of vertices in T(H) are given in Table 3.2.

Sl.No	Number of edges uv in H	Eccentricity of end vertices in T(H) ($e_T(v)$, $e_T(u)$)
1	2p p	(p + q/2 + (q/2 – 1), p + q/2 + (q/2 – 1)) (p + q/2 + (q/2 – 1), p + q/2 + (q/2 – 2))
2	2p p	(p + q/2 + (q/2 – 2), p + q/2 + (q/2 – 2)) (p + q/2 + (q/2 – 2), p + q/2 + (q/2 – 3))
---	---	---
q / 2	2p p	(p + q/2, p + q/2) (p + q/2, p + q/2)
q / 2 +1	2p p	(p + q/2, p + q/2) (p + q/2, p + q/2 + 1)
---	---	---
q – 1	2p p	(p + q/2 + (q/2 – 2), p + q/2 + (q/2 – 2)) (p + q/2 + (q/2 – 2), p + q/2 + (q/2 – 1))
q	2p	(p + q/2 + (q/2 – 1), p + q/2 + (q/2 – 1))

Table 3.1

Sl.No	Number of vertices v in H	Eccentricity of point vertices in T(H) $e_T(v)$	Degree of the point verticesv in T(H), $d_T(v)$
1	p	(p + q/2) + (q/2 – 1)	4
2	p	(p + q/2) + (q/2 – 1)	6
3	p	(p + q/2) + (q/2 – 2)	6
4	p	(p + q/2) + (q/2 – 2)	6
5	p	(p + q/2) + (q/2 – 3)	6
6	p	(p + q/2) + (q/2 – 3)	6
---	---	---	---
q/2 – 1	p	p + q/2	6
q/2	p	p + q/2	6
q/2 + 1	p	p + q/2 + 1	6
q/2 + 2	p	p + q/2 + 1	6
---	---	---	---

q – 3	p	(p + q/2) + (q/2 – 2)	6
q – 2	p	(p + q/2) + (q/2 – 2)	6
q – 1	p	(p + q/2) + (q/2 – 1)	6
q	p	(p + q/2) + (q/2 – 1)	4

Table 3.2

Example: Let H = $TUZC_6(8, 8)$. The graph $TUZC_6(8, 8)$ has 128 vertices and 184 edges. The number of edges uv ∈ E(G) and eccentricity of end vertices u, v in T(H) are given in Table 3.3 and the number of vertices v∈ V(G) and eccentricity of vertices v in T(H) are given in Table 3.4.

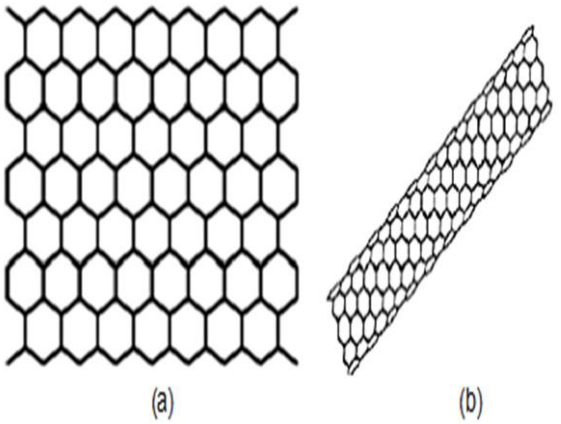


Fig (a) The 2-dimensional lattice
(b) $TUZC_6(8, 8)$ nanotube

Sl. No	Number of edges uv in H	Eccentricity of end point vertices in T(H) ($e_T(u)$, $e_T(v)$)
1	16 8	(15, 15) (15, 14)
2	16 8	(14, 14) (14, 13)
3	16 8	(13, 13) (13, 12)
4	16 8	(12, 12) (12, 12)
5	16 8	(12, 12) (12, 13)
6	16 8	(13, 13) (13, 14)
7	16 8	(14, 14) (14, 15)
8	16	(15, 15)

Table 3.3

Sl. No	Number of	Eccentricity of vertices	Sl. No	Number of	Eccentricity of vertices
	vertices in H	in T(H) $e_T(v)$		vertices in H	in T(H) $e_T(v)$
1	8	15	9	8	12
2	8	15	10	8	12
3	8	14	11	8	13
4	8	14	12	8	13
5	8	13	13	8	14
6	8	13	14	8	14
7	8	12	15	8	15
8	8	12	16	8	15

Table 3.4

$ET_1(H) = 2\{8(15) + 8(15) + 8(14) + 8(14) + 8(13) + 8(13) + 8(12) + 8(12)\}$

$= 2\{ 120 + 120 + 112 + 112 + 104 + 104 + 96 + 96\} = 2(864) = 1728$

(ii)$ET_2(H) = 33408$ (iii) $ET_3(H) = 4944$ (iv) $ET^c(H) = 9888$

(v) $ETΠ_1(H) = (1.800560349 \times 10^{16})^2$

(vi) $ETΠ_2(H) = (2.147103396 \times 10^{23})^2(1152)$

(vii) $ETΠ_3(H) = (3.442829678 \times 10^{17})^2(192)$

(viii) $ETΠ^c(H) = (2.016166647\times 10^{22})^2$

Theorem 3.1(i): First eccentricity T-index of H = $TUZC_6(p, q)$ is $ET_1(H) = 2\sum_{k=0}^{q/2-1} 2p(p+q/2+k)$

(ii) Second eccentricity T-index of H = $TUZC_6(p, q)$ is $ET_2(H) = 2\sum_{k=0}^{q/2-1} 2p(p+q/2+k)^2 +$

$2\sum_{k=1}^{q/2-1} p((p+q/2+k)(p+q/2+(k-1)) + p(p + q/2)^2$

(iii): Third eccentricity T-index of H = $TUZC_6(p, q)$ is $ET_3(H) = 2\sum_{k=0}^{q/2-1} 4p(p+q/2+k) +$

$2\sum_{k=1}^{q/2-1} p((p+q/2+k)+(p+q/2+(k-1)) +$

2p(p + q/2)

Proof(i): $ET_1(H) = \sum_{v \in E(H)} e_T(v)$

= p(p + q/2 + (q/2 – 1)) + p(p + q/2 + (q/2 – 1)) + p(p + q/2 + (q/2 – 2)) +

p(p + q/2 + (q/2 – 2)) +…+p(p + q/2) + p(p + q/2) + p(p + q/2 +1) +…+

2p(p + q/2 + (q/2 – 2)) + p(p + q/2 + (q/2 – 2)) + p(p + q/2 + (q/2 – 1)) + p(p + q/2 + (q/2 – 1))

$= 2\sum_{k=0}^{q/2-1} 2p(p+q/2+k)$

Proof(ii): $ET_2(H) = \sum_{(u,v) \in E(H)} e_T(u) e_T(v)$

= {2p(p + q/2 + (q/2 – 1)) (p + q/2 + (q/2 – 1))}+ {p(p + q/2 + (q/2 – 1)) (p + q/2 + (q/2 – 2))} + {2p(p + q/2 + (q/2 – 2)) (p + q/2 + (q/2 – 2))} +…+ {2p(p + q/2) (p + q/2)} + {p(p + q/2) (p + q/2)} + {2p(p + q/2) (p + q/2)} +…+ {2p(p + q/2 + (q/2 – 2)) (p + q/2 + (q/2 – 2))} + {p(p + q/2 + (q/2 – 2)) (p + q/2 + (q/2 – 1))} + {2p(p + q/2 + (q/2 – 1)) (p + q/2 + (q/2 – 1))}

$= 2\sum_{k=0}^{q/2-1} 2p(p+q/2+k)^2 + 2\sum_{k=1}^{q/2-1} p((p+q/2+k)(p+q/2+(k-1)))$ + p(p + q/2)^2

