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## INTEGRATION OF SIGNAL PROCESSING TECHNIQUES AND NEURAL NETWORK FOR GULF COOPERATION COUNCIL STOCK MARKET FORECASTING

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#### ABSTRACT

Forecasting stock market movements poses significant challenges due to market volatility, hindering traditional statistical methods. Consequently, more sophisticated techniques are essential for precise predictions. This study investigates the integration of advanced preprocessing methods—the Gaussian Zero-Phase filter (GZP), Fast Fourier Transform (FFT), and Discrete Wavelet Transform (DWT)—with an Artificial Neural Network (ANN) to evaluate their collective efficacy in enhancing prediction reliability. Empirical analysis utilizes a decade of data from four distinct Middle East/Gulf region stock market indices: Kuwait, UAE, Oman, and Qatar. The primary aim is to validate and compare the performance of these techniques in predicting stock market trends. Through applying GZP, FFT, and DWT for data preprocessing before ANN input, the study seeks to augment the neural network's pattern detection capabilities and improve accuracy in forecasting future market movements. Results from this experimental approach could yield significant insights into the feasibility of integrating these methods for stock market prediction, potentially advancing more robust and dependable forecasting models in financial markets. This methodological innovation underscores the critical integration of advanced signal processing techniques with machine learning for intricate predictive tasks.

Keywords: Forecasting, Stock Market, Fourier Transform, Discrete Wavelet Transform, Artificial Neural Network.

## FORECASTING DENGUE OUTBREAKS IN INDIA ACROSS INDIAN PROVINCES: A TIME SERIES AND MACHINE LEARNING APPROACH

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#### ABSTRACT

Dengue poses a significant public health challenge in India. This study uses a multi-model strategy to predict dengue outbreaks and examine their geographic differences across the country. We apply Autoregressive Integrated Moving Average (ARIMA) models, Decision Trees, Random Forests, and Gated Recurrent Unit (GRU) models for our analysis. To ensure the reliability of our models, we conduct stationarity testing using Augmented Dickey-Fuller tests. Our results reveal considerable geographic variation, indicating the necessity for forecasting models that can adapt to regional differences. According to our predictions, West Bengal and Punjab are expected to have approximately 14,328.6 and 14,498.2 dengue cases, respectively. In terms of fatalities, Maharashtra may experience around 40.2 deaths, while Punjab and Rajasthan could see 23.6 and 28.8 deaths, respectively. This comprehensive approach provides valuable insights into dengue patterns and supports public health planning. Additionally, the study highlights the need to tailor models to the unique characteristics of each region for more effective disease management.

Keywords: Dengue, ARIMA, Machine Learning, Forecasting.

## NTRU SCHEME ON GROUP ALGEBRAS

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#### ABSTRACT

The NTRU Cryptosystem is one of the efficient cryptosystems based on hardness of computational hard problems in Lattices due to which it is resistant to Quantum computers in large dimensions, the operations in NTRU are easy to compute with fewer key sizes than RSA and ECC. In this paper, we extended NTRU on Group algebras, so that on some Groups we may have better security estimates than Original NTRU. We compared the results with QTRU and extended various results to NTRU on group algebras.

Keywords: NTRU, Lattice-based Cryptography, Post-Quantum Cryptography, Lattice Reduction, Group algebras.

## UNDERNUTRITION AMONG UNDER-FIVE CHILDREN IN UTTAR PRADESH, INDIA: A SIMULTANEOUS QUANTILE REGRESSION MODELLING APPROACH

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#### ABSTRACT

Childhood undernutrition has an irreversible impact on the physical as well as mental development of the child. Nutrition-related factors were responsible for about 35% of child deaths and 11% of the total global disease burden. This health condition continues to be a major public health issue across the globe. Three standard indices based on anthropometric measurements viz. weight and height, that describe nutritional status of children are: height-for-age (stunting), weight-for-age (underweight) and weight-for-height (wasting). This paper utilizes unitlevel data on under-five children of Uttar Pradesh from the NFHS-5, 2019-2021 to find out factors which exert a differential impact on the conditional distribution of the outcome variable. A class of models that allow flexible functional dependence of an outcome variable on covariates by using nonparametric regression have been applied to determine possible factors causing undernutrition. This study also fits a Bayesian additive quantile regression model for the provision of a complete picture of the relationship between the outcome variable (stunting) and the predictor variables on different desired quantiles of the response distribution. Different types of quantile regression models were fitted and compared according to each Deviance Information Criteria (DIC) for determination of the best model among them. Maternal characteristics like nutritional status and educational status showed significant impact of child's nutritional status, consistent with the findings of other studies. Also, it could be seen that maximum number of covariates were found significant for severe undernutrition, indicating that differential effect of predictors on the conditional distribution of the outcome variables.

**Keywords:** Anthropometric Measurements, Bayesian Additive Quantile Regression, under-five children, Undernutrition.

## A STUDY TO ANALYZE THE REGIONAL DISPARITIES IN VACCINATION AMONG CHILDREN AGED 12-23 MONTHS IN UTTAR PRADESH

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#### ABSTRACT

Despite implementation of universal vaccination program, Uttar Pradesh, the India's most populous state, struggles to achieve full immunization among children between the ages of 12 and 23 months. In Uttar Pradesh, the child immunization is 78.4% out of which, 60.47% of fully vaccinated children reside in East region while 73.75% in the West region. This study examined differences in childhood vaccination between the East and West areas of Uttar Pradesh using data from the NFHS-5. Out of total, 6,577 children aged 12-23 months old were used to analyse the factors affecting vaccination status (not vaccinated, partially vaccinated, and completely vaccinated) using multinomial logistic regression. The analysis showed that in the East Region, children from low-income and Muslim households had higher odds of being partially and not vaccinated. Furthermore, children born at home in both the regions showed higher odds of being unvaccinated. In the West Region specifically, children from Muslim households had greater odds of being not vaccinated, while those from low-income households had higher odds of being partially vaccinated. Across both regions, children whose mothers received tetanus injection before delivery showed lower odds of being partially and not vaccinated. Children born in the rural household showed lower odds of being not vaccinated in the East region and lower odds of being partially vaccinated in the West region. According to the study, children residing in the West region had higher immunization status than those who lived in the East region. The study highlighted that child in the West had better immunization rates, possibly due to higher maternal education levels and more mothers receiving tetanus injections in this region. According to the study, the immunization program needs to be more area-specific because Uttar Pradesh is a diverse state with different vaccination status in each region depending on several variables.

## PERFORMANCE EVALUATION OF SDNs USING A DISCRETE-TIME MAP/PH/1/N QUEUE MODEL

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#### ABSTRACT

Software-Defined Networking (SDN) revolutionizes network management through dynamic configuration and enhanced performance. Controllers, acting as the network's brain, guide switches on packet routing using the OpenFlow protocol. However, the interaction between switches and controllers introduces additional delays in packet processing, and the impact of the number of ingress and egress tables at the switch is often overlooked in existing research. This study introduces a discrete-time MAP/PH/1/n queue model designed to evaluate the performance of Software-Defined Networks (SDNs) under complex and bursty traffic patterns. The model accounts for packet processing across different switch components, including the switch buffer, ingress processing unit, and egress processing unit. By integrating a finite buffer queue with a Markovian arrival process (MAP) and phase-type (PH) service times, the model effectively captures the data transmission behaviors within OpenFlow switches. To analyze the system's performance, the matrix geometric method is employed to compute steadystate probabilities, which are essential for assessing key quality of service (QoS) metrics such as average delay, throughput, and blocking probabilities. Furthermore, the study formulates additional performance measures including output action, packet drop, and send-to-controller probabilities, providing a comprehensive assessment of SDN efficiency. This model offers a robust analytical tool for optimizing SDN design and ensuring reliable network performance under varying traffic conditions.

**Keywords:** Software-Defined Network, Markovian Arrival Process (MAP), Phase-Type (PH) Service Times, Matrix Geometric Method, Network Performance Evaluation.

## AN EMPIRICAL INVESTIGATION OF THE IMPACT OF AFFORDABLE CARE ACT DELIBERATIONS ON HEALTH CARE STOCK PRICES

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#### ABSTRACT

Since its inception in 2010, the Patient Protection and Affordable Care Act (Affordable Care Act or ACA) continues to be a topic of high interest, as evidenced during the 2024 Presidential election campaign trail. This study explores the effect of key news events related to the passage and implementation of the Affordable Care Act on stock prices overall. An examination of these events assists with determining the financial implications of the controversial legislation on stock prices for publicly traded companies. When assessing cumulative abnormal returns, publicly traded healthcare firms' stocks demonstrate significantly positive abnormal price changes in response to market news events related to the ACA. This research highlights how regulatory and legislative changes influence market behavior, especially in sectors directly affected by such policies, like health care.

Keywords: Stock Price Change; Health Care; Affordable Care Act; Abnormal Returns; Stock Market

## MULTI-OBJECTIVE OPTIMIZATION AND TRANSIENT ANALYSIS OF ENERGY SAVING APPROACH FOR COGNITIVE RADIO NETWORKS BY USING DISCRETE-TIME MULTI-SERVER PRIORITY G-QUEUE

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#### ABSTRACT

The significant challenge for 5G and future networks is high energy consumption due to highly dense overlapping heterogeneous network architecture. Furthermore, during the next decade, 5G networks must enhance energy efficiency by a factor of 2000. In this work, we present an energy-saving approach for the Cognitive Radio networks (CRN) using the discrete-time multi-server priority queue model. In the energy-saving approach, each port of Base Station (BS) toggled between the active state and the sleep state and conserved energy during the sleep period. In addition, we implemented the energy-saving approach for the heterogeneous CRN in which each port of BS is unreliable. Then, the whole system is modeled as a five-dimensional Markov chain, and conduct the transient analysis by using the recursive method. Using the transient probability vector, we obtained the numerical results based on the queueing and reliability analysis and presented the impact of reliability on the performance metrics. After that, by calculating the degree of energy savings, we showcased the efficacy of the proposed energy-saving approach. Finally, a reward cost is formulated, and a Pareto optimal solution for the reward cost and degree of energy saving is obtained using the multi-objective optimization technique.

**Keywords:** Cognitive radio networks, Energy saving approach, Multi-server discrete-time queue, Reliability analysis, Transient analysis, Multi-objective optimization

## ASSESSING THE RELATIONSHIP BETWEEN AUDITOR COMPETENCE AND WORK EXPERIENCE ON THE QUALITY OF INFORMATION SYSTEMS AUDITS AND SUPPLY CHAIN (CASE STUDY: DEUTSCHE BANK INDIA)

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#### ABSTRACT

An auditor's experience is a critical factor in enhancing their knowledge and skills over time. The longer an auditor has worked, the higher the quality of their audits and supply chain management will be. The purpose of this study is to determine the effect of auditor competence and work experience on the information systems Audit quality and supply chain in the Deutsche Bank India. This study collected primary data through interviews, questionnaires, library studies, and internet research. The research design used was descriptive analysis with a quantitative approach, aiming to present and analyze data to provide a clear picture of the object under study. The population and sample consisted of 50 employees of Deutsche Bank India. The multiple linear analysis techniques that previously tested for validity, reliability test, and classical assumption test such as normality test are used as analytical techniques. Data analysis is done using SPSS version 23 program. The results of the study prove that Work Experience has a positive effect on information systems audit quality and supply chain at the Deutsche Bank. Competence of Auditor positively influences to information systems Audit quality and supply chain at the Deutsche Bank. Some Suggestions for Deutsche Bank are to Optimize the use of work experience to detect irregularities in activity implementation and Encourage objective audit task execution, unaffected by personal relationships, to produce high-quality information systems audits and supply chain processes.

Keywords: Auditor Competence, Information Systems Audits, Supply Chain, Deutsche Bank, Professional Experience

## PREDICTION OF CONTRACEPTIVE UTILIZATION AMONG EVER-MARRIED WOMEN IN INDIA: A HIERARCHICAL MACHINE LEARNING CLASSIFICATION APPROACH

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#### ABSTRACT

Family planning is pivotal for promoting gender equality, women's empowerment, and sustainable development. Despite the global progress, an estimated 257 million women desiring to avoid pregnancy lack access to effective contraceptive methods due to sociocultural barriers and inadequate access to healthcare services. This study investigates the factors influencing contraceptive use among married women and evaluates the effectiveness of various machine-learning algorithms in predicting contraceptive practices. The study utilized a comprehensive dataset from NFHS-5 to analyze the sociodemographic and health profiles of a sample of women, focusing on their contraceptive behaviours.. The majority of participants were aged 25-29 years (18.97%), 30-34 years (17.91%), and 35-39 years (17.74%). Only 28.84% of the women were employed, indicating potential economic dependency and sociocultural discouragement from workforce participation. To predict contraceptive use, seven machine learning models were developed and evaluated: Logistic Regression, Random Forest, Naive Bayes, LASSO Regression, Classification Trees, AdaBoost, RT, and Artificial Neural Networks (ANN). Among these, the ANN model demonstrated superior performance with an accuracy of 80.81%, a Cohen's Kappa value of 0.577, precision of 81.55%, recall of 81.42%, and an F1-score of 81.51%. It also achieved the highest Area Under the Curve (AUC) of 89.84% and specificity of 71.07%, making it the most reliable model for accurately identifying non-contraceptive users. The implications of this research are significant for public health policy and intervention strategies. Accurate prediction of contraceptive use can guide the allocation of resources and the design of targeted educational campaigns to enhance contraceptive uptake.

## ENHANCING NON-PHARMACOLOGICAL MANAGEMENT OF KNEE OSTEOARTHRITIS THROUGH COMBINED HOT AND COLD COMPRESS THERAPY AND YOGA

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#### ABSTRACT

Knee osteoarthritis (OA), a leading cause of chronic disability globally, profoundly impacts mobility, functionality, and quality of life. This study evaluates the effectiveness of integrating hot and cold compress (HCC) therapy with yoga to manage pain, stiffness, and overall well-being in individuals with knee OA. An observational study was conducted with 80 participants diagnosed with knee OA, divided into two groups. Group A underwent yoga therapy alone, while Group B received a combination of yoga and HCC therapy. The intervention lasted 90 days, with assessments conducted using the Western Ontario and McMaster Universities Arthritis Index (WOMAC) and the Visual Analog Scale (VAS) to measure changes in pain, stiffness, and joint functionality. Both groups showed significant improvements; however, Group B demonstrated superior outcomes. Participants receiving the combined therapy reported faster and more substantial relief from stiffness, enhanced pain reduction, and improved joint mobility compared to the yoga-only group. The combination of HCC therapy with yoga significantly amplifies the benefits of traditional yoga practices, providing a synergistic and effective non-pharmacological approach to managing knee OA. This multimodal therapy not only addresses physical symptoms but also improves functional limitations, highlighting its potential as a holistic treatment strategy for chronic musculoskeletal disorders.

Keywords: Knee osteoarthritis, hot and cold compress, yoga therapy, pain management, stiffness reduction

## A NOVEL ENTROPY MODEL-BASED DECISION ANALYSIS UNDER FUZZY INTERVAL ENVIRONMENT

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#### ABSTRACT

An interval-valued fuzzy set expands the classical fuzzy set by integrating both interval uncertainty and the notion of hesitation, providing a more comprehensive representation of uncertainty in decision-making situations. In various real-world scenarios, decision-makers often face complex decisions involving multiple attributes, where uncertainty prevails in the form of interval data. This paper introduces a decision analysis framework designed specifically to tackle these challenges, aiming to improve the strength and dependability (reliability) of decision-making procedures. To measure the objective weights of attributes, we propose a novel interval-valued entropy model. Furthermore, for comparative analysis and ranking, we suggest an extended minimax regret-based approach and demonstrate the advantages of the proposed decision analysis framework using illustrative examples.

## MODELING AND COST OPTIMIZATION OF NON-MARKOV MACHINING SYSTEMS WITH MULTIPLE VACATIONS AND ARRIVAL CONTROL POLICY

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#### ABSTRACT

This study examines the queue management, performance analysis, and cost optimization of a fault-tolerant machining system (FTMS) that integrates multiple vacations for a repairman and an arrival control F-policy. <br/>Sbr/>The arrival control F-policy is a useful strategy for mitigating congestion resulting from the arrival of failed machines needing repair in the system. It helps regulate the flow of these failed machines, thereby improving the overall efficiency of the repair process. Moreover, when the system is empty, and no failed machines are available, the repairman has the option to take a vacation. If the repairman returns and there are still no machines to repair, they can choose to take another vacation. Furthermore, the mathematical analysis of the model is carried out by formulating and solving the Chapman–Kolmogorov (C-K) steady-state equations. This is done by introducing supplementary variables for vacation times and then applying the Laplace-Stieltjes transform (LST) along with a recursive method to derive probability distributions. These distributions are then used to develop various performance metrics, such as the expected number of failed machines in the system, waiting time, machine availability, and other relevant measures. Additionally, cost optimization for the FTMS is performed using trapezoidal fuzzy numbers as cost elements, with meta-heuristic techniques like particle swarm optimization (PSO) and artificial bee colony (ABC) algorithms.

## VARIANTS OF GENETIC ALGORITHM TO SOLVE FUZZY MULTI-OBJECTIVE MULTI-ITEM FIVE-DIMENSIONAL TRANSPORTATION PROBLEM

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#### ABSTRACT

The genetic algorithm, known as GA, is a methodical optimization technique that can effectively tackle a range of challenging optimization problems. It is based on natural selection and genetics and is classified as an evolutionary algorithm. The GA and its variants are employed for solving various real-life optimization issues that involve multiple objectives. In this paper, GA and its variants are used to solve the transportation problem. The transportation problems with various dimensions and objectives reflect the transportation difficulties encountered in real life. This study develops a complex framework for a fuzzy multi-objective, multi-item fivedimensional transportation problem (FMOMI5DTP), emphasizing the complexity of transportation difficulties in practical scenarios. While traditional optimization algorithms are commonly applied to address TPs, they may struggle to understand the intuition and judgment of decision-makers. To address the issue, NSGA III is being employed to produce solutions that consider multiple objectives at different levels while avoiding domination by others. Nevertheless, NSGA III requires an initial feasible population to produce the solutions. To tackle the problem, the paper proposes a systematic approach to efficiently generate an initial population for managing the FMOMI5DTP. Furthermore, a numerical example is used to validate the proposed model. The problem is solved using NSGA III, which is compared to the outcomes of NSGA II, hybrid genetic algorithm (HGA), and fuzzy programming technique (FPT). A sensitivity analysis is conducted to assess the robustness of the solutions concerning both objective functions and levels of confidence. Measures such as coverage and generation distance are employed to evaluate how well NSGA III performs in handling multi-dimensional transportation problems with multiple objectives.

Keywords: GA, NSGA II, NSGA III, Multi-objective Multi-item Five-Dimensional Transportation Problem.

## FUZZY-BASED ANALYSIS AND COST OPTIMIZATION OF A FINITE CAPACITY RETRIAL QUEUE WITH BALKING, RENEGING, AND SERVICE CONTROL

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#### ABSTRACT

This paper examines an M/M/1/K retrial queueing model under the N-policy, accounting for customer discouragement. Customers may become discouraged before entering the system or after joining the queue, particularly when the system is congested. If a customer arrives to find the server occupied, they enter a retrial orbit and attempt service again after some time, hoping the server will be free. The N-policy regulates the service process, with the server only becoming active when at least N customers are in the system. The study formulates and solves the steady-state Chapman-Kolmogorov equations using a recursive method to derive probability distributions and key system metrics. Additionally, the model is extended to a fuzzy environment by treating the input parameters as triangular fuzzy numbers (TFNs). Zadeh's extension principle (ZEP), the alpha-cut method, and parametric nonlinear programming (PNLP) are employed to develop membership functions for system size and customer loss. The numerical results, presented for both crisp and fuzzy environments, demonstrate that the fuzzy model offers more accurate and realistic system performance predictions than traditional models. Furthermore, a cost function is constructed with decision variables such as the threshold N and the service rate. This cost function is minimized using the Artificial Bee Colony (ABC) algorithm. The model's practical applicability is validated through a real-life example.

## KANNAN TYPE MAPPING AND ITS APPLICATION

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#### ABSTRACT

One of the fundamental results of functional analysis is the mapping of the Banach contraction. Typically, it is the origin of metric fixed-point theory. It also has many significant applications in many other areas of mathematics. Kannan proposed a fixed-point theorem for a map that satisfies a contraction constraint without needing continuity at every point. Kannan's fixed-point theorem is widely recognised. In this paper, I proved a few coincidence and common fixed-point theorems for Kannan type maps. Three further conditions were used: complete metric space, asymptotic regularity, and Kannan fixed point.

Keywords: Asymptotic regularity, fixed point, coincident point, metric space, and Kannan mapping.

## REVOLUTIONIZING QUERY PERFORMANCE: THE ROLE OF IN-MEMORY DATABASES

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#### ABSTRACT

In-memory databases (IMDBs) represent the next step in query evolution, harnessing the speed of RAM to reduce latency and maximize throughput. This paper identifies key technologies embodied in IMDBs, including adaptive indexing, data compression, and query workload awareness, all contributing to efficient data access and processing. However, challenges remain in terms of memory constraints, scalability, and persistence requirements. IMDBs have great potential for fields like real-time analytics, big data, and machine learning. This paper evaluates widely used IMDBs based on time to complete operations and memory usage efficiency, showing no single database excels in all data operations.

## A STUDY TO ANALYZE THE REGIONAL DISPARITIES AMONG CHILDREN AGED 12-23 MONTHS IN UTTAR PRADESH

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#### ABSTRACT

Despite implementation of universal vaccination program, Uttar Pradesh, the India's most populous state, struggles to achieve full immunization among children between the ages of 12 and 23 months. In Uttar Pradesh, the child immunization is 78.4% out of which, 60.47% of fully vaccinated children reside in East region while 73.75% in the West region. This study examined differences in childhood vaccination between the East and West areas of Uttar Pradesh using data from the NFHS-5. In total of 6,577 children aged 12-23 months old were used to analyze the factors affecting vaccination status (not vaccinated, partially vaccinated, and completely vaccinated) using multinomial logistic regression. The analysis showed that in the East Region, children from low-income and Muslim households had higher odds of being partially and not vaccinated. Furthermore, children born at home in both the regions showed higher odds of being unvaccinated. In the West Region specifically, children from Muslim households had greater odds of being not vaccinated, while those from low-income households had higher odds of being partially vaccinated. Across both regions, children whose mothers received tetanus injection before delivery showed lower odds of being partially and not vaccinated. Children born in the rural household showed lower odds of being not vaccinated in the East region and lower odds of being partially vaccinated in the West region. According to the study, children residing in the West region had higher immunization status than those who lived in the East region. The study highlighted that child in the West had better immunization rates, possibly due to higher maternal education levels and more mothers receiving tetanus injections in this region. According to the study, the immunization program needs to be more area-specific because Uttar Pradesh is a diverse state with different vaccination status in each region depending on several variables.

## HEALTHCARE UTILIZATION PREDICTORS AMONG ELDERLY POPULATION IN INDIA: EVIDENCE FROM LONGITUDINAL AGEING STUDY (LASI)

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#### ABSTRACT

Healthcare utilization among the elderly in India is affected by multiple factors, and identifying the predictors of healthcare usage is crucial for enhancing healthcare delivery to this vulnerable population. This study aims to identify the factors that influence health facilities utilization among the older population in India. Limited research has been conducted on the impact of demographic aging on health and healthcare utilization. Therefore, this study focuses on examining the trends in illness prevalence and healthcare-seeking behavior among older individuals in India. The objective is to shed light on the determinants that shape healthcare-seeking behaviours, morbidity prevalence utilization of public and private health facilities for enhancing access and utilization of healthcare services for older adults. To understand the socio-demographic factors affect the prevalence of morbidity and healthcare utilization among older individuals, univariate, bivariate, and binary logistic regression analyses are done.

Keywords: elderly, healthcare utilization, predictors, India, socioeconomic factors, health insurance, rural healthcare, chronic illnesses, culture, health literacy.

## THE TOURISM BRANDING INFLUENCE ON COUNTRY BRAND STRATEGY: CASE ANALYSIS OF UNITED KINGDOM FOOTBALL

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#### ABSTRACT

The current age is the most prosperous for English football having a distinct culture from the UK and having a well-known and complicated league structure. In addition to being profitable, this success has assisted the economy in overcoming recent financial challenges. The influence of football teams on destination branding is still a worry despite their capacity to create income and support the faltering economy, and further study is required. Given that cities strive to have distinctive brand identities and use various branding techniques, this research investigates the function of football teams in destination branding. They are focusing on the influence of football clubs through cross-case studies and in-depth interviews in the UK. These cases of Welsh Premier League clubs and the main cities were analyzed to determine the impact of football clubs as the brand signals. Four indepth interviews were conducted in London and Birmingham, big cities, to explore the influence of a famous fan club on the town. Upon analyzing the cases and interviews, only a few factors were identified as crucial to a successful partnership between football clubs and destinations. Therefore, it is recommended that further research be done in different cities using various research methods to examine this relationship. This additional research could assist numerous cities in developing their branding strategies around football clubs. The paper proposes that integrating new technology is the immediate solution, which should be accompanied by an understanding the context of its application and specific effects on Asian culture and Western society. In the future, technology and business methodology should be developed with the active involvement of customers, corporations that interact with the community, institutions, and stakeholders, and the new perspective of football clubs.

## **FUZZY TRI-IDEALS IN SEMIRINGS AND METATHEOREM**

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#### ABSTRACT

Point-wise definition of the concept of fuzzy (left tri-, right tri-, tri-) ideals in semirings are developed, and the equivalence between these definitions and the previous set-theoretic formulations is established. Additionally, we explore their characterizations within the context of semirings, guided by Tom Head's metatheorem. In this paper, various applications of the metatheorem are presented, providing fuzzy analogs of results related to these notions without involving complex calculations. The proofs derived via the metatheorem are concise, straightforward, and free from computational complexity. Furthermore, the characterization of fuzzy tri-ideals in both simple and regular semirings is thoroughly examined. It is demonstrated that the classes of fuzzy tri-ideals, along with other types of fuzzy ideals in a semiring, are closed under projection. The regularity of semirings is also investigated through the notions of fuzzy left (right, two sided, and tri-)ideals, utilizing the metatheorem framework.

## EXPLORING AI IMPACT ON SUSTAINABLE SUPPLY CHAIN PRACTICES: A BIBLIOMETRIC STUDY

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#### ABSTRACT

This study conducts a bibliometric analysis to explore the integration of Artificial Intelligence in sustainable supply chain management, aiming to bridge the gap between AI research and its environmental and social impacts. Using the PRISMA framework and Scopus database, 51 scholarly articles from 2014-2024 were analyzed. The study identifies key trends, themes, and gaps in the literature, highlighting AI's role in improving decision-making, optimizing operations, and promoting sustainability. Findings suggest AI significantly contributes to reducing the bullwhip effect, enhancing supply chain resilience, and improving transparency, with implications for future research, business practices, and policy development in sustainable supply chains.

## CONTROLLABILITY RESULT FOR SEMILINEAR INTEGRODIFFERENTIAL SYSTEM WITH DELAY IN CONTROL

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#### ABSTRACT

This manuscript delves into the controllability analysis of a class of semilinear sytems described by integrodifferential equations with fixed delay in control. Initially, we establish suitable conditions to ensure the existence of solutions. Thereafter, the sufficient conditions are obtained for the controllability of semilinear system. Finally, an example is provided to illustrate the practical relevance of the theoretical findings.

## UNRAVELING THE GENDER WAGE GAP IN INDIA: A STUDY USING SAMPLE SELECTION-ADJUSTED QUANTILE REGRESSION

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#### ABSTRACT

The gender wage gap in India constitutes a significant socio-economic issue, reflecting disparities in compensation between men and women for comparable work. This research utilized the quantile regression (QR) model to analyze wage differences across various income levels, incorporating sample selection correction to address sampling biases by considering factors such as marital status and the number of dependent family members, which may influence an individual's employment decision. Data from the National Statistical Office's Periodic Labour Force Survey 2022-23 was employed, and a copula function was applied to model the dependence structure between the selection process and wages. Findings from the QR model demonstrated that male employees generally received higher daily wages across all percentiles compared to female employees. Variables such as age, area, and social group also contributed to wage disparities, with differing impacts based on gender and percentile. However, higher education levels, both general and technical, provided more significant benefits to females, thereby reducing the wage gap at higher percentiles. The bootstrapped decomposition, based on the sample selection-adjusted QR model, revealed substantial unexplained effects at higher percentiles of the wage distribution. By accounting for the fact that only employed individuals have observable wages, which can lead to biased estimates of the wage distribution, our study's model offered more robust and reliable estimates of wage distribution across different quantiles. This research emphasizes the necessity of advanced statistical techniques, such as QR with sample selection correction, to unravel the complexities of the gender wage gap.