Proof(iii): $ET_3(H) = \sum_{(u,v) \in E(H)} e_T(u) + e_T(v)$

= {2p((p + q/2 + (q/2 – 1)) + (p + q/2 + (q/2 – 1)))}+ {p((p + q/2 + (q/2 – 1)) + (p + q/2 + (q/2 – 2)))} + {2p((p + q/2 + (q/2 – 2)) + (p + q/2 + (q/2 – 2)))} +…+ {2p((p + q/2) + (p + q/2))} + {p((p + q/2) + (p + q/2))} + {2p((p + q/2) + (p + q/2))} +…+{2p((p + q/2 + (q/2 – 2)) + (p + q/2 + (q/2 – 2)))} + {p((p + q/2 + (q/2 – 2)) + (p + q/2 + (q/2 – 1)))} + {2p((p + q/2 + (q/2 – 1)) + (p + q/2 + (q/2 – 1)))}

$= 2\sum_{k=0}^{q/2-1} 4p(p+q/2+k) + 2\sum_{k=1}^{q/2-1} p((p+q/2+k)+(p+q/2+(k-1)))$ + 2p(p + q/2)

Theorem 3.2: Eccentric connectivity T-index of H = $TUZC_6(p, q)$ is $ET^c(H) = 2\sum_{k=0}^{q/2-2} 12p(p+q/2+k) +$ 20p(p + q – 1)

Proof: $ET^c(H) = \sum_{u \in V(H)} d_T(u) e_T(u)$

= p4(p + q/2 + (q/2 – 1)) + p6(p + q/2 + (q/2 – 1)) + p6(p + q/2 + (q/2 – 2)) +

p6(p + q/2 + (q/2 – 2) + …+ p 6(p + q/2) + p6(p + q/2) + ...+ p 6(p + q/2 + (q/2 – 2)) + p6(p + q/2 + (q/2 – 2)) + p6(p + q/2 + (q/2 – 1)) + p6(p + q/2 + (q/2 – 1))

$= 2\sum_{k=0}^{q/2-2} 12p(p+q/2+k)$

+20p(p + q – 1)

Theorem 3.3(i): First Multiplicative eccentricity T-index of H = $TUZC_6(p, q)$ is $ET\Pi_1(H) = \prod_{k=0}^{q/2-2} \left(p^2(p+q/2+k)^2\right)^2$

(ii) Second Multiplicative eccentricity T-index of H = $TUZC_6(p, q)$ is

$ET\Pi_2(H) = \prod_{k=1}^{q/2-1} \left(2p(p+q/2+k)^2\right)^2 \prod_{k=1}^{q/2-1} \left(p((p+q/2+k)(p+q/2+(k-1))\right)^2$ p(p + q/2)^2

(iii): Third Multiplicative eccentricity T-index of H = $TUZC_6(p, q)$ is

$ETΠ_3(H) = \prod_{k=0}^{q/2-1}\left(4p(p+q/2+k)\right)^2$

$\prod_{k=1}^{q/2-1}\left(p((p+q/2+k)(p+q/2+(k-1))\right)^2$ 2p(p + q/2)

Proof(i): $ETΠ_1(H) = \prod_{v\in E(H)} e_T(v)$

= p(p + q/2 + (q/2 – 1)) p(p + q/2 + (q/2 – 1)) p(p + q/2 + (q/2 – 2)) p(p + q/2+(q/2 – 2)) …p(p + q/2)p(p + q/2)p(p + q/2 +1) …p(p + q/2 + (q/2 –2)) p(p + q/2 + (q/2 – 2)) p(p + q/2 + (q/2 – 1))

= p^2(p + q/2 + (q/2 – 1))^2 p^2(p + q/2 + (q/2 – 2))^2 … p^2(p + q/2)^2 … p^2(p + q/2 + (q/2 – 2))^2 p^2(p + q/2 + (q/2 – 1))^2

$= \prod_{k=0}^{q/2-1}\left(p^2(p+q/2+k)^2\right)^2$

Proof(ii): $ETΠ_2(H) = \prod_{(u,v)\in E(H)} e_T(u)e_T(v)$

= 2p{(p + q/2 + (q/2 – 1)) (p + q/2 + (q/2 – 1))} p{(p + q/2 + (q/2 – 1)) (p + q/2 + (q/2 – 2))} 2p{(p + q/2 + (q/2 – 2)) (p + q/2 + (q/2 – 2))} … 2p{(p + q/2) (p + q/2)} p{(p + q/2) (p + q/2)} 2p{(p + q/2) (p + q/2)} …2p{(p + q/2 + (q/2 – 2)) (p + q/2 + (q/2 – 2))} p{(p + q/2 + (q/2 – 2)) (p + q/2 + (q/2 – 1))} 2p{(p + q/2 + (q/2 – 1)) (p + q/2 + (q/2 – 1))}

$= \prod_{k=1}^{q/2-1}\left(2p(p+q/2+k)^2\right)^2$

$\prod_{k=1}^{q/2-1}\left(p((p+q/2+k)(p+q/2+(k-1))\right)^2$ $p(p + q/2)^2$

Proof(iii): $ETΠ_3(H) = \prod_{(u,v)\in E(H)} e_T(u) + e_T(v)$

= 2p{(p + q/2 + (q/2 – 1)) + (p + q/2 + (q/2 – 1))} p{(p + q/2 + (q/2 – 1)) + (p + q/2 + (q/2 – 2))} 2p{(p + q/2 + (q/2 – 2))} 2p{(p + q/2 + (q/2 – 2))} … 2p{(p + q/2) + (p + q/2)} p{(p + q/2) + (p + q/2)} 2p{(p + q/2) + (p + q/2)} …2p{(p + q/2 + (q/2 – 2)) (p + q/2 + (q/2 – 2))} p{(p + q/2 + (q/2 – 2)) + (p + q/2 + (q/2 – 1))} 2p{(p + q/2 + (q/2 – 1)) + (p + q/2 + (q/2 – 1))}

$= \prod_{k=0}^{q/2-1}\left(4p(p+q/2+k)\right)^2$

$\prod_{k=1}^{q/2-1}\left(p((p+q/2+k)(p+q/2+(k-1))\right)^2$ 2p(p + q/2)

Theorem 3.4: Multiplicative Eccentric connectivity T-index of H = $TUZC_6$(p, q) is

$ET^c(H) = \prod_{k=0}^{q/2-2}\left(36p^2(p+q/2+k)^2\right)^2$ [$24p^2$(p + q – 1)^2]^2

Proof: $ET^c(H) = \prod_{u\in V(H)} d_T(u)e_T(u)$

= p4(p + q/2 + (q/2 – 1)) p6(p + q/2 + (q/2 – 1)) p6(p + q/2 + (q/2 – 2)) p6(p + q/2 + (q/2 – 2) … p6(p + q/2) p6(p + q/2) p 4(p + q/2 + 1) ... p6(p + q/2 + (q/2 – 2)) p6(p + q/2 + (q/2 – 2)) p6(p + q/2 + (q/2 – 1)) p4(p + q/2 + (q/2 – 1))

$= \prod_{k=0}^{q/2-2}\left(36p^2(p+q/2+k)^2\right)^2$

[$24p^2$(p + q – 1)^2]^2

Conclusion

In this paper we computed the exact value of two new topological indices namely eccentric connectivity T-indices and multiplicative eccentric connectivity T-indices of Armchair polyhex nanotubes and Zigzag polyhex nanotubes.

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NEIGHBORHOOD CONNECTED DOMINATION AND ECCENTRIC DOMINATION IN BOOLEAN GRAPH $BG_1(G)$ OF A GRAPH G

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ABSTRACT

Let G be a simple (p, q) graph with vertex set V(G) and edge set E(G). $BG_1(G)$ is a graph with vertex set $V(G) \cup E(G)$ and two vertices are adjacent if and only if they correspond to two adjacent vertices of G or to a vertex and an edge not incident to it in G. In this paper, we study the concept of neighborhood connected domination number and eccentric domination number of Boolean graph $BG_1(G)$, obtained bounds of these parameters and determined its exact value for several classes of graphs. We also find the exact value of $\gamma_{ed}(BG_1(G))$ when G is a connected graph with pendant vertices and characterize graphs G for which $\gamma_{ed}(BG_1(G)) = 2$.

Keywords: *Neighborhood connected domination number, eccentric domination number, Boolean graph $BG_1(G)$.*

INTRODUCTION

Graphs discussed in this paper are undirected and simple graphs. For a graph G, let V(G) and E(G) denote its vertex set and edge set respectively. Let $v \in V$. The open neighborhood N(v) of a vertex v is the set of all vertices adjacent to v in G. $N[v] = N(v) \cup \{v\}$ is called the closed neighborhood of v. If $S \subseteq V$, then $N(S) = \bigcup_{v \in s} N(v)$ and $N[S] = N(S) \cup S$. The degree of vertex v is the number of edges incident with it and is denoted deg v or $\deg_G$ v. The minimum degree among the vertices of a graph G is denoted by $\delta(G)$, while the maximum degree $\Delta(G)$ is the largest such number.

A vertex and an edge are said to cover each other if they are incident. A set of vertices which covers all the edges of a graph G is called a point cover for G, while a set of edges which covers all the vertices is a line cover. The smallest number of vertices in any point cover for G is called its point covering number or simply covering number and is denoted by $\alpha_0(G)$ or α_0. Similarly, α_1 is the smallest number of edges in any line cover of G and is called its line cover number. A set of vertices in G is independent if no two of them are adjacent. The largest number of vertices in such a set is called the point independence number of G and is denoted by $\beta_0(G)$ or β_0. A set of edges in a graph is independent if no two edges in the set are adjacent. By a matching in a graph G, we mean an independent set of edges in G. The edge independence number $\beta_1(G)$ of a graph G is a maximum cardinality of an independent set of edges. A perfect matching is a matching with every vertex of the graph is incident to exactly one edge of the matching. The graph G^+ is obtained from the graph G by attaching a pendent edge to each of the vertices of G.

The distance d(u, v) between two vertices u and v in G is the minimum length of a path joining them if any; otherwise d(u, v) = ∞. Let G be a connected graph and v be a vertex of G. The eccentricity e(v) of v is the distance to a vertex farthest from v. Thus, $e(v) = \max\{d(u, v): u \in V\}$.The radius r(G) is the minimum eccentricity of the vertices, whereas the diameter diam(G) = d(G) is the maximum eccentricity. For any connected graph G, $r(G) \leq diam(G) \leq 2r(G)$. The vertex v is a central vertex if e(v) = r(G). The center C(G) is the set of all central vertices. The central sub graph ⟨C(G)⟩ of a graph G is the subgraph induced by the center. The vertex v is a peripheral vertex if e(v) = diam(G). The periphery P(G) is the set of all peripheral vertices. For a vertex v, each vertex at a distance e(v) from v is an eccentric vertex. Eccentric set of a vertex v is defined as $E(v) = \{u \in V(G) : d(u, v) = e(v)\}$. A graph is self-centered if every vertex is in the center. Thus, in a self-centered graph G all vertices have the same eccentricity, so r(G) = diam(G).

In 2004[2], Bhanumathi, defined the Boolean graph $BG_1(G)$ and studied its

properties [5,7].

Let G be a simple (p, q) graph with vertex set V(G) and edge set E(G). $BG_1(G)$ is a graph with vertex set $V(G) \cup E(G)$ and two vertices are adjacent if and only if they correspond to two adjacent vertices of G or to a vertex and an edge not incident to it in G. The vertices of $BG_1(G)$, which are in V(G) are called point vertices and vertices in E(G) are called line vertices. $V(BG_1(G))) = V(G) \cup E(G)$, $E(BG_1(G)) = [E(\overline{T(G)}) - (E(\overline{L(G)}) \cup E(\overline{G}))] \cup E(G)$.

$BG_1(G)$ has p + q vertices, p point vertices with degree q and q line vertices with degree p – 2. $BG_1(G)$ is always bi-regular and is regular if and only if q = p – 2; clearly, in this case G is disconnected. It is easy to determine that $BG_1(G)$ has $q(p-1)$ edges.

The concept of domination in graphs was introduced by Ore [9]. A set $D \subseteq V(G)$ is said to be a dominating set of G, if every vertex in V(G) – D is adjacent to some vertex in D. D is said to be a minimal dominating set if $D - \{u\}$ is not a dominating set for any $u \in D$. The domination number $\gamma(G)$ of G is the minimum cardinality of a dominating set.

A dominating set D of G is called a connected dominating set if the induced subgraph ⟨D⟩ is connected. The minimum cardinality of a connected dominating set of G is called the connected dominating number of G and is denoted by $\gamma_c(G)$.

A dominating set D of G is called an independent dominating set if no two vertices are adjacent in D. The minimum cardinality of an independent dominating set of G is called the independent dominating number of G and is denoted by $\gamma_i(G)$.

Arumugam and Sivagnanam [1] introduced the concept of neighborhood connected domination in graphs. A dominating set D of a connected graph G is called a neighborhood connected dominating set (ncd-set) if the induced subgraph ⟨N(D)⟩ of G is connected. The neighborhood connected domination number $\gamma_{nc}(G)$ is the minimum cardinality of a ncd-set.

Let $D \subseteq V(G)$, D is known as an eccentric point set of G if for every $v \in V-D$, D has at least one u such that $u \in E(v)$. An eccentric point set D of G is a minimal eccentric point set if no proper subset D′ of D is an eccentric point set of G. D is known as a minimum eccentric point set if D is an eccentric point set with minimum cardinality. The cardinality of a minimum eccentric point set of G is denoted by e(G). e(G) is known as eccentric number of G.

Janakiraman, Bhanumathi and Muthammai [6] introduced the concept of eccentric domination number of a graph. A set $D \subseteq V(G)$ is an eccentric dominating set if D is a dominating set of G and for every $v \in V-D$, there exists at least one eccentric point of v in D. An eccentric dominating set D is a minimal eccentric dominating set if no proper subset $D'' \subseteq D$ is an eccentric dominating set. The eccentric domination number $\gamma_{ed}(G)$ of a graph G equals the minimum cardinality of an eccentric dominating set. V(G) is an eccentric dominating set for any graph G. Hence, $\gamma_{ed}(G)$ is an well defined parameter. Obviously, $\gamma(G) \leq \gamma_{ed}(G)$.

Theorem 1.1 [2] If G has a pendant vertex, then $\gamma(BG_1(G)) = 2$.

Theorem 1.2 [2] Let G be a graph without pendant and isolated vertices.

(i) If diam G = 1, then $\gamma(BG_1(G)) = 3$.

(ii) If r(G) = 1, diam(G) = 2, and if there exists non-adjacent u, $v \in V(G)$ such that {u, v} dominates G, then $\gamma(BG_1(G)) = 2$; otherwise $\gamma(BG_1(G)) = 3$.

(iii) If $\gamma(G) = 2 = \gamma_c(G)$, and $\gamma_i(G) > 2$, then $\gamma(BG_1(G)) = 3$ and $\gamma_i(BG_1(G)) \leq 1 + \delta(G)$.

(iv) If $\gamma(G) = 2 = \gamma_i(G)$, then $\gamma(BG_1(G)) = \gamma_i(BG_1(G)) = 2$.

(v) If $\gamma(G) \geq 3$, then $\gamma(BG_1(G)) = 3$ and $\gamma_i(BG_1(G)) \leq 1 + \delta(G)$.

Theorem 1.3 [2, 5] If $BG_1(G)$ is connected, eccentricity of a point vertex is 2, 3 or 4.

Theorem 1.4 [2, 5] If G is connected with more than 4 vertices and has no pendant vertex, then $BG_1(G)$ is self-centered with diameter two.

Theorem 1.5 [2, 5] If G is connected with p > 3 and has pendant vertices, then eccentricity of a pendant vertex and the corresponding pendant edge in $BG_1(G)$ is 3.

For $G = K_{1,2}$, eccentricity of pendant point

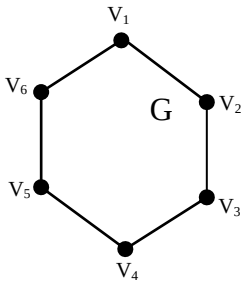
vertex v is 3 and eccentricity of pendant edge is 4. For $G = K_3$, eccentricity of point vertex v is 2 and eccentricity of line vertex is 3.