## AN EXTENDED CLASS OF ESTIMATORS OF THE POPULATION MEAN UTILIZING SUPPLEMENTARY INFORMATION: A SIMULATION STUDY

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#### ABSTRACT

The primary objective of this study is to suggest an efficient class of estimators of population mean by utilizing information from auxiliary variable to enhance the efficiency of the estimator of a target variable. We have computed the bias and mean squared error (MSE) of a proposed class of estimators under a large sample approximation, focusing on first-order terms. Comprehensive theoretical and empirical analyses have been conducted to demonstrate the superior performance of the suggested class of estimators compared to existing estimators. Additionally, a simulation analysis was performed to judge the performance of the suggested family of estimators with the other mentioned estimators.

Keywords: Auxiliary Information, Bias, Mean Square Error, simple random sampling without replacement (SRSWOR).

## ADVANCED MULTI OBJECTIVE PORTFOLIO OPTIMIZATION USING HYBRID DEEP LEARNING AND EVOLUTIONARY ALGORITHMS

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#### ABSTRACT

This study introduces multi-objective portfolio optimization by combining a hybrid deep learning model and its solution with advanced evolutionary algorithms. This hybrid model integrates LSTM, GRU, and CNN architectures to predict stock prices using historical market data accurately. The process begins with Initially, historical stock market data is utilized to develop a foundational understanding of market behaviors. This data is then precisely processed and prepared for deep learning models, ensuring the models have the highest quality input to generate accurate predictions. This study utilizes the deep learning model and LSTM to capture temporal dependencies in stock prices, enabling precise future price predictions. The portfolio optimization model maximizes return, skewness, and entropy, while minimizing variance and kurtosis with transaction costs and budget constraints to build a robust portfolio. The model is tested using four data types: historical data, actual & amp; predicted data from the deep learning model during the testing phase and future forecast data, offering a comprehensive evaluation framework. The optimization is further enhanced using four evolutionary algorithms: Genetic Algorithms, NSGA-III, NSGA-III, and an aspiration level-based NSGA-III. These algorithms address the multi- objective nature of the problem, providing flexible and adaptive portfolio solutions tailored to different investor preferences.

Keywords: Portfolio Optimization, Hybrid Deep Learning, LSTM, Evolutionary Algorithms, AL NSGA-III, Investment Strategy.

## **EXPLORING LFSR-ENCRYPTION FOR DICOM IMAGES**

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#### ABSTRACT

In this paper, we examine the application of linear feedback shift registers (LFSRs)-based stream ciphers for the encryption of digital imaging and communications in medicine (DICOM). DICOM is the de facto standard for generating images from a variety of medical technologies and communicating such images in different platforms. The meta information stored in these digital images are of privileged nature and their security is very critical, not only when the images are at rest but also in motion. Since DICOM was established in the early 1990s and with the proliferation of cloud-based technologies, interests in the study of security protocols for DICOM images have been on the increase. Encryption plays a major role in these security protocols. Several encryption algorithms have been applied. Linear feedback shift registers-based encryption is breakable, therefore, this paper addresses cascading LFSR-based encryption algorithms that ensure nonlinearity in the generated keystream. This encryption is more secure and typically less in computational cost. The results from use cases demonstrate suitability of the cascading LFSR encryption.
### ANALYSIS OF THE STATE OF CYBERSECURITY IN NIGERIA

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#### ABSTRACT

In this paper, we provide an exposition of cybersecurity in Nigeria in West Africa. The paper shed some lights on the differences in the concepts of cyberspace, cyber domain, Internet and cybersecurity and the historical perspective of cyber infrastructure in Nigeria. Within the last two decades, Nigeria has recorded an exponential growth in cyber infrastructure and mobile connectivity, telecommunications and information technologies. Consequently, this growth is not without heighten level of security challenges in cyberspace. The research examines pertinent cybersecurity attacks in Nigeria, providing a variety of attack incidents. Adopting lessons learned from previous security attacks in Nigeria and from other nations of the world, this paper attempts to provide important cybersecurity solutions for Nigeria and nations of similar challenges.

# INTEGRATING VR, EGLO, AND TRADITIONAL METHODS FOR ENHANCED CONSTRUCTION SAFETY TRAINING

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### ABSTRACT

The construction industry has several issues associated with accident incidence prevention and mitigating occupational risks. Traditional safety methods are exhausted in many cases as they may not consider the changing and complex factors in construction environments. This research wants to explore the impact of Virtual Reality (VR) and Environmental Graphics Light Overlay (EGLO) systems on safety in the construction sector. The study looks at the efficiency, user experience, and side effects of VR and EGLO compared to safety training programs. It also evaluates the performance of VR and EGLO safety training programs in terms of accident reduction rates post-implementation in the construction sector, as well as the cost considerations when using these training programs. The study proposes an outline for the use of VR and EGLO during safety training programs in the construction industry based on the results of the study. The study is designed to equip the readers with practical recommendations to improve safety procedures and eliminate risks during construction.

# TECHNOLOGY INTEGRATION IN HIGHER EDUCATION: FACULTY PERSPECTIVES ON INTERACTIVE LEARNING TOOLS

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#### ABSTRACT

This study delves into the utilization of online interactive learning tools by faculty at the Higher Colleges of Technology (HCT) in the UAE. Drawing upon data from a survey of HCT faculty, we examine the frequency, duration, and preferred types of interactive tools employed, alongside perceptions of their usefulness, complexity, and impact on teaching and learning. Descriptive analysis reveals that Nearpod and Kahoot are the most preferred interactive learning tools among HCT faculty, with a significant majority using these tools frequently. Furthermore, faculty reported spending an average of 4 to 7 hours per week on interactive learning tools, indicating a considerable investment in this technology. The analysis also highlights a strong perception of usefulness among HCT faculty, with most respondents agreeing or strongly agreeing that interactive tools enhance students' learning, effectiveness, and productivity. However, the study identifies notable concerns regarding perceived complexity and technophobia, suggesting that further support and training may be necessary to overcome these barriers. These findings offer a snapshot of the current landscape of interactive tool integration at HCT, providing valuable insights for educators, policymakers, and technology developers in fostering a more technology-driven learning environment.

# EARLY DETECTION OF PALM TREE DISEASES USING A TAILORED DEEP LEARNING MODEL AND HYPERSPECTRAL IMAGING DATA

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#### ABSTRACT

Agriculture is a critical field of study, especially in the context of food security and sustainability. Within this domain, the early detection and classification of plant diseases are vital for preventing the spread of diseases that could lead to significant yield losses. This task, however, poses several challenges for researchers specializing in computer vision. While many state-of-the-art methods have been proposed for plant disease classification, these approaches often face limitations such as handling noise in images, effectively extracting relevant features, and excluding redundant information. Deep learning models have recently gained prominence in this area due to their ability to automatically learn complex features from data, making them highly effective for tasks like plant leaf disease classification. This study proposes two deep learning approaches for classifying palm leaf diseases. Residual Networks (ResNet) and transfer learning with Inception-ResNet. ResNet's deep architecture and skip connections enhance feature learning, addressing issues like image luminance variation and inter-class similarity. Meanwhile, Inception-ResNet utilizes pre-trained models adapted for palm leaf disease, improving classification with minimal training data.

Keywords: Deep Learning, Plant Disease Classification, Hyperspectral Imaging, Residual Networks (ResNet), Transfer Learning.

# TIME SEQUENTIAL BIPOLAR FERMATEAN HESITANT FUZZY CONFIGURATION IN INTEGRATION TO A NON-LINEAR TRANSPORTATION MANAGEMENT FOR CORRUGATED WASTE WITH CIRCULAR ECONOMY

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#### ABSTRACT

In the era of increasing environmental awareness, the importance of efficient waste management cannot be overstated. Cardboard stands out among the many materials contributing to waste generation. With proper cardboard collection and recycling practices, one can make a significant difference and lead the way toward a more sustainable future. In this regard this article configured an integrated green non-linear transportation system with circular economy approach to mitigate the negative affect of old corrugated carboard (OCC) on social, economic and environmental sites. This non-linear transportation system aims to optimize objectives including overall transportation expenses (TE), greenhouse gas emissions (GHGE) and overall transportation time (TT). One sub model is further developed from the proposed model by disuniting the effect of the circular economy. Here, to depict the uncertainty time sequential fermatean bipolar hesitant fuzzy set (TS-FBHFS) is devised along with its all-dimensional aspects. The suggested transportation system is addressed by employing two approaches, weighted sum technique (WST) and global criterion method (GCM). Finally, there is a case study, management insights, and a conclusion with limitations and future plans.

Keywords: 4-dimensional transportation problem, non-linear transportation problem, fermatean fuzzy set, circular economy, time-sequential fermatean bipolar hesitant fuzzy set, corrugated waste, municipal waste management, sustainability

# IMPROVED PARTICLE SWARM OPTIMIZATION TECHNIQUE TO SOLVE THE NON-LINEAR TRANSPORTATION PROBLEMS: AN APPLICATION

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#### ABSTRACT

The key objective of this research is to address the NP-hard non-linear transportation problems that occur in industry. These types of problems are challenging to tackle using the traditional approaches as these methods are generally inefficient for the non-linear problems, computationally costly and these may stuck at the local optimal solutions. Hence, this paper presents an improved version of the particle swarm optimization that involves non-linear acceleration parameters to solve such problems. Additionally, an innovative negative repair procedure and fraction repair procedure is also proposed to maintain the non-negative nature of the transportation problem's solution. The small scale as well as large-scale transportation problems are solved to test the efficiency of the said algorithm. The obtained results are compared with seven existing variants of particle swarm optimization. The comparative analysis shows that the suggested method offers better solutions for each considered problem and that too in a lesser computational time.

# SINGLE-SERVER POISSON QUEUE INVENTORY SYSTEM WITH THRESHOLD SERVICE AND RANDOM ORDER SIZE POLICY

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#### ABSTRACT

We have a supply chain (SCM) that delivers to a retail store (RS) tied to a queueing inventory system (QIS). RS activates orders of up to Q units when inventory drops from Q to zero with SCM's random ordering policy. This SCM, after receiving the order from RS, will deliver packages of size j > 0 with probability r j, where  $\sum (j=1)^{O}$  i = 1, at the end of the delivery period. Suppose such delivery times follow an exponential distribution with parameter "n." This SCM addresses customer requirements for a unit through an M/M1+M2/1/Kpolicy service facility. Requests arriving at the RS node follow a Poisson process with a parameter ( $\lambda$ ).Each customer requests a single unit of the item and is served by a single server in a first-come, first-served (FCFS) manner, after an exponential service time with a parameter  $\mu$  ( $\mu$ > 0) if the queue length is less than or equal to K or otherwise the server increases the service rate by  $\mu$  1> $\mu$ . The server will take a few breaks after the inventory is exhausted. When the server finishes serving a customer and finds that the inventory is empty, the server goes into an exponential vacation mode with parameter  $\theta$ . Customers cannot enter the system when the available inventory level is 0 or when the server is down due to a vacation. Various performance measures are computed for a two-variable system Z=(X(t), I(t)), where X(t) denotes the number of customers present and I(t)the number of units available in inventory. The expected total cost (TEC) based on storage cost, customer loss cost, replenishment cost, and waiting time cost is computed for a given data set with varying O values. The numerical results show the optimal result for economic order quantity, i.e., Q\* and TEC (Q\*).

# MODEL-ASSISTED OPTIMAL ALLOCATION FOR UNEQUAL PROBABILITY TWO-STAGE CLUSTER DESIGNS

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### ABSTRACT

The literature on small area estimation is mostly concerned with analysis methods, while effective sample design for small areas has received less attention. Optimal allocations have been developed for stratified sampling, where strata consist of the small areas and the goals include efficient composite estimation of small area means. In many situations, however, it is not feasible for every small area to be represented in sample. This paper develops optimal designs allowing for this case, by assuming unequal probability two-stage sampling where clusters are small areas. The aim is to minimize a linear combination of the anticipated mean squared errors of composite small area estimates and a grand mean estimate. The optimal design has the undesirable property that some clusters may have zero probability of selection. Several alternative designs, including making the cluster selection probability proportional to a power of the cluster size, are found to perform nearly as well as the optimal allocation but with better practical properties. Designs are evaluated numerically using Switzerland canton data as well as Botswana districts data.

### ESTIMATING GARCH MODEL FOR GOLD PRICE RETURNS

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#### ABSTRACT

The rate of returns of any stock from time to time is constantly changing due to available supply and demand made by stakeholders. In this study, we propose a volatility model for gold price series of daily observations using the stan-garch function of the 'bayesforecast' package. For this work, we will use the recent 2500 observations to estimate the Bayesian GARCH (Generalized Auto Regressive Conditional Heteroskedastic) parameters. This study focuses on samples under the assumption of a studen's-t distribution and a normal error distribution.

Keywords: rate of return, volatility, GARCH, student-t, MCMC, estimates.

# ON MODELING ROAD ACCIDENT DATA USING NEGATIVE BINOMIAL AND GENERALIZED POISSON REGRESSION

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#### ABSTRACT

Fatalities caused by road accidents have become a major concern worldwide and road traffic accidents almost every day. According to the World Health Organization, approximately 1.3 million road users are at high risk of road accidents yearly. Road accidents are a significant public health issue globally, leading to loss of life, injuries, and economic costs. Understanding the factors that contribute to road accidents and predicting the frequency of these events is critical for developing effective traffic management policies and safety interventions. Statistical models, such as the Negative Binomial (NB) and Generalized Poisson (GP) distributions, are often used to model count data, such as the number of accidents occurring over a specific period or in a particular area. These models help account for the inherent variability and over-dispersion in road accident data

# TOPP-LEONE-LOGISTIC ODD BURR X-G FAMILY OF DISTRIBUTIONS WITH APPLICATIONS

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### ABSTRACT

In this paper, a new Topp-Leone-Logistic Odd Burr X-G family of distributions is developed and its properties are explored. Several special models are presented from which the Topp-Leone-Logistic Odd Burr X-log-logistic (TL-LOBX-LLoG) distribution is used for simulation studies to compare several estimation methods including maximum likelihood estimation, Anderson-Darling, Right-Tail Anderson Darling, Cramer-von Mises, ordinary and weighted least-squares. Furthermore, the TL-LOBX-LLoG distribution is applied to real life data and compared to some competing models. Parameters of the Topp-Leone logistic Odd Burr X-LLoG distribution are best estimated by the maximum likelihood method. The TL-LOBX-LLoG distribution outperformed competing models.