Theorem 1.6 [2, 5] In $BG_1(G)$, eccentricity of point vertex is 2 and line vertex is 3 if and only if $G = K_3, K_4, C_4$.

Theorem 1.7 [2, 5] (i) Eccentricity of point vertex in $BG_1(G)$ is 4 if and only if $G = 2K_2 \cup nK_1$.

(ii) Eccentricity of line vertex in $BG_1(G)$ is 4 if and only if $G = K_{1,2}$.

Example 2.1



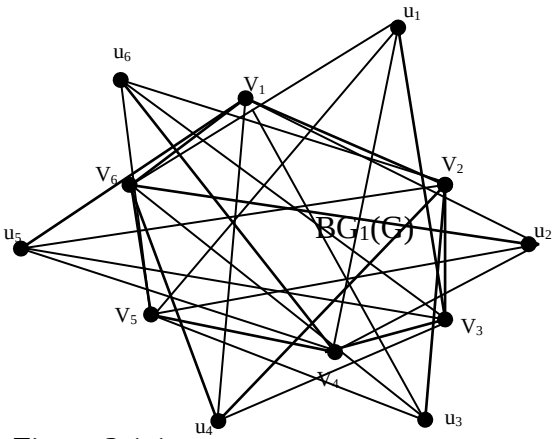


Figure 2.1.1

D = {v_1, v_3, v_5} is an eccentric dominating set of G. Hence, $\gamma_{ed}(G) = 3$.

D = {v_1, u_1, v_2} is an eccentric dominating set of $BG_1(G)$. Hence, $\gamma_{ed}(BG_1(G)) = 3$

A dominating set D of a connected graph G is called a neighborhood connected dominating set (ncd-set) if the induced subgraph ⟨N(S)⟩ of G is connected. The neighborhood connected domination number $\gamma_{nc}(G)$ is the minimum cardinality of a ncd-set.

Clearly, $\gamma(BG_1(G)) \le \gamma_{nc}(BG_1(G))$ and $\gamma(BG_1(G)) \ge 2$. If G is connected then the set of all point vertices is a ncd-set of $BG_1(G)$. Hence, we have $2 \le \gamma_{nc}(BG_1(G)) \le p$.

Both the bounds are sharp, since $\gamma_{nc}(BG_1(P_n^+)) = 2$ and $\gamma_{nc}(BG_1(C_3)) = 3$.

In the following theorems, some ncd-set of $BG_1(G)$) is studied.

Theorem 2.1 Let G be a connected graph with radius r(G) > 1. If there exists a minimal ncd-set S of G which has atleast two non adjacent vertices, then S is a ncd-set of $BG_1(G)$ also.

NEIGHBORHOOD CONNECTED DOMINATION IN BOOLEAN GRAPH $BG_1(G)$ OF A GRAPH G

In this section, neighborhood connected domination of $BG_1(G)$ of a graph G is initiated; some theorems and bounds related to neighborhood connected dominating set of the Boolean graph $BG_1(G)$ of a graph G is studied.

Proof: Let $S \subseteq V(G)$ be a minimal ncd-set of G with atleast two non adjacent vertices. Let u, v ∈ S be such that u is not adjacent to v in G. S dominates all point and line vertices of $BG_1(G)$. All line vertices are dominated by u and v in $BG_1(G)$. Also, ⟨N(S)⟩ is connected in G, since S is a ncd-set of G. Hence, the induced subgraph ⟨N(S)⟩ is connected in $BG_1(G)$ also. This proves the result. In this case, $\gamma_{nc}(G) \ge \gamma_{nc}(BG_1(G))$.

Theorem 2.2 If G is a connected graph with $diam(G) \le 2$ and $\delta(G) \ge 2$, then $\gamma_{nc}(BG_1(G)) \le 1 + \delta(G)$.

Proof: Consider u ∈ V(G) with degree $\delta(G) = \deg u$. In $BG_1(G)$, $N_G(u)$ dominates all point vertices and line vertices, which are not incident with elements of $N_G(u)$ in G. Let $S = N_G[u]$. Clearly S is a ncd-set of $BG_1(G)$. Hence, $\gamma_{nc}(BG_1(G)) \le 1 + \delta(G)$.

Theorem 2.3 Let G be a graph without isolated vertices with $p \ge 3$ and $\gamma(G) \ge 3$. Then, γ_{nc}-set S of G is a neighborhood connected dominating set of $BG_1(G)$.

Proof: Let S be a γ_{nc}-set of G. Since, $\gamma(G) \ge 3$, in $BG_1(G)$, S dominates all point vertices

and line vertices. Since G is an induced subgraph of $BG_1(G)$, $\langle N(S)\rangle$ is connected in $BG_1(G)$. Thus S is a neighborhood connected dominating set of $BG_1(G)$.

Theorem 2.4 If $G \neq 2K_2$ is a graph with K_2 as a component of G, then any γ-set of G is a ncd-set of $BG_1(G)$.

Proof: Let $G = G_1 \cup G_2$, G_1 may be connected. Let u, v be vertices of K_2. Let S be a γ-set of G. Then S contains u or v and at least one vertex w from G_1. Assume $u \in S$ and $v \notin S$, u dominates all line vertices which are edges of G_1 and w dominates the edge e = uv in $BG_1(G)$. Thus, S is a dominating set of $BG_1(G)$. The induced subgraph $\langle N(S)\rangle$ is connected in $BG_1(G)$. Hence, S is a neighborhood connected dominating set of $BG_1(G)$.

Remark 2.1 If $G \neq K_{1,n}$ is a connected graph then the set of all line vertices form a ncd-set of $BG_1(G)$.

Theorem 2.5 If $G \neq K_{1,n}$ is a connected graph with a pendant vertex and $p \geq 4$, then $\gamma_{nc}(BG_1(G)) = 2$.

Proof: Let u be a pendant vertex and e = uv be a pendant edge in G. In $BG_1(G)$), S ={u, e}is a dominating set and its neighborhood is connected. Hence, $\gamma_{nc}(BG_1(G)) = 2$.

Theorem 2.6 If $G \neq K_{1,n}$ is a connected graph with no pendant vertices and $p \geq 4$, then $\gamma_{nc}(BG_1(G)) = 3$.

Proof: Let u and v be adjacent vertices in G and let e = uv in G. Since G has no pendant vertices, G–e is connected. In $BG_1(G)$), S = {u, v, e}is a dominating set. The induced subgraph $\langle N(S)\rangle$ of $BG_1(G)$) contains G as its subgraph and is connected in $BG_1(G)$). Hence, $\gamma_{nc}(BG_1(G)) = 3$.

NEIGHBORHOOD CONNECTED DOMINATION NUMBER OF $BG_1(G)$ FOR SOME PARTICULAR GRAPHS

Here, we give $\gamma_{nc}(BG_1(G))$ for some particular classes of graphs.

Theorem 3.1

1. For a non- trival path P_n on n vertices $\gamma_{nc}(BG_1(P_n)) = 2$, if $n \geq 3$.
2. For a cycle C_n on n vertices, $\gamma_{nc}(BG_1(C_n)) = 3$, if $n \geq 3$.
3. $\gamma_{nc}(BG_1(K_n)) = 3$, if $n \geq 3$.
4. $\gamma_{nc}(BG_1(K_{1,n})) = 3$, if $n \geq 3$.
5. $\gamma_{nc}(BG_1(K_{m,n})) = 3$.
6. $\gamma_{nc}(BG_1(W_n)) = 3$, if $n \geq 3$.
7. $\gamma_{nc}(BG_1(F_n)) = 3$, if $n \geq 3$.
8. $\gamma_{nc}(BG_1(P_n^+)) = 2$ for all $n \geq 3$.
9. $\gamma_{nc}(BG_1(C_n^+)) = 2$ for all $n \geq 3$.

Proof: Proof follows from Theorems 2.5 and 2.6.

ECCENTRIC DOMINATION IN BOOLEAN GRAPH $BG_1(G)$ OF A GRAPH G

Let G be a connected graph. Eccentric domination number of $BG_1(G)$ and its bounds are studied in this section.

We have, $\gamma(BG_1(G)) \leq \gamma_{ed}(BG_1(G))$ by Theorem 1.3.

If G is connected with more than 4 vertices and has no pendant vertex, then $BG_1(G)$ is self-centered with diameter two. Hence, $\gamma_{ed}(BG_1(G)) \leq 1+p-2 = p-1$ by Theorem 1.4.

If G is connected with $p > 3$ and has pendant vertices, then eccentricity of a pendant vertex and the corresponding pendant edge in $BG_1(G)$ is 3. Hence, $\gamma_{ed}(BG_1(G)) \leq (p+q)-q/2 = p+q/2$ by Theorem 1.5.

Theorem 4.1 If G is a unicentral tree of radius 2 with center u which is not a support, then $\gamma_{ed}(BG_1(G)) \leq p - deg(u)$.

Proof: If is G of radius 2 with unique central vertex u, then in $BG_1(G)$, $r(BG_1(G)) = 2$ by Theorem 1.6. $V(G) - N_G(u)$ dominates all point and line vertices of $BG_1(G)$. Each vertex of $V(BG_1(G)) - N_G(u)$ has their eccentric vertices in $N_2(u)$ only. Therefore, $V(G) - N_G(u)$ is an eccentric dominating set of $BG_1(G)$. Hence, $\gamma_{ed}(BG_1(G)) \leq p - deg(u)$.

Remark 4.1 If u is a support vertex, then $V(G) - N_G(u)$ need not be an eccentric dominating set of $BG_1(G)$.

For example, if G is a tree given in Figure 4.1, $V(G) - N_G(u)$ is not an eccentric dominating set of $BG_1(G)$, since the line vertex e = uv has no eccentric vertex in $V(G) - N_G(u)$.

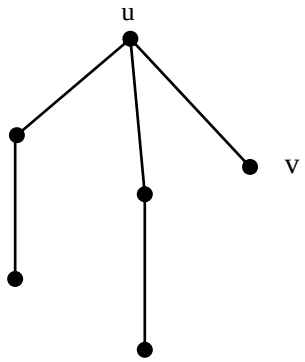


Figure 4.1

Theorem 4.2 If G is a bi-central tree with radius 2 and diameter 3, then $\gamma_{ed}(BG_1(G)) \leq p - 1$.

Proof: Let u and v be the central vertices of T and uv = e ∈ E(G). In $BG_1(G)$, $r(BG_1(G)) = 2$ and $diam(BG_1(G)) = 3$ by Theorem 1.6. The set $V(G) - \{u, v\}$ dominates all point and line vertices in $BG_1(G)$. Each vertex of $BG_1(G)$ has their eccentric vertices in $V(G) - \{u, v\} \cup \{e\}$ only. Therefore, $(V(G) - \{u, v\}) \cup \{e\}$ is an eccentric dominating set of $BG_1(G)$. Hence, $\gamma_{ed}(BG_1(G)) \leq p - 1$.

Theorem 4.3 For a tree T with radius > 2 and has a vertex u such that deg u = Δ(T) and u is not a support vertex then $\gamma_{ed}(BG_1(T)) \leq p - \Delta(T)$.

Proof: Let G = T be a tree and u ∈ V(G) such that deg u = Δ(G). In $BG_1(G)$, $r(BG_1(G)) = 2$ and $diam(BG_1(G)) = 3$ by Theorem 1.6 and $V(G) - N_G(u)$ dominates all point and line vertices of $BG_1(G)$. Therefore, $D = V(G) - N_G(u)$ is an eccentric dominating set of $BG_1(G)$. Hence, $\gamma_{ed}(BG_1(G)) \leq p - \Delta(G)$.

Remark 4.2 If u is a support vertex, then $V(G) - N_G(u)$ need not be an eccentric dominating set of $BG_1(G)$.

For example, if G is a tree given in Figure 4.2, $V(G) - N_G(u)$ is not an eccentric dominating set of $BG_1(G)$, since a pendant line vertex incident with u has no eccentric vertex in $V(G) - N_G(u)$.

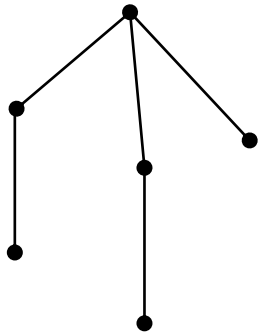


Figure 4.2

Theorem 4.4 If $G \neq K_{1,n}$ is of radius one, diameter 2 and has atmost one pendant vertex, then $\gamma_{ed}(BG_1(G)) \leq 2 + \delta(G)$.

Proof: diam(G) = 2. Let u ∈ V(G) with deg u = δ(G) and e(u) = 2 in G. In $BG_1(G)$, $diam(BG_1(G)) = 3$, $r(BG_1(G) = 2$ if G has a pendant vertex, otherwise $BG_1(G)$ is two self-centered. Consider $S = N_G(u) \cup \{u, e\}$, where e = uv ∈ V(G). S dominates all point and line vertices of $BG_1(G)$. Also, for point vertices, which are not in S, u is an eccentric point vertex. Vertex e ∈ S is eccentric to all other line vertices in $V(BG_1(G))$. Therefore, S is an eccentric dominating set of $BG_1(G)$. Hence, $\gamma_{ed}(BG_1(G)) \leq 2 + \delta(G)$.

Theorem 4.5 If G is a graph of radius 2, diameter 3, and if G has only one pendant vertex v of eccentricity three, then $\gamma_{ed}(BG_1(G)) \leq 2 + \Delta(G)$.

Proof: If G has a pendant vertex v of eccentricity three, then support vertex u is of eccentricity 2 in G. Let uv = e in G. In $BG_1(G)$, consider $S = N_G(u) \cup \{u, e\}$. S dominates all point and line vertices of $BG_1(G)$. Every point and line vertices of $BG_1(G)$ has their eccentric vertices in $N_G(u) \cup \{u, e\}$ only. Hence, $\gamma_{ed}(BG_1(G)) \leq 2 + \Delta(G)$.

Remark 4.3 If G has more than one pendant vertex with different support vertices, then $N_G(u) \cup \{u, e\}$ need not be an eccentric dominating set of $BG_1(G)$.

For example, if G is a graph given in Figure 4.3, $N_G(u) \cup \{u, e\}$ is not an eccentric

dominating set of $BG_1(G)$, since the pendant vertex w has no eccentric vertex in $N_G(u) \cup \{u, e\}$.

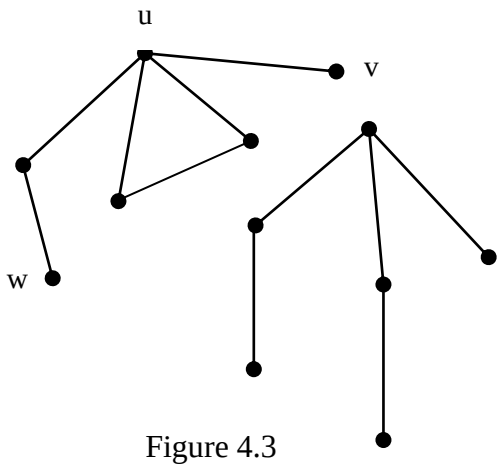


Figure 4.3

Theorem 4.6 If G is of radius one with unique central vertex u, then $\gamma_{ed}(BG_1(G)) \leq p$, $p \geq 4$.

Proof: Let G be a graph with radius one with unique central vertex u. Let $e_i = uv_i$, i = 1, 2, 3, …, p−1, be the edges incident with u. In $BG_1(G)$, $r(BG_1(G)) = 2$. Vertex u dominates all point and non incident line vertices in $V(BG_1(G))$. Consider $S = \{e_i\}_{i = 1, 2, \ldots p-1} \cup \{u\}$. S is an eccentric dominating set of $BG_1(G)$. Hence, $\gamma_{ed}(BG_1(G)) \leq p - 1 + 1 = p$.