Keywords: Topp-Leone, Logistic, Odd Burr-X, Estimation Method, Simulations.

# THE ANALYSIS OF RELIABILITY DATA USING A TRANSFORMED MODEL

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#### ABSTRACT

We present the exponentiated generalized alpha-log-power transformed approach, a novel generalization of the alpha log power transformed-G family which does not derive from any existing parent model and introduces two new shape parameters. There are numerous examples of the new family given. Furthermore, a number of significant statistical characteristics of the new family are examined. The new family's model parameters are estimated using the maximum likelihood estimation technique. A member of the exponentiated generalized alpha log power transformation is used in Monte Carlo simulation to assess the estimators' performance using the exponential model as baseline. The potential relevance and usefulness of the exponentiated generalized alpha log power transformed exponential are empirically demonstrated using two genuine reliability datasets. When it comes to describing observations in survival analysis, the innovative model is highly competitive.

# **RECENT ADVANCEMENT AND SUCCESSES OF ANTIBACTERIAL ACTIVITY OF SCHIFF BASES AND THEIR METAL COMPLEXES**

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### ABSTRACT

The researcher developed new antimicrobial compounds from a variety of sources as a result of microbial resistance. As a result, greater attention is being paid to the screening and evaluation techniques for antimicrobial activity. Schiff bases and related lanthanide complexes have received far greater attention in the fields of pharmacology, medicine, and science. As a result, in an effort to validate claims of biological activity, numerous papers have proven the therapeutic benefit of synthetically produced substances. Interest in Schiff base compounds has grown as a result of recent research showing that coordination with a metal ion significantly improves their anticancer, antibacterial, antiviral, and antifungal activity. Since the 19th century, lanthanides have been studied for their antibacterial properties and used to cure various ailments, with varying degrees of effectiveness. This article has examined significant research on Schiff bases and their lanthanide complexes that deal with crystal structure, antibacterial activity methods, antibacterial data, and the mechanism that makes lanthanide complexes more active than free ligands.

Keywords: Schiff bases, lanthanide complexes, antibacterial activity, antibacterial measurement techniques

# A NOVEL APPROACH TO OPTIMIZE TRANSPORTATION MODELS IN TYPE-2 FUZZY FRAMEWORK

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#### ABSTRACT

This research introduces a novel approach to optimize the transportation problems within Type-2 fuzzy environment. The primary goal is to develop a cutting-edge methodology that leverages a type-2 fuzzy logic to enhance the optimization of transportation problems (TP). To validate the effectiveness of the proposed approach, it was applied to numerical examples drawn from the established literature, followed by an in-depth analysis. The performance of the method was rigorously assessed using specific numerical indices, demonstrating that it outperforms existing techniques. The findings indicate that this approach is not only highly effective but also widely applicable across various transportation problem scenarios.

Keywords: Optimization, Transportation problem (TP), Fuzzy set, Type- 2 fuzzy set.

# DARK MATTER-DARK ENERGY INTERACTIONS: NEW PARAMETRIC INSIGHTS

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### ABSTRACT

In this study, we revisit the interaction between dark matter (DM) and dark energy (DE) within the framework of a spatially homogeneous and isotropic Friedmann-Robertson-Walker (FRW) universe. Our primary focus is to explore the behavior of cosmological parameters—such as deceleration, density, and equations of state—under various parametric approaches. By employing a novel parametrization of the scale factor, we provide new insights into the evolution of DM-DE interactions and their potential to resolve outstanding issues in the ACDM model, including the cosmic coincidence problem. Our results suggest that DM-DE interactions can significantly alter the expansion history of the universe, particularly in the transition from deceleration to acceleration. Furthermore, we discuss the implications of these findings for future observational studies and propose a refined method for fitting cosmological data, enhancing the model's relevance to contemporary astronomical datasets. These insights pave the way for improved consistency between theoretical models and observational data.

# FACTORS INFLUENCING DIGITAL TRANSACTION ADOPTION IN INDIA: A DEMOGRAPHIC AND BEHAVIORAL ANALYSIS

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#### ABSTRACT

This study provides a descriptive analysis of key factors influencing the adoption of digital transaction systems in India. Drawing on survey data from 317 respondents, the analysis focuses on demographic characteristics such as age, gender, income, and education level, as well as behavioral aspects like continuous intention to use and innovation resistance. The findings reveal that the majority of the respondents are male (74.8%) and fall within the age range of 40-49 years (31.9%). Higher-income groups (more than ₹45,000 per month) and individuals with postgraduate education show a stronger preference for digital transactions, with 97.5% of respondents expressing a clear preference for using digital transactions. Furthermore, 45.7% of respondents "Agree" that they will continue using digital transactions regularly in the future, while 53.9% "Disagree" with the statement that they may use digital transactions in the future but not now, suggesting a general inclination toward immediate and sustained usage. However, about 11.4% of respondents report some degree of resistance, indicating hesitation in adopting digital transactions in the near future. This descriptive analysis offers valuable insights into the demographic and behavioral patterns of digital transaction adoption in India. These findings provide a foundation for policymakers and financial institutions to address barriers to adoption, with particular attention to innovation resistance, and to encourage wider use of digital financial systems. Digital Payments, Behavioral Analysis, Demographics.

# COST OPTIMIZATION OF MODULE BASED DISCRETE SOFTWARE RELIABILITY MODEL WITH TESTING EFFORT FUNCTION

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### ABSTRACT

The present investigation discusses the module based discrete software reliability growth model with imperfect debugging and testing effort function. In this paper we consider a software system consist of different types of failures. We suggest reliability concept to improve the better quality of software and also discussed optimal release policies on cost and reliability functions. A sensitivity analysis on cost and reliability functions are performed to validate the numerical results.

Keywords: Modular software, Discrete SRGM, Imperfect debugging, Testing effort function, Optimal release policy.

# DECOMPOSED NEUTROSOPHIC SET AND ITS APPLICABILITY IN A SOLID TRANSPORTATION SYSTEM

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#### ABSTRACT

The purpose of this article is to explore a Decomposed Neutrosophic Set that combines a Decomposed Fuzzy Set and Neutrosophic Set. Additionally, the proposed set includes the fundamental operations as well as a ranking function. To elaborate the pragmatic applicability of the proposed set, a three-dimensional transportation system with multiple objectives is formulated. Optimum profit and workload deviation are the goals of the model. We deploy a -constraint in order to verify that the established transportation system is Pareto optimal. Through a numerical example, we give a deeper understanding of the proposed model's complexity, providing insight into how it works. Furthermore, conclusions outline unforeseen avenues for future research and exploration.

# A SYSTEMATIC REVIEW OF THE EVOLVING ROLE OF THE METAVERSE IN TOURISM

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#### ABSTRACT

The area of tourism is rapidly transforming with the introduction and use of artificial intelligence (AI) systems. The metaverse is a new way of interacting with reality and is bringing major changes to tourism, and, is increasingly being used in the travel experience. The metaverse is a virtual platform, which delivers Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR), collectively referred to referred to as Extended Reality (ER), and is changing the travel experience. The metaverse, a shared virtual environment, delivers the tourist into a visual, audio, and haptic environment. According to Statista, virtual tourism is projected to reach \$24.1 billion by 2027. Using the Academic Search Ultimate, Business Source Complete, and Hospitality & amp; Tourism Complete databases, an initial keyword search on "metaverse tourism" yielded 107 results. After reading and reviewing all titles, abstracts, and keywords, and excluding non-tourism and non-academic journals, and duplicates or irrelevant articles, a selection of 94 articles was made. Page et al. (2020), was used for the systematic content review and analysis of the role of the metaverse in tourism research, published between 2020-2024. The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA 2020) helps identify relevant studies, objectively summarize large amounts of data, and synthesize and report study results. This study will provide a systematic review of the evolving role of the metaverse in tourism, and, identify significant trends and key themes in the current literature regarding the use of the metaverse by tourism and destination marketing organizations (DMO). The results of this study will provide insight into the practices and the use of the metaverse in tourism and destination marketing and branding, and, the potential for increasing tourism and improving customer experiences.

# IMPACT OF POULTRY LITTER AND ALTERNATE NUTRIENT AMENDMENTS ON HEIRLOOM TOMATO GROWN UNDER CONVENTIONAL AND ORGANIC CONDITIONS

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#### ABSTRACT

This Evans Allen funded project was to compare poultry litter (PL) and alternative fertilizer sources for their effects on tomato plant development, productivity and economic return in organic and conventional systems. A 3-year field study was conducted under organic and conventional systems using heirloom tomato (Lycopersicon esculentum) cultivars, Brandywine Red (BR) and Debarao Plum. The experiments over three years were conducted using a split plot design with four replications; cultivar was the main plot and soil amendments was the subplot. Main and interaction effects were tested with analysis of variance using proc GLM. Multiple comparisons with least square means were performed by Tukeys Studentized range test. Using poultry litter (PL) and alternate sources as fertilizer for heirloom tomatoes did not affect the growth characteristics (SPAD, shoot biomass, marketable yield) of the organic plants and had limited effect on conventionally grown ones. However, the cultivars sometimes responded differently in their SPAD, biomass and yield. The economic analysis showed that the organic tomatoes could be grown profitably when fruits are harvested in full growing season.

# PEDAGOGY AND PROMISE: USING THE FEDERAL RESERVE CHALLENGE AS A LEARNING MECHANISM

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#### ABSTRACT

The Collegiate Federal Reserve Challenge is a team competition for undergraduate students held across all Federal Reserve districts in the United States. Teams analyze current economic and financial conditions in the economy focusing on inflation and employment. Teams use theoretical approaches, models and data trends to arrive at a set of monetary policy recommendations. Our team models the Governors on the Federal Open Market Committee and presents findings from varying perspectives. Teams make presentations to a panel of judges who are experts in economics and monetary policy. Presentations include an analysis of current economic conditions (up to the day of the competition). These conditions may include broad macroeconomic conditions as well as conditions experienced in different geographic areas, in urban/rural areas, or among different demographic and socioeconomic groups (e.g., racial and ethnic groups, age groups), borrowers and savers, etc. A forecast of near-term economic and financial conditions relevant to the formulation of monetary policy is made keeping risks to the upside and downside in consideration. Finally, a monetary policy recommendation is made on the stance, interest rates and other necessary financial tools to implement the policy. The policy response may include both traditional tools and newer approaches as warranted. Using data analysis tools, it is also possible to forecast what monetary policy moves the Federal Reserve is likely to make. The faculty authors have experience in fielding more than 20 teams in the annual competitions.

# AI-DRIVEN FORECASTING MODELS IN CRM-ERP SYSTEMS FOR SUPPLY CHAIN OPTIMIZATION

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### ABSTRACT

The integration of AI with CRM and ERP systems has revolutionized the management of supply chain operations by enabling comprehensive predictive capabilities. Utilizing machine learning techniques like as neural networks, regression methodologies, and time series analysis, these models have the potential to enhance logistics, control inventory levels, and forecast demand. By integrating vast amounts of data from all stages of the supply chain, these models may enhance inventory management, reduce carrying costs, and optimize resource allocation. Accurate forecasting of demand, supplier performance, and lead times enables more effective supplier selection and contract negotiation decisions, therefore enhancing supply chain management. Integration of artificial intelligence (AI) with customer relationship management (CRM) and enterprise resource planning (ERP) systems enables firms to actively track their supply chain operations in real-time, therefore facilitating prompt responses to market fluctuations. The use of AI-supported personalized marketing and service methods will lead to increased customer satisfaction. However, there are challenges such as concerns about data privacy, complex integration processes, and the ongoing need to train and assess models. An effective approach is to implement a hybrid model that integrates artificial intelligence with conventional statistical techniques and strong data governance. The results indicate that AI-driven forecasting models significantly enhance supply chain optimization, inventory management, and real-time decision-making practices. Further investigation on the scalability and implementation of AI-driven models in many industries is necessary to sustain a competitive advantage in the global market.

Keywords: Artificial Intelligence (AI), Customer Relationship Management (CRM) and Enterprise Resource Planning (ERP) and Forecasting.

# DESIGN OF SMART BATTERY MANAGEMENT SYSTEM FOR ELECTRIC VEHICLE

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### ABSTRACT

Battery management system (BMS) emerges a decisive system component in battery-powered applications, such as (hybrid) electric vehicles and portable devices. However, due to the inaccurate parameter estimation of aged battery cells and multi-cell batteries, current BMSs cannot control batteries optimally, and therefore affect the usability of products. In this paper, we proposed a smart management system for multi-cell batteries, and discussed the development of our research study in three directions: i) improving the effectiveness of battery monitoring and current sensing, ii) modeling the battery aging process, and iii) designing a self-healing circuit system to compensate performance variations due to aging and other variations.

# CONSUMERS' PERCEPTION OF GREEN MARKETING TOWARDS ECO-FRIENDLY FAST MOVING CONSUMER GOODS: A SYSTEMATIC LITERATURE REVIEW

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#### ABSTRACT

Because of increasing care towards the environmental sustainability, Eco-friendly products are now being demanded everywhere hence these organizations start taking using of green marketing. A systematic literature review (SLR) is conducted to uncover consumer perceptions and attitudes of green marketing in case of eco-friendly fast moving consumer goods (FMCG). The purpose of the article is to summarize the results from previous research about green marketing strategies and environmentally friendly products and to discuss what are the pros and cons for companies when they decide to invest in these kinds of campaigns. habbofy, n.d.) The SLR employed a rigorous methodology to guide the systematic identification, selection, and examination of pertinent research studies or articles, then data extracted findings that were structured and critically appraised for key insights. The review suggests that, even if the level of consumer consideration for green product has increased, more and better education and communication is necessary to stimulate the bridge towards an increase in actual purchasing behavior. Perceived environmental benefits, product quality, price and brand trust are factors affecting consumer preferences for green FMCG. The review also brings to the fore some sustainable green marketing strategies, and research issues for future studies. The results may help FMCG companies in designing focused green marketing campaigns and will also help in achieving the ultimate aim of sustainable development.

Keywords: Green marketing, Eco-friendly products, Consumer Perception, FMCG, Sustainable consumption.