Theorem 4.7 Let G be a connected graph with $p > 4$ and radius greater than one, with no pendant vertices, then $\gamma_{ed}(BG_1(G)) \leq 2 + e(G)$.

Proof: In this case, $BG_1(G)$ is self centered with diameter two. Consider the vertices u, v $\in V(G)$ and let $e = uv \in E(G)$. $S = \{u, v, e\}$ dominates all point and line vertices of $BG_1(G)$. Also, e is eccentric to other line vertices. Let D be a minimum eccentric set of G with cardinality e(G). Then $D \cup S$ is an eccentric dominating set of G. Hence, $\gamma_{ed}(BG_1(G)) \leq 2 + e(G)$.

Theorem 4.8 Let G be a connected graph with $p > 4$. Then, the set of all line vertices of G is an eccentric dominating set of $BG_1(G)$.

Proof: If G has pendant vertices, $BG_1(G)$ is bieccentric with diameter 3. Obviously E(G) is a dominating set of $BG_1(G)$ by the definition of $BG_1(G)$. Vertex $u \in V(G)$ is pendant and $e = uv \in E(G)$, then e is eccentric to u in $BG_1(G)$. Hence, u has eccentric vertex in E(G). If $u \in V(G)$ is not pendant, then eccentricity of u′ in $BG_1(G)$ is two and if e is an edge incident with u in G, then d(u′, e′) in $BG_1(G)$ is 2, therefore e′ is eccentric to u′. Hence, E(G) is an eccentric dominating set of $BG_1(G)$. Therefore, $\gamma_{ed}(BG_1(G)) \leq q$.

Observation 4.9 If $D \subseteq E(G)$ is an eccentric dominating set of $BG_1(G)$, then D = E(G) since E(G) is independent in $BG_1(G)$. But there may exist an eccentric dominating set D of $BG_1(G)$ such that $D \subseteq V(G)$.

Theorem 4.10 Let G be a connected graph with $p > 4$. Then, V(G) is an eccentric dominating set of $BG_1(G)$.

Proof: Case(i): e is a pendant edge

If u is a pendant vertex and $e = uv \in E(G)$. In $BG_1(G)$, e is eccentric to u in $BG_1(G)$ and eccentricity of e is 3 in $BG_1(G)$. Also, e is adjacent to all other point vertices in $BG_1(G)$. Hence, V(G) is an eccentric dominating set of $BG_1(G)$.

Case(ii): e is a non pendant edge

The eccentricity of e in $BG_1(G)$ is two and if $e = uv \in E(G)$, u and v are eccentric vertices of e in $BG_1(G)$ and e is adjacent to all other point vertices. Hence, V(G) is an eccentric dominating set of $BG_1(G)$. This implies that $\gamma_{ed}(BG_1(G)) \leq p$.

Remark 4.4 Let G be a connected graph with $p > 4$. Then $\gamma_{ed}(BG_1(G)) \leq \min\{p, q\}$.

Theorem 4.11 Let G be a connected graph with $p > 4$ and has exactly one pendant vertex. Then $\gamma_{ed}(BG_1(G)) = 2$.

Proof: Let v be the pendant vertex of G and let $e = uv \in E(G)$. Let $D = \{v, e\}$, the vertex v dominates u and all other line vertices and e dominates all other point vertices. Hence, D is a dominating set of $BG_1(G)$. The vertex e is eccentric to u and other line vertices; vertex v is eccentric to other point vertices. Hence D is an eccentric dominating set of $BG_1(G)$. Thus $\gamma_{ed}(BG_1(G)) = 2$.

In the following, we study some strict bounds for $\gamma_{ed}(BG_1(G))$ when G is a connected graph with pendant vertices.

Lemma 4.12 Let G be a connected graph with p > 4 and has pendant vertices. Then $\gamma_{ed}(BG_1(G)) \leq s + 1$.

Proof: If G has a pendant vertex u and uv = e, then {u, e} is a dominating set and {u, e} ∪ S, where S is the set of all pendant vertices, is an eccentric dominating set of $BG_1(G)$. Hence, $\gamma_{ed}(BG_1(G)) \leq s + 1$, where s is the number pendant vertices of G.

Lemma 4.13 Let G be a connected graph with p > 4, and G has a pendant vertex v, then $\gamma_{ed}(BG_1(G)) \geq s$, where s is the number of pendant vertices of G.

Proof: G has a pendant vertex v incident with an edge e = uv ∈ E(G), then v or e must be in any eccentric dominating set of $BG_1(G)$. Hence, $s \leq \gamma_{ed}(BG_1(G))$, where s is the number of pendant vertices of G. This implies that $\gamma_{ed}(BG_1(G)) \geq s$.

Theorem 4.14 Let G be a connected graph with p > 4, and G has a pendant vertex v, then $\gamma_{ed}(BG_1(G)) = s$ or s+1, where s is the number of pendant vertices of G.

Proof: Proof follows from the previous two lemmas.

Remark 4.5 In general, set of all pendant vertices cannot be an eccentric dominating set of $BG_1(G)$. Similarly, set of all pendant edges cannot be an eccentric dominating set of $BG_1(G)$. For example, if $G = C_n^+$ or $G = P_n^+$, $\gamma_{ed}(BG_1(G)) = n$, number of pendant vertices, but the set of all pendant vertices or edges cannot be an eccentric dominating set of $BG_1(G)$.

Following theorem characterizes graphs G for which $\gamma_{ed}(BG_1(G)) = 2$.

Theorem 4.15 Let G be a connected graph such that $BG_1(G)$ is also connected. Then $\gamma_{ed}(BG_1(G)) = 2$ if and only if G has exactly one pendant vertex.

Proof: Assume that $\gamma_{ed}(BG_1(G)) = 2$

Case(i): Let D = {u, v} ⊆ V(G) is an eccentric dominating set for $BG_1(G)$. D is a dominating set for $BG_1(G)$. Therefore, all point vertices are adjacent to both u or v in G and all the edges in G are non incident with either u or v and the vertices u and v are non adjacent in G. Therefore, D is a point cover of G. Hence, G is of the form $K_{1,n} \cup K_{1,m}$. But in his case, G is disconnected and the pendant edges has no eccentric vertices in $BG_1(G)$. So, this case is not possible.

Case(ii): D = {u, e} ⊆ V($BG_1(G)$), u ∈ V(G), e ∈ E(G) is an eccentric dominating set for $BG_1(G)$. D is a dominating set of $BG_1(G)$, therefore e must be incident with u in G and u is a pendant vertex. If G has some other pendant vertex then this D is not an eccentric dominating set. Hence D is an eccentric dominating set if G is a connected graph with only one pendant vertex.

Case(iii): D = $\{e_1, e_2\} \subseteq V(BG_1(G))$, $e_1, e_2 \in E(G)$ is an eccentric dominating set for $BG_1(G)$.

Since D is a dominating set of $BG_1(G)$, e_1 and e_2 must be nonadjacent edges of G. But D cannot dominate other line vertices. Hence G must be $2K_2$. Thus this case is also not possible, since G is connected.

Conversely, if G has exactly one pendant vertex u, then u and e, where e is the pendant edge incident with u in G form an eccentric dominating set of $BG_1(G)$, and hence $\gamma_{ed}(BG_1(G)) = 2$.

ECCENTRIC DOMINATION NUMBER OF $BG_1(G)$ FOR SOME PARTICULAR GRAPHS

In this section, eccentric domination number of Boolean graph $BG_1(G)$ is obtained when G is a path, cycle, star, complete graph, wheel graph, Fan graph and corona graphs of path and cycle.

Theorem 5.1 For a non- trival path P_n on n vertices, $\gamma_{ed}(BG_1(P_n)) = 3$ if $n \geq 3$.

Proof: Let $V(P_n) = \{v_1, v_2, \ldots, v_n\}$ and $e_i = v_iv_{i+1}$, $1 \leq i \leq n - 1$. Let $u_i \in V(BG_1(P_n))$ be the vertex corresponding to e_i in $BG_1(P_n)$. Then $v_1, v_2, v_3, \ldots, v_n, u_1, u_2, u_3, \ldots, u_{n-1} \in V(BG_1(P_n))$. Thus $|V(BG_1(P_n))| = 2n - 1$.

Consider $D = \{v_1, u_1\}$. In $BG_1(G)$, the point vertex v_1 dominates all other line vertices and v_2, and the line vertex u_1 dominates point vertices except v_1 and v_2. Hence, D is a dominating set of $BG_1(P_n)$. In $BG_1(G)$, v_1 is of eccentricity 3 and u_1 is of eccentricity 3; v_1, u_1 are eccentric to each

other; u_{n-1}, v_n are eccentric to other vertices and u_{n-1}, v_n are eccentric to each other. Hence, $S = \{v_1, u_1, v_n\}$ is an eccentric dominating set of $BG_1(P_n)$. Therefore, $\gamma_{ed}(BG_1(P_n)) \leq 3$. But, $\gamma(BG_1(G)) \leq \gamma_{ed}(BG_1(G))$ and $\gamma(BG_1(P_n)) = 2$ by Theorem 1.2. Thus, $2 \leq \gamma_{ed}(BG_1(P_n)) \leq 3$. Hence, by theorem 4.14, $\gamma_{ed}(BG_1(P_n)) = 3$.

Theorem 5.2 For a cycle C_n on n vertices, $\gamma_{ed}(BG_1(C_n)) = 3$ if $n > 4$.

Proof: Let $V(C_n) = \{v_1, v_2, \ldots, v_n\}$ and $e_i = v_iv_{i+1}$, $1 \leq i \leq n-1$ and $e_n = v_nv_1$. Let $V = V(BG_1(C_n))$. Let u_i be the vertex corresponding to e_i in $BG_1(C_n)$. Then $v_1, v_2, v_3, \ldots, v_n, u_1, u_2, u_3, \ldots, u_n \in V(BG_1(C_n))$. Thus, $|V(BG_1(C_n))| = 2n$. Let $S = \{v_1, u_1, v_2\}$. The vertex u_1 dominates all point vertices and v_1, v_2 dominates all line vertices in $V - S$. $BG_1(C_n)$ is a two self-centered graph. Any other point vertex has v_1 or v_2 as eccentric vertex. Also, any other line vertex and u_1 have common adjacent point vertices. Hence, u_1 is eccentric to other line vertices. Therefore, S is an eccentric dominating set of $BG_1(C_n)$. Hence, $\gamma_{ed}(BG_1(C_n)) \leq 3$. But there exists no eccentric dominating set with cardinality 2 in $BG_1(C_n)$. Hence, $\gamma_{ed}(BG_1(C_n)) = 3$.

Theorem 5.3 (i) $\gamma_{ed}(BG_1(K_n)) = (n / 2) + 2$, if n is even and $n \geq 6$.

(ii) $\gamma_{ed}(BG_1(K_n)) = \lceil n / 2 \rceil + 2$, if n is odd and $n \geq 5$.

Proof: Let $v_1, v_2, v_3, \ldots, v_n$ be the vertices of K_n and let u_{ij}, $i < j$, $i, j = 1, 2, 3, \ldots, n$ be the added vertices corresponding the edges e_{ij} of K_n to obtain $BG_1(K_n)$. Thus $V(BG_1(K_n)) = \{v_1, v_2, v_3, \ldots, v_n\} \cup_{i<j} \{u_{ij}\}$, $i, j = 1, 2, 3\ldots, n$. The graph $BG_1(K_n)$ has $n + \frac{n(n-1)}{2} = \frac{n(n+1)}{2}$ vertices. Eccentricity of every point vertex and line vertex of $BG_1(K_n)$ is two. Therefore, it is a two self-centered graph.

Case(i): n is even

Let $S = \{v_1, u_{1n}, u_{2,n-1}, u_{3,n-2}, u_{4,n-3}, \ldots, u_{n/2,n/2-1}, v_n\}$. S is a minimal eccentric dominating set of $BG_1(K_n)$ and $|S| = (n/2) + 2$. Therefore, $\gamma_{ed}(BG_1(K_n)) \leq (n/2) + 2$. To each point vertex v a line vertex e which is incident to it in G is an eccentric vertex and vice versa. Also, for a line vertex any other line vertex is at distance two and hence is eccentric, when $n \geq 5$. Hence, $\gamma_{ed}(BG_1(K_n)) \geq n/2$. But a subset of line vertices cannot dominate other line vertices. So, atleast two more point vertices are needed. This implies that $\gamma_{ed}(BG_1(K_n)) \geq (n/2) + 2$. Thus $\gamma_{ed}(BG_1(K_n)) = (n / 2) + 2$.

Case(ii): n is odd

Let $S = \{v_1, u_{1n}, u_{2,n-1}, u_{3,n-2}, u_{4,n-3}, \ldots, u_{\lceil n/2 \rceil \lceil n/2 \rceil - 1} v_n\}$. S is a minimal eccentric dominating set of $BG_1(K_n)$. $|S| = \lceil n / 2 \rceil + 2$. Therefore, $\gamma_{ed}(BG_1(K_n)) \leq \lceil n / 2 \rceil + 2$. Thus, $\gamma_{ed}(BG_1(K_n)) \geq \lceil n / 2 \rceil + 2$. Hence, $\gamma_{ed}(BG_1(K_n)) = \lceil n / 2 \rceil + 2$.

When $G = K_3$. $S = \{e_1, e_2, e_3\}$ is a minimum eccentric dominating set of $BG_3(G)$. Hence, $\gamma_{ed}(BG_1(K_n)) = 3$. When $G = K_4$. $S = \{v_1, u_{12}, u_{34}\}$ is a minimum eccentric dominating set of $BG_1(G)$. Hence, $\gamma_{ed}(BG_1(K_4)) = 3$.

Theorem 5.4 $\gamma_{ed}(BG_1(K_{1,n})) = n$, $n \geq 3$

Proof: Let $v_1, v_2, v_3, \ldots, v_n, v$ (v is the central vertex of $K_{1,n}$) be the vertices of $K_{1,n}$ and let $e_j = vv_j$, $j = 1,2,\ldots, n$ be the edges of $K_{1,n}$. Let $v_1, v_2, v_3, \ldots, v_n, v, u_1, u_2, u_3, \ldots, u_n$, be the corresponding vertices of $BG_1(K_{1,n})$. Thus $BG_1((K_{1,n})$ has $2n + 1$ vertices. $V' = V(BG_1(K_{1,n}))$. $BG_1(G)$ is bi eccentric with diameter 3. Also, a pendant vertex v_i of G has only u_i as its eccentric vertex where $e_i = v_iv \in E(G)$. Hence, v_i or u_i must be in any eccentric dominating set. Therefore, $\gamma_{ed}(BG_1(K_{1,n})) \geq n$. Let $S = \{u_1, u_2\} \cup \{v_3, \ldots, v_n\}$, where $v_1, v_2, \ldots, v_n$ are pendant vertices of G. S is an eccentric set of $BG_1(G)$ and it is also a dominating set of $BG_1(G)$. Hence, S is an eccentric dominating set of $BG_1(K_{1,n})$ and $|S| = n$. Thus, $\gamma_{ed}(BG_1(K_{1,n})) \leq n$. This proves the theorem.

When $G = K_{1,2}$. $S = \{v, v_1, v_2\}$ is a minimum eccentric dominating set of $BG_1(G)$. Hence, $\gamma_{ed}(BG_1(K_{1,2})) = 3$.

Theorem 5.5 $\gamma_{ed}(BG_1(K_{m,n})) = 3$.