### SECURE CACHING AND COMPUTING FOR EDGE COMPUTING UTILIZING BLOCKCHAIN TECHNOLOGY

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#### ABSTRACT

According to the significant increase in user traffic, it is necessary to position edge servers near Internet of Things (IoT) devices. This allows for the transfer of computational activities to the edge servers. The objective of this approach is to reduce the overall delays of traffic requests by allowing user/IoT devices to perform time-sensitive tasks locally or transfer them to edge servers within the edge computing framework. This new approach will enable the caching of data at edge servers. However, due to the growing number of user requests and the limited storage capacity of edge servers, selecting which content to cache at the edge is a difficult task. Furthermore, although there is widespread agreement that this technology has the potential to offer numerous advantages, there are significant concerns regarding its security ramifications. The reason for this is that malevolent users have the ability to manipulate the caching decisions made by the edge servers by sending fraudulent traffic requests. This manipulation results in a decrease in the caching effectiveness of the edge servers, which are already limited in their resources. In this paper, we present a content caching and computation strategy that utilizes blockchain technology to verify the legitimacy of cached content and prohibit illegitimate queries from fraudulent clients. The Proof of Stake (PoS) consensus method is designed to efficiently handle low computing work, verify block operations, and facilitate activities among edge servers and authorized users. Next, a solution relying on Deep Q Network (DON) is suggested to intelligently create a content caching and computation approach that is efficient. Based on the performance evaluation, the presented approach demonstrates a substantial improvement over the traditional caching approaches. On average, it enhances the cache hit rate by up to 8.2% and decreases the response delay by up to 7.45%.

# USING HYBRID GATED RECURRENT NETWORKS TO ANALYZE TWITTER SENTIMENT AND UNVEIL SENTIMENTS

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#### ABSTRACT

The most popular and active area of data mining study is sentiment analysis. Twitter is an important instrument for gathering and disseminating people's thoughts, feelings, views, and attitudes regarding specific entities. There are several social media platforms available today. Due to this Natural Language Processing is applied for sentiment analysis field gave rise to fascinating. While numerous methods for sentiment analysis have been devised, there is always room for improvement in system efficiency and accuracy. The suggested framework combines sentiment analysis based on deep learning with efficient optimization-driven feature selection to tackle these requirements. On a dataset of 140 sentiment-labelled texts, we assessed the efficiency of the proposed (GRN) architecture named gated recurrent network. We first cleaned and filtered the dataset to remove any errors or inconsistencies. Then, we used accuracy, precision, to measure and same time we also calculated performance metrics to estimate recall, and F-measure towards the GRN. The results which we have found and shows that on the dataset, the GRN performed at the cutting edge. These results suggest that the GRN is a promising new architecture for sentiment analysis.

Keywords: Deep learning, gated recurrent network, natural language processing, Twitter sentiment.

# IN THE RUPEES' REACH: A COMPREHENSIVE ANALYSIS OF FINANCIAL INCLUSION DETERMINANTS IN INDIA

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#### ABSTRACT

This research explores the complexities surrounding financial inclusion in India using data from the Findex 2021 database and employing a Probit model methodology. Our aim is to examine the determinants and barriers affecting the effectiveness of financial inclusion policies, exploring the dynamic interplay between socioeconomic factors, policy interventions, and individual behaviors. Through a comprehensive analysis, we seek to shed light on the intricate dynamics shaping inclusive financial ecosystems. By critically evaluating the drivers of financial inclusion and the obstacles hindering progress, this study aims to offer valuable insights into policy formulation.

# A HYBRID MCDM APPROACH FOR ECONOMY-CLASS PASSENGER AIRLINE SELECTION DECISIONS

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### ABSTRACT

The airline industry is a competitive field, with various services offered by firms; therefore, it is hard for the customer to choose a company, as there are numerous selection criteria. Selection of airlines for economy class passangers depends upon various criteria. MCDM techniques are useful in airline ticketing for evaluating and selecting the best option of airline based on multiple factors. In view of the economy-class passengers, the aim of this paper is to identify the list of most preferred criteria of selecting airlines. The purpose of the research work is to identify the criteria that influence passengers while deciding to book tickets for top-ranked airlines. Here, BWM has been used to assess the weights of chosen criteria, and another MCDM, technique TOPSIS, for ranking alternatives of the airlines. A case study on a segment of a travel route from Muscat (Oman)-New Delhi (India) was considered.

# TOWARDS A CONCEPTUAL FRAMEWORK OF BUSINESS MODELS FOR CORPORATE DIGITAL RESPONSIBILITY

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### ABSTRACT

Sustainability Management has forced organisations to focus on societal issues, matters pertaining around environmental protection, climate change hence orienting firms towards Corporate Social Responsibility (CSR). The Fourth Industrial Revolution has in a parallel way radically transformed business operations, with digitalization and technological advancements thus reshaping the business landscape. Organizations are undergoing digital transformation fuelled by emerging technologies such as interconnectivity, automation, machine learning, artificial intelligence, and real-time data. Additionally, they are implementing cutting-edge digital technologies that are now at the forefront of their operations, supply chains, market coordination, and economic development. As the digital revolution progresses and data technology becomes an integral part of daily life, data responsibility is increasingly seen through the lens of Corporate Social Responsibility (CSR) and the related concept of Corporate Digital Responsibility (CDR). The aim of this paper is to design an innovative business model considering the responsible aspect of organisation's digital use and digital management while creating value.

**Keywords**: Sustainable business management, sustainable management practices, Digitalisation, Corporate Digital Responsibility, business models.

# A REVIEW ON DIFFERENT AYURVEDIC MODALITIES FOR THE TREATMENT OF KNEE OSTEOARTHRITIS WITH SPECIAL REFERENCE TO JANU BASTI

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#### ABSTRACT

Knee osteoarthritis (OA) is a prevalent degenerative joint disorder that significantly affects the elderly, causing pain, stiffness, and impaired mobility. Conventional treatments offer symptomatic relief but often fail to address the root cause of the condition. Ayurveda, an ancient holistic system of medicine, provides a range of treatment modalities that focus on the underlying imbalances, particularly of Vata Dosha, associated with knee osteoarthritis (Janu Sandhigata Vata). This review explores various Ayurvedic therapies for managing knee osteoarthritis, with a special focus on Janu Basti, a localized oil retention treatment. Classical Ayurvedic texts, including Charaka Samhita, Sushruta Samhita, and Ashtanga Hridaya, emphasize the importance of Snehana (oleation) and Swedana (fomentation) in addressing Vata disorders. Janu Basti involves retaining warm medicated oils like Mahanarayan Taila or Ksheerbala Taila over the knee joint, which helps to nourish the joint tissues, reduce inflammation, and alleviate pain. Other Avurvedic interventions for knee OA include internal medication (Rasavana for rejuvenation, Vatahara drugs), Panchakarma therapies such as Abhyanga (therapeutic massage), Swedana (herbal fomentation), and Virechana (purgation) to expel accumulated toxins. These treatments aim to balance Vata and restore joint function, promoting long-term healing. This review highlights the effectiveness of Ayurvedic modalities, particularly Janu Basti, in managing knee osteoarthritis, offering a holistic and non-invasive approach compared to modern treatments. By combining classical knowledge with clinical research, the therapeutic potential of Ayurveda in treating osteoarthritis can be further validated, providing a comprehensive alternative for patients suffering from this debilitating condition.

# ANALYSIS OF INDIA'S RELATIONS WITH NEIGHBOURS IN 21<sup>ST</sup> CENTURY WITH SPECIAL REFERENCE TO NEPAL AND BANGLADESH

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#### ABSTRACT

In this paper, we explore the difficulties of the 1950 Treaty of Peace and Friendship, which established diplomatic connections, even as historical records emphasize times of mutual regard. This paper also tries to connect China's actions in South Asia that effect India Nepal relations. This paper's goal is to draw attention to the significant changes, as those changes had a significant impact on how the relationship between two countries. Quantitative method is used in this research like conducting survey, interview. Territorial disputes and Illegal Migrants are major challenges contributing to tensions India relations with neighbours.

Keywords: common past, China's actions, territorial disputes, treaty of peace and friendship, Illegal migrants, South Asia .

#### INTRODUCTION

India's foreign policy is that India maintains peaceful relations with its neighbouring nations. India's foreign policy has also been that it opposes imperialism and colonialism. For example, we have had very good relations with Nepal. You will see that whenever a government was formed there, India has also helped in making its constitution. You will see that once a very dangerous earthquake had struck Nepal. India was the first country to help them. India had sent its army. If seen in this, India always wants to cooperate and help. It is also an important nation from a strategic point of view because it shares its borders with India as well as China. On the other hand, we have also cooperated with Bangladesh. India has helped in its rise. Bangladesh has also run many projects with the help of India. If we look at the issue of Bangladesh-India dispute, one issue is the Farakka dispute because that river flows through our India. Due to flowing between two countries, such issues often arise. India and Bangladesh share a number of issues, such as militancy, poverty, illiteracy, and the proliferation of small guns. This might be the start of a journey to create mutually beneficial ties in a world that is becoming more interconnected, despite the fact that the two nations disagree on a number of topics. (Rather,2014)

On May 31, 2010, Bangladesh and India signed a deal to complete a transshipment arrangement that would permit the movement of Indian goods through Bangladeshi territory to the city of Tripura in the northeastern Assamese state. The distance to the port of Kolkata is the primary reason why everything produced in northeastern India is difficult to market to the rest of the nation. Due to many issues, such as the increased cost of transportation, no private or international corporation will be interested in investing in the northeastern region of India as a result of globalization and the liberalization policy. hence hampering the growth of the sector in the northeast. (Dutta,2022) Transportation and commercial ties are currently the main areas of concentration in Indo-Bangladesh economic relations, with a view toward mutual progress and general development, particularly in the area of bilateral commerce. It should be noted that more than 225 Indian companies first offered foreign direct investments (FDI) worth USD 558.77 million as a gauge of this. Unfortunately, because of their continued suspicion of one another, these private companies were unable to meet expectations. (Balaji,2016)

India's political involvement in Nepal tends to rise in tandem with rising political unrest. With their India-Nepal-China Relations & A Development Strategy, the Maoist peace process got underway in 2005. Nepal's entry into the political mainstream was not an anomaly. Following the 2007 Aandolan in the Terai, India helped to foster communication between the Madhesis and the Nepali government as well as between political parties and the Maoists. Though Nepali politicians and opinion leaders made proposals urging closer Indian engagement, it purposefully avoided providing any advice on the Constitution writing exercise this time around as they got irritated with the drawn-out process. (Sood,2016) In this paper we analyse and demonstrate the India's relations with neighbours like Nepal Bangladesh in 21<sup>st</sup> Century. The aim of research is not only finding the Nepal Bangladesh relations with India but also try to find China involvement in Nepal and Bangladesh that effect India's relations with neighbours.

#### **RESEARCH METHODOLOGY**

We used quantitative approach in this study like structured interview and Survey. (Mahar, 2024)

In Survey 20 students of Masters of Arts filled a questionnaire which helped to identify the post graduate students' perspective towards changing nature of India's foreign policy. The software tool JotForm was used during making questionnaire and in analysis of data. To find out current scenario with neighbours we conducted interview of Dr. C Anupa Tirkey an Assistant professor in Government Mata Shabari Naveen Girls College, Bilaspur in Chhattisgarh. This interview helped us to gain more ideas and knowledge about India's relations with Nepal and Bangladesh.



Figure 1 Dr. C Anupa Tirkey, Assistant Professor (Naveen Girls College, Bilaspur Chhattisgarh)

#### **PROPOSED WORK**

A. Survey conducted in Govt. J.P Verma College on 25th November 2024

Out of the 20 students, 45% students agree that India always try to make peaceful relations and 30% students strongly agree about this, others remaining neutral 15%, 5% disagree and strongly disagree.

When we ask about India's relations with neighbours changed after Narendra Modi became P.M then 55% agree that it is true and 35% strongly agree about statement. Then we ask China becoming stronger day by day in South Asia, 45% agree about this but 25% also disagree on it. While asking about kalapani dispute effecting strongly India Nepal relations we got 55% students agree with this.

On the issue of Illegal migrants from Bangladesh increase tension between both countries 40% students agree on the other hand 35% disagree about it. When we ask Bangladesh and India are connected on a cultural, social, economic level than 45% students agree on the other hand 35% disagree about it. On question of 1950 Treaty of Peace and Friendship between India and Nepal now completely becoming Irrelevant 55% students agree about it remaining 15% response from each disagree, neutral, strongly agree. 65% Students agree on the fact that China is trying to manipulating small countries like Nepal and Bangladesh. 60% Students agree that Akhaura Agartala rail link is good step regarding making India Bangladesh relations stronger. While asking about 3 Sister city Agreement between India and Nepal will make India Nepal relations more peaceful then 55% Students agree about it.



Figure 1: shows the results obtained by survey of 20 students

A. Interview of Dr.C Anupa Tirkey, Assistant Professor (Naveen Girls College)

We conducted an audio interview of Dr. C Anupa Tirkey on India's relations with Nepal and Bangladesh in 21<sup>st</sup> Century. We start by asking on peaceful relations with neighbours then we get to know that India always opposes imperialism and colonialism and India always come ahead to help its neighbours whenever crisis come.

On kalapani issue she replied, Kalapani Lipu Lake issue. India showed this part in its map on 10 November 2019. Since then, there has been a little conflict between the two. Nepal got angry because of this. The reason for this is that India built a road to Kailash Man Sarovar via Lipu Lake and inaugurated it formally on 8 May 2020. Nepal strongly opposed this move.

She replied about issue of Illegal migrants from Bangladesh ", we should also see that India has its own population but a lot of refugees come to India from our neighbouring countries as well. This is one of the reasons for the increase in our population. Akhaura Agartala rail link has greatly impacted India-Bangladesh relations, whether it is a road or a railway route, if seen economically, it strengthens the relations between the two countries, but the refugee problem can increase significantly. "

Then she continued by China's role in South Asia she said "we can't stop China to influence but its time to understand that China is only following its imperialistic policy as example of Srilanka it helped srilanka economically later on China show its real face by destroying its infrastructure and made srilanka depend on it so Nepal and Bangladesh should understand this and maintain distance from China.

#### CONCLUSION

India maintains cordial ties with its neighbours as part of its foreign strategy. India has also opposed colonialism and imperialism in its foreign policies. For instance, our relationship with Nepal has been excellent. You'll notice that India has contributed to the creation of its constitution each time a government has been established there. As you can see, Nepal was previously hit by a very catastrophic earthquake. The first nation to assist them was India. India had dispatched its troops. This demonstrates India's constant desire to assist and collaborate. From a strategic perspective, it is also a significant country because it borders both China and India. However, we have collaborated with Bangladesh as well. Its rise was aided by India. Bangladesh has also worked with India on a number of initiatives. Since the Farakka River flows through India, it is one of the issues that arises when we examine the Bangladesh-India disputes. If we look at the 1950 Treaty of Peace and Friendship which was signed between India and Nepal, it has brought about a lot of changes. Over time, both the countries have seen a lot of ups and downs. Nepal starts leaning towards China, so it is natural for India to get angry because we behaved well with them, we also helped them a lot, even then they are leaning towards China. Sometimes Nepal feels that India can help them, then Nepal looks towards us. As India's policy has always been that it will cooperate with everyone and no matter what, India plays the role of an elder brother. Nepal is a buffer state, so it knows that even if it is a compulsion, India will help them.