Proof: When $G = K_{m,n}$, $V(G) = V_1 \cup V_2$ with $|V_1| = m$ and $|V_2| = n$. $E(G) = \{e_{ij} / 1 \leq i \leq m, 1 \leq j \leq n\}$ where $e_{ij} = u_iv_j$ for all $1 \leq i \leq m$, $1 \leq j \leq n$. Thus $V(BG_1(K_{m,n})) = (V_1 \cup V_2) \cup \{e_{ij} /$

$1 \le i \le m$, $1 \le j \le n\}$. Let $S = \{u, v, e\}$. $u \in V_1$, $v \in V_2$ and $uv = e \in E(G)$. Vertex u dominates all point vertices which are in V_2; v dominates all point vertices of V_1; u and v dominate all other line vertices. The vertex u is eccentric to other vertices of V_1 and line vertices which are incident with u in G. Similarly, the vertex v is eccentric to other vertices of V_2 and line vertices which are incident with v in G. Also, e is eccentric to line vertices which are not incident with u or v in G. Hence, S is an eccentric dominating set of $BG_1(K_{m,n})$. Therefore, $\gamma_{ed}(BG_1(K_{m,n})) \le 3$. Also, $\gamma_{ed}(BG_1(K_{m,n})) \ge \gamma(BG_1(K_{m,n})) = 3$ by Theorem (1.3). Thus, $\gamma_{ed}(BG_1(K_{m,n})) = 3$.

Theorem 5.6 $\gamma_{ed}(BG_1(W_n)) = 3$, $n \ge 6$, where $W_n = K_1 + C_n$.

$\gamma_{ed}(BG_1(W_3)) = 4$, $\gamma_{ed}(BG_1(W_4)) = 4$, $\gamma_{ed}(BG_1(W_5)) = 4$

Proof: Let $S = \{v, w, e\}$, where u and w are adjacent vertices and v is the central vertex. $uv = e \in E(G)$. v dominates all point vertices and non incident edges in $BG_1(W_n)$. Eccentricity of every point vertex and line vertex of $BG_1(W_n)$ is two. Therefore it is a self-centered graph. S is an eccentric dominating set of $BG_1(W_n)$. Also, we have $\gamma(BG_1(W_n)) = 3$ from Theorem (1.3). Hence, $\gamma_{ed}(BG_1(W_n)) = 3$.

When $G = W_3$. $S = \{u, v, w, x\}$ is a minimum eccentric dominating set of $BG_3(G)$. Hence, $\gamma_{ed}(BG_1(W_3)) = 4$. When $G = W_4$. $S = \{v, u, e, w\}$ is a minimum eccentric dominating set of $BG_1(G)$. Hence, $\gamma_{ed}(BG_1(W_4)) = 4$. When $G = W_5$. $S = \{v, u, e, w\}$ is a minimum eccentric dominating set of $BG_1(G)$. Hence, $\gamma_{ed}(BG_1(W_5)) = 4$.

Theorem 5.7 $\gamma_{ed}(BG_1(F_n)) = 3$, where $F_n = K_1 + P_n$.

Proof: Let $v_1, v_2, v_3, \ldots, v_n, v$ (v is the central vertex of F_n) be the vertices of F_n and let $e_j = vv_j$, $j = 1, 2, \ldots, n$, and $v_iv_j = e_{ij}$ ($j = i + 1$, $i = 1, 2, 3, \ldots, n$) be the edges of F_n. Let $v_1, v_2, \ldots, v_n, v, u_1, u_2, \ldots, u_n, e_{12}, e_{23}, \ldots, e_{n-1,n}$ be the corresponding vertices of $BG_1(F_n)$. Thus $V((BG_1(F_n))$ has 3n vertices. Let $S = \{u, w, e\}$, where u and w are adjacent vertices and v is the central vertex. $vw = e \in E(G)$. S is a dominating set of $BG_1(F_n)$. Eccentricity of every point vertex and line vertex of $BG_1(F_n)$ is two. Therefore it is a 2 self-centered graph. The vertex u, w are the eccentric vertex of the point vertex in $BG_1(F_n)$. For other e_{ij}'s e is the eccentric vertex in $BG_1(F_n)$. Therefore, S is an eccentric dominating set of $BG_1(F_n)$. Hence, $\gamma_{ed}(BG_1(F_n)) \le 3$. Also, we have $3 = \gamma(BG_1(F_n)) \le \gamma_{ed}(BG_1(F_n))$ by Theorem (1.3). Hence, $\gamma_{ed}(BG_1(F_n)) = 3$

Theorem 5.8 $\gamma_{ed}(BG_1(P_n^+)) = n$.

Proof: Let $G = P_n^+$ be a graph obtained from P_n by attaching exactly one pendant edge at each vertex of P_n. Let $v_1, v_2, v_3, \ldots, v_n$ be the vertices and $e_{12}, e_{23}, e_{34}, \ldots, e_{n-1,n}$ be the edges in P_n, where $e_{i,i+1} = v_iv_{i+1}$, $i = 1, 2, 3, \ldots, n-1$. Let u_i be the pendant vertex attached to v_i in P_n^+, $i = 1, 2, 3, \ldots, n$ and $e_{ii} = u_iv_i \in E(G)$. Then $v_1, v_2, v_3, \ldots, v_n, u_1, u_2, u_3, \ldots, u_n, e_{11}, e_{22}, e_{33}, \ldots, e_{nn}, e_{12}, e_{23}, e_{34}, \ldots, e_{n-1,n} \in V(BG_1(P_n^+))$. Thus $|V(BG_1(P_n^+))| = 4n - 1$. Let $S = \{e_{11}, u_2, u_3, \ldots, u_{n-1}, e_{nn}\}$. Vertices $u_2, u_3, \ldots, u_{n-1}$ are peripheral vertices of $BG_1(G)$. S is an eccentric dominating set of $BG_1(P_n^+)$ and $|S| = n$. Thus, $\gamma_{ed}(BG_1(P_n^+)) \le n$. Point vertex u_i and line vertex e_{ii} are eccentric to each other and they have no other eccentric vertices. Therefore, either u_i or e_{ii} must be in an eccentric dominating set. Hence, $\gamma_{ed}(BG_1(P_n^+)) \ge n$. Thus we have, $\gamma_{ed}(BG_1(P_n^+)) = n$.

Theorem 5.9 $\gamma_{ed}(BG_1(C_n^+)) = n$.

Proof: Let $G = C_n^+$ be a graph obtained from C_n by attaching exactly one pendant edge at each vertex of C_n. Let $v_1, v_2, v_3, \ldots, v_n$ be the vertices and $e_{12}, e_{23}, e_{34}, \ldots, e_{n1}$ be the edges in C_n, where $e_{i,i+1} = v_iv_{i+1}$, $1 \le i \le n-1$ and $e_{n1} = v_nv_1$. Let u_i be the pendant vertex attached to v_i in C_n^+, $i = 1, 2, \ldots, n$, where $e_{ii} = u_iv_i$, $1 \le i \le n$. Then $v_1, v_2, v_3, \ldots, v_n, u_1, u_2, u_3, \ldots, u_n, e_1, e_2, e_3, \ldots, e_n, e_{12}, e_{23}, e_{34}, \ldots, e_{n1} \in V(BG_1(C_n^+))$. Thus $|V(BG_1(C_n^+))| = 4n$. $u_i, e_i \in V(BG_1(C_n^+))$ has all u_j's and e_j's, as eccentric vertices in $V - S$. Let $S = \{e_{11}, u_2, u_3, \ldots, u_{n-1}, e_{nn}\}$. S is an eccentric dominating set of $BG_1(C_n^+)$ and $|S| = n$. Therefore, $\gamma_{ed}(BG_1(C_n^+)) \le n$. Point vertex u_i and line vertex e_{ii} are eccentric to each other and they have no other eccentric vertices. This implies that $\gamma_{ed}(BG_1(G)) \ge n$. Hence, $\gamma_{ed}(BG_1(C_n^+)) =$

n.

CONCLUSION

In this paper we computed the exact value of the neighborhood connected domination number and eccentric domination number for Boolean graph of path, cycle, complete graph, complete bipartite graph and some special graphs. Also we found some upper bounds for neighborhood connected domination number and eccentric domination number for Boolean graph $BG_1(G)$ of a graph.

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