Ever since Narendra Modi became the Prime Minister, India's relations with its neighbours have changed. Modi Ji takes strong decisions and it will be said that his policies have been very strong. Whatever decision he takes, he takes it very well. He does not take any decision under pressure. A strong leader is one who not only keeps his people happy but also takes the neighbouring nations along. As an example, during the Corona period, India has provided a lot of help to its neighbouring nations. If we compare Modi Ji with former Prime Minister Jawaharlal Nehru, then Nehru Ji was an idealistic leader and the country does not run only on idealism. Nehru Ji wanted to be friends with everyone, which is not possible because if any nation attacks us, will we keep watching silently? If we consider them as friends, then he could not take any strong decision, like the Kashmir issue or the dispute with China, it could have been resolved. Modi Ji also resolved the Kashmir problem in a very good manner and he did a milestone in establishing India's position as a strong nation. Although he had to face criticism from many people, he still did this work.

In South Asia, China is becoming more powerful every day and is attempting to draw in smaller neighbors like Bangladesh and Nepal, particularly in the economic sphere. China is drawing Bangladesh and Nepal closer to itself, and they should realize this. For instance, you should look at Sri Lanka's problem and realize that this is China's imperialist approach, which means that while it may be offering money on interest now, it will eventually destroy all of your property and the entire nation. It also has authority over several of our sectors under this policy. You'll notice that it first controls a sizable portion of Sikkim.

When discussing or worrying about the Indian population, we should keep in mind that while India has its own population, many refugees also arrive from other nations. This is among the factors contributing to our population growth. There are no restrictions on our borders, nor are there roadblocks. They have boundaries, and it's also true that Indians own fields on the other side. There is a lot of coming and going because some of the people from there have farms here, making it difficult to tell who is Indian or Bangladeshi. People come from both sides since our borders are so close together.

India Bangladesh relations have been mixed during the time of Sheikh Hasina, sometimes they have been good, sometimes they have been tensing, the issue of dispute is of water as well as of refugees, when they come it becomes a problem because due to increasing population there is also a problem of employment. Ever since K P Oli has come to Nepal, his inclination is more towards China and it is natural that if any country which is adjacent to our border is inclined towards China, then it is natural for India to worry because China's policy has been an imperialist policy and under this policy, suppose in future China also occupies Nepal, in that situation China's border will be directly adjacent to India, this can become a matter of concern for India.

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# A STUDY INTO THE INTEGRATION OF STACKED LS-TM AND TECHNICAL INDICATORS FOR STOCK MARKET FORECASTING

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#### ABSTRACT

Forecasting stock price movements is vital as stock markets underpin economic development and efficient capital allocation. While the Efficient Market Hypothesis suggests future prices cannot be predicted, advancements in Artificial Intelligence, particularly Machine Learning, challenge this notion. This research explores stock price prediction using a Stacked LSTM algorithm, optimized with the Adam optimizer for efficiency and evaluated with MSE as the loss function. Additionally, technical indicators like MACD and Bollinger Bands are incorporated to analyze market momentum, trends, and buy/sell signals, enhancing decision-making in complex financial markets.

Keywords: LSTM, Stock Market, Time series, Technical Analysis, Machine Learning

#### INTRODUCTION

The stock market has always piqued the interest of traders, investors, and scholars due to its complex and dynamic characteristics. Predicting stock price trends has long been a challenging endeavor for traders and analysts aiming to maximize profits (Hu et al., 2015). The intricate interaction of variables influencing market behavior has made accurate stock price prediction a persistently difficult task. Modern technologies like Long Short-Term Memory (LSTM) neural networks have drawn a lot of attention lately because of their potential applications in time series analysis and stock market predictions. Time series analysis is a vital tool for accurately predicting future moves in the market since it looks for patterns, trends, and linkages among sequential data. A particular kind of Recurrent Neural Network (RNN) called Long Short-Term Memory (LSTM) is very good at spotting patterns and relationships over time in sequential data, which makes it a powerful tool for stock price prediction. A large number of studies are currently active on the subject of LSTM neural networks used in finance. Some studies used various sets of parameters with a different number of epochs to measure the RMSE of the LSTM neural network model so as to improve the accuracy of the model. (Roondiwala m et al. 2017) With the help of this innovative approach, investors may make better decisions and maximize their risk management tactics.

This study aims to empirically show that LSTM models provide better predictive accuracy than traditional time series methods using historical stock price data and advanced LSTM frameworks. The study also looks into Technical Indicators namely Bollinger bands and MACD (Moving Average Converge Divergence Indicator) to enhance the precision and dependability of stock market projections.

Traditional time series models, such as the Autoregressive Integrated Moving Average (ARIMA) model (Asteriou & Hall, 2011) and the Generalized Auto-Regressive Conditional Heteroskedasticity (GARCH) model (Engle, 2001), have long been employed for stock forecasting. However, these models face significant limitations in accurately capturing nonlinear time series data, as they require several prerequisites that are often unmet in the complex and volatile financial markets. Even while exponential smoothing and Autoregressive Integrated Moving Average (ARIMA), two classic time series models, are frequently employed in financial analysis, they frequently fail to adequately capture the complex and non-linear nature of stock price fluctuations. Current advancements demonstrate the increasing significance of long short-term memory neural networks (LSTM neural networks), which are becoming more widely acknowledged for their ability to get over these restrictions and reveal underlying patterns and trends in stock data. The unique capacity of Long Short-Term Memory Recurrent Neural Networks (LSTM) to handle and update data over long periods of time makes them an excellent choice for advanced Recurrent Neural Network analysis of stock price data. The aim of this study is to establish Long Short-Term Memory (LSTM) as a preeminent technique for market forecasting along with technical indicators like Bollinger bands and MACD to provide noteworthy perspectives that can augment the precision and efficacy of investment approaches.
# **RESEARCH METHODOLOGY**

### Long Short-Term Memory

The Long Short-Term Memory (LSTM) model is a prominent choice among recurrent neural network (RNN) architectures for analyzing sequential data. Unlike traditional RNNs, LSTM networks incorporate memory cells designed to evaluate the relevance of information. Each memory cell includes three gates: the forget gate, the input gate, and the output gate (Jin et al., 2021). The data used for the research was historical stock price data predominantly obtained from Yahoo Finance. The data was then split into two parts training data set and testing data set into an 80:20 ratio. The 'Adj Close' price of the data was used for training the LSTM model. Feature scaling using MinMax Scaler is applied to normalize the data and range of features so that data falls within a specific range for the LSTM model to converge efficiently.

Since a stacked LSTM model is used each layer of the LSTM unit passes its hidden state output to the next immediate layer. Stacking layers enables the network to progressively refine and learn complex relationships from the data. The basic architecture of LSTM layers in a stacked configuration consists of cell state, forget gate, output gate, and candidate memory. Input sequence from the training data is created to feed into the LSTM model. This sequence consists of stock prices and the immediate corresponding target values as the next step. This helps LSTM learn temporal patterns to make predictions. The LSTM model is created with dropout regularization to prevent outliers and improve generalization. Dropout works by randomly disabling connections between stacked layers during the training to prevent the model from relying heavily on specific pathways. Once the architecture is in place, the model is compiled by specifying the optimizer and loss function. Mean Squared Error (MSE) is used for time series forecasting and Adam Optimizer is used to achieve faster convergence and better performance. To evaluate model training process losses over epochs are plotted. The learned LSTM model is used on test data. Long Short-Term Memory (LSTM) networks are a type of recurrent neural network (RNN) designed to effectively model temporal sequences and handle long-range dependencies (Gers et al., 2021). LSTMs overcome the vanishing gradient problem, which is prevalent in traditional RNNs, through a sophisticated gating mechanism that regulates information flow.

### **BOLLINGER BANDS**

Bollinger bands are used to analyze price volatility and potential price reversals. SPY price data is fetched within a one-hour time frame. These bands consist of three lines. The middle band is the Simple Moving Average (SMA) of closing prices a 20-period SMA is used. The upper band is the sum of 20 periods SMA and two times the 20-period standard deviation of the closing prices. The lower band is plotted with a 20-period SMA minus the two times 20-period standard deviation of closing prices. The data is obtained from Yahoo Finance and the software used is Python. Plotly library was used for data visualization.

### MACD (MOVING AVERAGE CONVERGENCE DIVERGENCE)

MACD is plotted on a one-hour time frame. MACD is derived from 2 EMA's namely: 12 period short term EMA and 26 period long term EMA. A 12-period EMA is plotted using the method specifying a span of 12 similarly, a 26-period EMA with a span of 26 is calculated. MACD is plotted as a difference between short-term EMA and long-term EMA. A 9-period signal line is calculated.

### **PROPOSED WORK**

A. In the pre-deep learning era, Financial Time Series modeling has mainly been concentrated in the field of ARIMA and any modification to this, and the result proves that the traditional time series model does provide decent predictive power within a limit. For example, since there is usually an asymmetric distribution in the return of financial time series, Minyoung Kim has replaced the traditional Maximum Likelihood Estimation with an asymmetric loss function. The research study by Mondale et.al applied the Arima model in order to predict the accuracy of the stock price prediction. This model was identified by using Akaike information criteria and it is found if there is a change in the training dataset, then the variation in accuracy is little. To determine the accuracy, mean absolute error is the efficient way. LSTM has been proven successful for time series prediction.

B. Hengijian Jia et al. proposed that the LSTM algorithm learns the stock price pattern in an effective way and by applying this approach, it gets a lower MAE and RMSE value. This study helps to identify this problem as time series prediction and to use the sliding window technique to get better results.

C. Sreelekshmy Selvin et al. proposed that three different deep learning architectures of the RNN, LSTM, and CNN are used. A sliding window to model prices to infer the performance of NSE-listed companies. For the forecast of future values on a short-term basis, they have applied a sliding window and used the percentage this model is quantified. They have been trained in the model data and the ability to predict the stock price of Infosys, TCS, and Cipla. It proves that the proposed system can recognize several intergovernmental relations within the scope of the data. Changing trends can be identified by the CNN architecture. The CNN is determined to be the best model, the proposed methodology.

LSTM has collected significant attention for stock price prediction. Sen et al. (2021) introduce a hybrid modeling method for this purpose, employing both machine learning and deep learning techniques, notably LSTM networks, validated through walk-forward validation. Their findings highlight the success of LSTM-based univariate models in using one-week prior data to forecast NIFTY 50 open values.

D. Software: Python is a general-purpose programming language for applying several machine-learning models. including Long Short-Term Memory (LSTM) networks, which are highly effective for forecasting. In fact, one of the most effective applications of RNNs consists of LSTMs while considering sequential data for understanding temporal patterns, which suit the best for analyzing fluctuated variations of stock prices over time. This research is implemented on the Python platform, with the usage of some of the powerful libraries like NumPy for numerical computation, Pandas for data manipulation, Matplotlib for visualization, TensorFlow for model building, and MinMaxScaler for normalization. These tools will be used jointly for model development and optimization.

# CONCLUSION



Figure 1 LSTM model losses, training, and testing/ validation

Once the training and testing loss data are available losses can be plotted over epochs. This gives insights as to how efficiently the model is performing. A decreasing training loss and a relatively stable testing loss indicate that the model is learning well from the data without an overfitting problem which can be seen in Figure 1. This overall depicts that the model will relatively give correct predictions since it was not overfitted while training.



Figure 2 SPY stock price prediction using Stacked LSTM

The graph shows an upward trend in SPY stock prices from January 2024 to January 2025, with the predicted price (green) closely following the actual price (black). The LSTM model captures the trend and volatility well but occasionally lags during sharp price changes, especially around October 2024's heightened volatility. The LSTM model predicted data from December 2025 to Jan 2025 with good accuracy.



Figure 3 SPY stock price with Bollinger Bands

Bollinger Bands are an important tool for analyzing the trend and volatility of stock prices. The middle band is based on a 20-period SMA, which forms the foundation for the price movement. The upper and lower bands, two standard deviations above and below the SMA, respectively, define overbought and oversold conditions. Wider bands indicate high volatility, as can be seen during sharp price moves like late November, whereas narrower bands, such as in early October, suggest reduced volatility and often precede breakouts. Prices tend to stay within the bands, with breaches indicating strong momentum or trend changes. Consolidation periods, characterized by band tightening, are indicative of potential directional shifts. Bollinger bands have efficiently enabled the identification of price trends, volatility shifts, and probable market reversals, availing very important information to traders and analysts.



Figure 4 MACD and Signal line for the SPY stock

The MACD plot for SPY shows the momentum and trend signals. Bullish momentum happens when the MACD (blue line) crosses over the Signal line (red), and bearish momentum occurs when it crosses under. Peaks above the zero line, as in early November, show strong upward trends, while dips below the zero line indicate bearish conditions. Wider gaps between the lines signal stronger momentum, while narrower gaps reflect weaker trends.

Overall, the research takes into account technical analysis like MACD indicator, Bollinger Bands, and LSTM framework to forecast stock prices. Relatively all three indicators predicted a dip in stock prices with MACD suggesting weaker trends. One direction of future work will be to see how Attention-LSTM performs on denoised data.

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# ARTIFICIAL INTELLIGENCE, MACHINE LEARNING, AND DIGITAL TWIN CONCEPTS IN RESPECT OF COMPUTATIONAL FLUID DYNAMICS

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# ABSTRACT

In this work, studies on artificial intelligence (AI), machine learning (ML), and digital twin (DT) concepts are reviewed with respect to their implications in computational fluid dynamics (CFD). The paper aims ease, enhancement, and cost effectiveness in CFD. Those emerging technologies are reviewed regarding surrogate models, optimization algorithms, and automated feature extraction. DT aspects such as real-time simulations and predictive maintenance of physical systems are emphasized. The findings imply the importance of the AI, ML, DT and their collective utilization for CFD. There are new challenges and opportunities.

Keywords: CFD, Data Driven, Low Computational Cost, Meshless, System Simulation.

# INTRODUCTION

Engineering utilizes common knowledge and technology, derived from fundamental sciences, and generates solutions for practical problems of humanity. Therefore, scholarly works of engineering background researchers are generally on benchmarking newly emerging techniques or generating data by applying engineering tools on engineering problems. In this sense, the research of engineering background scholars is somehow different from fundamental sciences where new knowledge on unknown phenomena is gathered. Nevertheless, today's dynamic world appreciates generated data by engineering background researchers since the data nowadays is used to train special computer models that are imitating intelligence.

Fluid mechanics and particularly fluid dynamics is a discipline where complex phenomena due to the nonlinear behavior of fluids and accordingly unique physical flow structures are tried to be explained and modelled systematically. Although the discipline is well established relatively, the unlimited possibilities and wide application field in real world engineering practice create need for continuous studies on the matter. There are analytical, experimental, and numerical methods and techniques that are used to conduct studies and investigations in the fluid dynamics world. The numerical methods are also called computational methods since a significant number of numerical computations are necessary, which also create computer technology to involve. One may assume that today's advanced computer technology and capacity can handle all kinds of computations for the fluid dynamics studies, however, the reality is different. The complexity of different types of fluids and flow types limits computable phenomena, or in other words, the flows that are deemed modelled or simulated are still limited. In most cases, there are serious simplifications, approximations, approaches, and ignorance to have a numerical solution, simulation or model. This brute computational force need, along with the distance from real world conditions, make Computational Fluid Dynamics (CFD) an advanced but expensive engineering tool without being a common tool for all. Most of the engineering applications use simplified empirical or analytical models. Computer games or rendered movie scenes are good examples for those simplified model utilization cases where, for example, a liquid free surface is desired to be visualized by simulation for enough time to be observed and perceived by humans. CFD would be inconvenient or impossible for generating physically correct simulations for such movie or game scenes. Furthermore, such CFD utilization would require repetition of all computations for a small change in the conditions. This example shows us that, despite all the development in the computation world and processors, we need intermediate solutions between simplified models and computational models. Nevertheless, the importance of CFD is non-negligible where physical accuracy tolerance is so small, such as aviation, defense industry, health technology, and so on.

CFD tries to numerically solve governing equations of the flow by analytical linearization of those equations while exploiting spatial and temporal domain modification thanks to the computer technology. Especially spatial domain arrangement is easier to grasp and understand by people who are unfamiliar with CFD concept. Flow phenomena are almost always nonlinear in space domain while, in smaller scales, there is a specific distance where the physical change between point a to point b becomes linear. So, CFD divides the spatial domain into tiny pieces

until each piece can yield flow phenomena that can be solved by linearized and discretized and integrable governing equations. That dividing task can be named by several different denominations. Most common ones are meshing and grid generation. In the present paper, meshing is used. The problem with meshing is that the mesh element size depends on the physics underlying the flow while the mesh itself is desired to be generated to solve or simulate the flow. So, the proper mesh size and structure is not known. Hence the procedure of mesh generation is an iterative and intuitive work. It makes CFD calculations and their verification and validation harder. Meshing is generally regarded as one of the major bottlenecks of the CFD. The human factor is highly involved. Therefore, ongoing work on CFD has a major branch where people work on meshless methods or tools that can assist meshing operations.

Digital Twin (DT) is a concept where a computationally cheap model can represent a real-world physical function or equipment in a bigger system model. Possible outcomes and benefits can be easily foreseen by such models, i.e., DTs. The real challenge is to create such DTs. Today, the most convenient way seems to be data driven methods. Nevertheless, algorithmic approaches together with reduced physical models constitute the mature part of the concept.

Data driven model generation contains a major subgroup that is called Machine Learning (ML) where less organized and/or complex data can be utilized without supervision by an algorithm to yield a working model of a physical phenomenon. The idea is to reduce the human factor as well as the need for human labor while vast amounts of data can be processed to yield and/or obtain meaningful and useful models. So, although not being an indispensable part, ML is a crucial part of DT generation. On the other hand, supervised machine learning may also have potential for specific applications, where supervision may necessitate special algorithms that are designed by humans. Also, optimization algorithms may prove worth in handling data since optimization algorithms are specialized in reducing iterations and avoiding local peaks from being sensed as the global peak (maximum or minimum).

Artificial Intelligence (AI) is a term that defines computer models, though commonly linguistic models are known, that can imitate human intelligence. The models are analogue to DT in representing human intelligence for specific tasks. Also, AI model generation vastly utilize supervised and/or unsupervised ML, while optimization algorithms and other operational algorithms may act crucial roles in the capabilities of AI. AI can be very useful in generating intermediate models between CFD and reduced physical models, as well as playing a role in reducing human role in CFD workload and phases.

Before proceeding further, some exemplary literature works are briefly viewed here to provide some insight about CFD utilization in engineering research. Ceviz, Canli, Ates, and Bilir (2021) utilized a commercial CFD code in order to conduct dimensionless analysis of a natural convection heat transfer through internal part of a vertical heated pipe. They provide a detailed scheme for nondimensionalization in commercial codes. In a similar manner, Canli, Altun, and Ates (2021) reported CFD investigation of three types of thermal boundary conditions in a pipe for forced convection heat transfer. Developing turbulent flow in the entrance region of a circular pipe is examined by Canli, Ates, and Bilir (2021) via a commercial CFD code. The underlying governing equations for such flow is explained by Canli, Ates, and Bilir (2020) for cylindrical coordinates. Nevertheless, some earlier CFD works may contain methodological points to be disputed in turbulent forced convection in circular pipe case (Canli, Ates, & Bilir, 2018a, 2018b), indicating possible pitfalls of CFD. One should be aware of the nature of CFD where the software almost always gives a result though the setup may contain crucially wrong inputs or elements. Some other physical phenomena examples that are investigated via CFD are radiation heat dissipation from circular pin fin heat sinks (Canli, Ozdemir, & Sertkaya, 2021), transient flow in a conical enclosure with spherical blockage (Canli & Ates, 2019), developing and validating algebraic equations for equal flow distributions through nozzles via manifolds using CFD investigation methodology (Canli, 2024a, 2024b), and aerodynamic analyses around ground vehicles (Canli, Kücüksariyildiz, & Carman, 2023).

A partial and particular DT example from mechanical engineering literature can be viewed from Ates, Dincer, Canli, and Ata (2017) where fuzzy logic is utilized to create a representing model of a vehicle air condition system for passenger vehicle seat surface temperature. Data driven model optimization for reduced results of experimental analyses can be also found in the literature (Abdulkarim et al., 2022). Last but not least, random forest like machine learning approaches are becoming more common in the literature (Ghareeb et al., 2024).

In this work, studies on AI, ML, and DT concepts are examined with respect to their applications in computational fluid dynamics CFD. The paper aims to identify and summarize the roles these emerging technologies play in enhancing the computational efficiency of fluid dynamics simulations. Particular emphasis is placed on how AI and ML techniques can be utilized to reduce computational costs through the development of surrogate models,

optimization algorithms, and automated feature extraction. Additionally, the integration of digital twin technology is explored, focusing on its potential to enable real-time simulations and predictive maintenance through continuous synchronization with physical systems. The findings suggest that these tools collectively contribute to a more efficient and cost-effective approach for simulating complex fluid behaviors while also presenting new challenges and opportunities for further research. Future prospects in the field are discussed, including the need for improved model accuracy, the development of hybrid approaches that combine traditional CFD methods with AI-driven techniques, and the potential for expanding the use of digital twins in broader engineering applications. This report aims to provide insights into the evolving role of AI, ML, and digital twins in CFD, highlighting their impact on advancing fluid dynamics research. In the following part; CFD title describes principal information about CFD while emphasizing the importance of the numerical grid, then DT title provides information on DT works and the concept itself, and machine learning title follows them by presenting a frame definition of the technique, while artificial intelligence title tries to prepare the reader for the last title before the concluding part, i.e., the AI aspects and prospects regarding CFD.

# COMPUTATIONAL FLUID DYNAMICS

CFD is actually an interpolation method where the boundary conditions (their values) are distributed to the calculation domain without violating the physical laws and with the help of the physical laws (during the interpolation). Thus, the main idea of the method is to obtain resolution of a known physical case in spatial or temporal manner (Anderson & Wendt, 1995). However, this technique is now usually manipulated to solve or simulate unknown problems. This is done by increasing or changing the calculation domain and accordingly changing the locations of the boundaries so that they are located places where their conditions can be known. Then, by brute calculation force, unknown spatial and temporal distribution around the problem is converged to the real-world situation. The whole CFD scheme includes solid modeling of the problem, dividing the spatial and temporal domains into finer volumes (meshing), setting physical models, setting numerical models, iterative computing, verification and validation, reiteration of the whole process when necessary, and then post processing the vast amount of data.

## **Meshless Methods**

Meshless methods are a class of numerical techniques in CFD that do not rely on a predefined mesh or grid to discretize the computational domain. Instead, these methods use scattered points distributed across the domain, making them highly flexible for handling complex geometries, moving boundaries, and large deformations. Unlike traditional mesh-based approaches, meshless methods eliminate the need for time-consuming and error-prone mesh generation processes, making them particularly advantageous in dynamic and adaptive simulations (Chanthawara, 2024). Common meshless techniques include Smoothed Particle Hydrodynamics (SPH), Moving Least Squares (MLS), and Radial Basis Function (RBF) methods. By directly approximating the governing equations at discrete points, meshless methods reduce computational overhead and enhance the versatility of CFD simulations. Recent advances in artificial intelligence and machine learning further augment these methods, enabling automatic point distribution and optimization, thereby unlocking new possibilities for accurate and efficient fluid dynamics modeling. Voronoi-based methods also play a significant role in meshless computational techniques. Voronoi-based methods stand out for their ability to naturally partition the domain into irregular cells based on proximity, creating a flexible and adaptive framework for CFD simulations (V. Sousa et al., 2024). The Voronoi tessellation and its dual, the Delaunay triangulation, provide a geometric foundation for constructing discretization schemes and solving fluid dynamics equations efficiently.

### **DIGITAL TWINS**

The digital twin is a virtual representation of a physical system, process, or object, continuously updated with real-time data to mirror its real-world counterpart. By integrating computational models, sensor data, and advanced simulation tools, digital twins enable the monitoring, analysis, and optimization of physical systems in a virtual environment. This concept allows for predictive analysis, improved decision-making, and enhanced operational performance by simulating scenarios, diagnosing issues, and forecasting future behavior. In the context of CFD, digital twins leverage AI and machine learning to refine models and ensure their alignment with real-time operational data, making them invaluable for dynamic and adaptive system management (Paternina-Verona, Coronado-Hernández, Pérez-Sánchez, & Ramos, 2024).

### MACHINE LEARNING

ML is a subset of AI that focuses on developing algorithms capable of learning from and making predictions or decisions based on data. By identifying patterns and relationships in large datasets, ML algorithms enable systems to improve their performance without explicit programming. In CFD, ML has gained traction as a powerful tool for accelerating simulations, enhancing model accuracy, and automating labor-intensive tasks such as mesh generation and optimization. Techniques such as neural networks, support vector machines, and decision trees are applied to predict flow behaviors, approximate solutions to complex equations, and even enable real-time simulations through surrogate modeling. Moreover, ML plays a key role in facilitating meshless methods by optimizing point distribution and refining numerical schemes. As computational capabilities and data availability continue to grow, machine learning offers significant opportunities to redefine traditional CFD workflows and improve efficiency across a broad range of fluid dynamics applications (Sousa, Rodrigues, & Afonso, 2024).

# **ARTIFICIAL INTELLIGENCE**

AI refers to the development of computer systems capable of performing tasks that typically require human intelligence, such as problem-solving, learning, reasoning, and decision-making. In the realm of CFD, AI is emerging as a transformative tool that enhances both the efficiency and accuracy of simulations. By leveraging vast amounts of data, AI-driven techniques such as machine learning, deep learning, and optimization algorithms enable automated workflows for complex tasks like mesh generation, parameter tuning, and flow pattern prediction. Additionally, AI facilitates the integration of CFD with digital twin technologies, allowing real-time monitoring and adaptive modeling of fluid systems. AI's ability to process high-dimensional data and uncover intricate patterns makes it indispensable for developing surrogate models, reducing computational costs, and tackling problems that are computationally prohibitive for traditional methods. As AI technologies continue to advance, their application in CFD is poised to drive innovation and open new frontiers in fluid dynamics research and engineering (Yetkin, Abuhanieh, & Yigit, 2024).

# AI ASPECTS AND PROSPECTS OF CFD

AI is revolutionizing CFD by addressing key challenges and unlocking new possibilities. One of the most impactful aspects of AI in CFD is the automation of mesh generation and refinement, traditionally labor-intensive processes that require significant expertise and time. AI-driven approaches enable adaptive meshing, optimizing computational resources while maintaining accuracy. Additionally, AI is transforming turbulence modeling through data-driven methods, which enhance the precision of Reynolds-averaged Navier-Stokes (RANS) and large-eddy simulations (LES) by learning from high-fidelity datasets. Another significant aspect is the development of surrogate models or reduced-order models, which dramatically accelerate simulations by approximating complex fluid behaviors in real time. Looking to the future, AI prospects in CFD include the integration of real-time simulation capabilities with digital twins, enabling predictive maintenance and operational optimization in industrial systems. Furthermore, advancements in reinforcement learning and generative AI have the potential to guide design processes, optimize flow configurations, and even propose innovative engineering solutions. By combining AI with traditional CFD approaches, the field is evolving toward more adaptive, efficient, and intelligent systems that reduce computational costs and expand the applicability of fluid dynamics simulations across diverse domains (Zago, Amato, & Del Negro, 2024).

#### CONCLUSION

In conclusion, the integration of AI, ML, and DT concepts into CFD holds transformative potential. These emerging technologies provide innovative solutions to longstanding challenges in CFD workflows, such as mesh generation and optimization, which are critical yet time-intensive processes. Additionally, AI and ML offer powerful tools for enabling meshless CFD approaches, broadening the applicability of CFD simulations to complex and dynamic systems. Furthermore, the creation of digital twins leverages CFD models enhanced by AI and ML to bridge the gap between virtual simulations and real-world operations, allowing for predictive maintenance, real-time monitoring, and system optimization. Together, these advancements promise to not only enhance the efficiency and accuracy of CFD analyses but also redefine how engineers and researchers interact with fluid dynamics problems, paving the way for more adaptive and intelligent simulation frameworks.

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# THE FUTURE-PROOF IT FRAMEWORK: LEVERAGING ADAPTIVE INFRASTRUCTURE FOR COMPETITIVE ADVANTAGE

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# ABSTRACT

This research investigates how adaptive IT infrastructure can serve as a key enabler for building operational resilience and competitive advantage from digital transformation. It identifies how this might be done through an in-depth examination of key components-cloud solutions, automation, and AI-that can enable a business from a fresh startup to an established enterprise to overcome key integration challenges, ensure security, and meet compliance requirements. It applies a mixed-method approach together with case studies that indicate how flexible and scalable IT frameworks help in innovations and responsiveness, considering that technology is evolving very fast. The study concludes by giving practical methods of adopting robust IT systems that are commensurate with the dynamic market demand and long-term growth.

Keywords: IT infrastructure, digital transformation, scalability, security, automation, responsiveness

# INTRODUCTION

Information technology has evolved from supportive to central in driving strategic advantage over the last decades. Nowadays, IT infrastructure is important in shaping the landscape of industries, especially in such cases where organisations are undergoing rapid digital transformation. Whether a large enterprise or a nimble startup, IT infrastructure provides the backbone on which any organisation operates to manage its operations with the necessary competitive advantage, innovating and scaling in an increasingly digital market environment.

For example, startups would heavily rely on advanced IT solutions that could allow rapid scaling in changing market conditions. While startups are usually small and resource-limited organisations, they tend to be highly energetic and more often than not tend to disrupt large and even traditional markets due to agility and innovative approaches. Established enterprises, on their part, with legacy systems to contend with and more complex structures of operations, often face difficulties when adjusting their IT frameworks. However, be it a for-profit business or a nonprofit organisation, for both, future-proof and adaptive IT infrastructure is a question of survival in the face of rapid technological changes and competitive pressures facing businesses today.

In analyzing this trend, the deployment of adaptive IT infrastructure has become one of the major facilitators in pursuing organisational strategy. The elements of adaptive infrastructure include but are not confined to cloud computing, automation, orchestration, and increasingly AI. Put together, these form a coherent, scalable, and resilient framework to support a company's ability to rapidly and effectively respond to market demand. For instance, cloud computing allows unlimited scalability in the use of IT resources without having to incur major advance investments in hardware, which is so helpful for a beginning business. On the other hand, automation alleviates the tedium of performing repetitive tasks, expanding the capacity of IT staff for high-value, strategic work.

Where it differs is in the determination of factors that allow the IT infrastructure to be resilient yet adaptable in dynamic business environments. It also answers some of the challenges that organisations face frequently, such as integrating legacy systems, ensuring security, and maintaining regulatory compliance. By leveraging an adaptive IT infrastructure, companies can build an operationally efficient business environment capable of long-term growth. But with this acceleration of digital transformation across industries, such an infrastructure is no longer an option; instead, it is a matter of survival to be competitive.

# **RESEARCH METHODOLOGY**

This study employs an integrative approach, combining extensive literature review, case studies, and mixedmethod data analysis in exploring the deployment of adaptive IT infrastructure. The methodology specifically focuses on the identification of those fundamental components that ensure enhanced adaptability, scalability, and operational efficiency within the IT framework, while at the same time addressing such key challenges as regulatory compliance, integration with legacy systems, and security.

# *a) Literature Review*

Such a review extends to encompass recent academic articles, industry reports, and whitepapers on subjects such as IT adaptability, automation, cloud infrastructure, and data governance. Works by such authors as Öbrand et al. (2007) and Zoubek & Michal (2020) consider adaptive infrastructure even in traditional industries for their need for flexibility and resilience to answer technological advancements and market pressures. It also considers the best-emerging practices with regard to automation and integration of AI, hence showing the increasing need for intelligent data-driven infrastructure.

Along with other studies regarding regulatory compliance, such as those on GDPR, HIPAA, and their implications concerning data governance practices, this will provide more insight. This study provides evidence that efficient data governance frameworks are one of the most important issues in managing security and, at the same time, ensuring compliance with international standards in industries that very often operate with sensitive information.

## b) Case Studies

This qualitative research has embedded two case studies to demonstrate adaptive IT practices across diverse contexts. Case 1 deals with the transformation of a manufacturing firm into a Smart Factory, focusing on how modular infrastructure, cloud-based systems, and automation merge to facilitate seamless operational processes. The second case study looks at the adaptation challenges of the process industry, in particular large enterprises, whose legacies are complex and not that easy to transform. These different cases realistically give an idea of how adaptive infrastructure can be fitted according to the various needs and natures of diverse challenges faced while integrating into any organisation.

# c) Data Collection and Analysis

Data collection was carried out through a mixed-method approach, involving qualitative interviews with IT leaders and some industry reports with quantitative analysis. Accordingly, the interviews with the IT managers, regulatory specialists, and automation engineers provided insight into real-world implementation challenges, integration, and security. Quantitative data from market analysis reports help identify measurable benefits of adaptive infrastructure in increased uptimes, cost savings, and productivity improvements.

Thematic analysis of interview transcripts identified key factors for successful IT adaptation: the role of agile project management and the vital role played by RCA as Infrastructure as Code to ensure that consistency and flexibility are maintained. The data analysis provided a high-level view of industry trends, and at the same time, it kept detailed insights on best practices around resilient IT framework design.

# **PROPOSED WORK**

Cloud solutions, automation and orchestration, adaptive AI, and data governance are the very basic components of the proposed adaptive IT framework, each tailored to support a responsive, scalable IT infrastructure. The framework will be developed by drawing best practices and real-world case studies with design principles aimed at meeting key operational challenges and requirements for modern-day digital transformation.

*a)* Cloud Solutions

Cloud computing has become indispensable in adaptive infrastructure, as it provides flexibility and scalability at an amazing rate. An organisation may be using a public, private, or hybrid model, whichever suits the needs. Public clouds are affordable for start-ups, while private clouds are opted for by big companies dealing with sensitive data owing to enhanced control. Hybrid models enable one organisation to balance flexibility with security by combining scalability through public clouds with compliance in private clouds.

Best practices to implement cloud solutions include evaluating provider compatibility, creating a migration plan, and applying cost management tools in order to keep the expenses under control. Cloud migration is an extremely complex process, and experts recommend taking it up in phases so that disruption to your organisation may minimize transition. It could be first moving non-critical workloads initially, followed by core operations utilizing the transition when proven. Monitoring and management tools can optimize resource utilization, reduce waste, and make sure businesses get the most value out of their investments in cloud infrastructure.

#### b) Automation and Orchestration

Automation is core in adaptive infrastructure primarily because it fills the role of increasing efficiency through automation of repetitive tasks, reducing damages caused by human intervention. This infrastructure automation platforms-including Jenkins, Ansible, and Terraform-facilitate the implementation of DevOps practices. These enable teams to realize Continuous Integration/Continuous Deployment, CI/CD, pipelines, which speed up and build reliability into software delivery.

Orchestration complements automation by elaborating on complex workflow coordination that integrates the automated tasks across a bunch of environments. The benefit of this is not only collaboration between development and operations teams, but also a certain kind of culture of agility and responsiveness this fosters. Their implementation, through orchestration tools like Kubernetes, allows for container management to ensure consistent performance and scaling that's hassle-free.

# c) Adaptive AI

The Adaptive Network is installing a fresh layer of intelligence within the IT infrastructure, predictive by nature, and allowing real-time optimization throughout the ecosystem. With analytics and intelligence, this network can "sense" diverse data coming from anywhere, turning it into actionable insights for smarter decisions and greater resiliency. Software control and automation integrated unabatedly allow the network to "act," applying intent-based policies and automation for seamlessly adapting. This will, in turn, allow the programmable infrastructure element to enable the network to "connect" for dynamic resource allocation, customized user experiences, and enriched service delivery. In addition to deploying adaptive networks, data governance frameworks would ensure that regulations, privacy, and ethics are complied with, and systematic training of staff is very important for handling, monitoring, and fine-tuning such systems.



Figure 1. The adaptive network

Reference: Cumello, Joe. (2018, February 19). "Why Adaptive is the Biggest Story in Networking." Ciena

### d) Governance and Regulatory Compliance

This requires potent practices in data governance, such as the handling of security, compliance, and quality in a competent and nimble IT infrastructure. Estimates for various regulatory compliance frameworks use strict standards of protection based on industries handling sensitive customer data. A sound model of data governance helps an organisation ensure compliance, mitigate risks, and ensure the integrity of data across the complete IT ecosystem.

Some of the key components of any valid data governance include controls based on roles to access and encrypt data, and periodic audits needed for compliance. One important function of the sensitive information management life cycle is data retention policies, which spell out methods through which the regulations on storing, setting aside, or disposing of data are directed. Automated monitoring will complement these governance policies by monitoring data access, logging activities, and alerting IT staff about anomalies. Each of these practices contributes a great deal to the outrageous security while building trust in the stakeholders through the demonstration of data protection.

e) Challenges and Considerations

There are several benefits that are associated with adaptive IT infrastructure, but implementation poses a host of challenges. One of the major issues is the integration of legacy systems-especially for organisations already established-and the existence of older and incompatible systems. Adoption of strategies related to phased and modular infrastructure would facilitate such complex transitions more easily. The other important aspect is scalability: investment in technology should be such that it will help business growth with minimum overhauls in key areas. Modular architecture and IaC are two of those necessary enablers of scalability-these enable the environment to be flexible and responsive.

The problem of security is without end in an automated cloud-based system. Advanced multi-factor authentication, tight access control, and AI-driven threat detection are among many protocols that shall be weaved to safeguard against data breach incidents. Hence, one may consider being careful in facilitating seamless access with security in a way that one doesn't void efficiency due to the other.

This proposal now provides a strategic approach toward developing an adaptive IT infrastructure that is resilient, cost-effective, and capable of meeting dynamic business demands in today's world.

### CASE STUDIES

Case Study 1: Transformation of an Industrial Company into a Smart Factory

This case study describes the transformation of a traditional industrial firm into a Smart Factory, reflecting Industry 4.0 principles and adaptive IT infrastructure implementation.

Current State:

- Company produces pipes for the automotive industry
- Multiple production lines for specific customers
- Basic inventory control system with manual assessment

Transformation Steps:

- Order Processing: Automated real-time communication between production lines and inventory management
- Modular Production Lines: Flexible, modular design for quick adaptation to demand changes
- RFID Technology: Tracking parts through the manufacturing process
- Material Handling Automation: Using AGVs and drones for material transport
- Cloud-Based Management: Enhancing communication and data sharing among stakeholders

Challenges and Solutions:

- Integration of New Technologies: Addressed through careful planning and phased implementation
- Employee Training: Continuous training programs to upskill staff
- Cybersecurity Risks: Implementation of stringent security measures

Conclusion: The transformation illustrates the principles of Industry 4.0 and adaptive IT infrastructure, leading to increased operational efficiency, lower costs, and improved product quality.

#### Case Study 2: IT Adaptation Challenges in the Process Industry

This case study focuses on the challenges of integrating and adapting IT infrastructure in the process industry, conducted at SCA, a Swedish multinational company in the paper and pulp industry.

Methodology:

- Qualitative case research with eight interviews from SCA and ABB representatives
- Focus on difficulties, challenges, and key aspects of successful IT integration

Current State of SCA's IT Infrastructure:

- Multiple interdependent levels driving production
- History of segregated systems leading to inefficiency and maintenance problems
- Need for real-time monitoring and production adaptation

Key Challenges Identified:

- Integration as a Continuous Process: Improvement and modification are required continuously.
- Stability in the Installed Base: Balancing new technologies with stability of existing systems
- Locking in the Right Stuff: Careful selection and management of IT resources.
- User value vs. continuity of production vs. compatibility: a trade-off among competing factors.

Practical Implications:

- Evolutionary approach to change management
- Minimizing business interruption while enabling change
- Identifying and addressing the challenges well in advance to enhance operational capabilities.

Conclusion: The case study extents insights into IT adoption strategies and challenges in the process industry. It underlines the need for an adaptive, continuous approach which has to balance the benefits from new technology against the need for production. These insights shall contribute to engaging both startups and established businesses in building adaptive IT infrastructures which can respond to dynamically changing demands by users in the digital age.

# CONCLUSION

Adaptive IT infrastructure has become the cornerstone for businesses to compete in a modern digital environment. Integration of cloud-based solutions, automation, and adaptive AI in developing IT systems will help organisations develop systems that are flexible, scalable, and hence resilient. Some benefits developed in key findings owing to an adaptive IT framework are increased operational efficiency, cost reductions, and enhanced agility to respond to shifts in technologies and markets.

Case studies of real-world applications show that adaptive IT infrastructures represent one of the most critical ways firms can achieve continuous innovation and attempt to match changing customer needs. Adaptation is a factor of critical success in industries undergoing fast digital transformation; these industries include manufacturing, finance, and healthcare. For instance, smart factory principles in manufacturing enable innovative manufacturing companies to boost efficiency compared to financial services, where institutions can use adaptive AI to boost client services and compliance.

Therefore, the holistic approach of adaptive IT infrastructure implementation should be rooted in organisational needs, technological advances, and security requirements. Investing in adaptive infrastructure will allow organisations to build a future-proof IT base that is compatible with today's needs and well-poised for the future. As more organisations embark on digital transformation, the importance of an adaptive, responsive, and resilient IT infrastructure will continue to rise as a much-needed vital approach toward achieving sustained competitive advantage.

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# THERMAL AGING IN POLYMERS AND POLYMER NANOCOMPOSITES: ACCELERATED AGING AND HEAT RESISTANCE TESTS

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### ABSTRACT

Thermal aging significantly impacts the durability of polymers and polymer nanocomposites. This study examines thermal degradation mechanisms, accelerated aging techniques, and heat resistance tests. While thermal degradation in polymers depends on molecular structure and environmental conditions, nano-fillers in nanocomposites improve aging resistance. Key methods include mechanical and thermal evaluations alongside accelerated aging protocols. Strategies to enhance thermal stability are discussed, emphasizing mechanisms driving improved performance in nanocomposites. The findings offer valuable guidance for predicting material lifespan and selecting appropriate materials for diverse applications, ensuring optimal performance under thermal stress.

Keywords: Thermal aging, Polymers, Nanocomposites, Accelerated aging, Heat Resistance

# INTRODUCTION

Polymers and polymer nanocomposites have become essential materials across a wide range of industries, including construction, automotive, electronics, and aerospace, due to their versatility and mechanical properties (Cavdar et al., 2024; Kandemir et al., 2023). However, one of the key challenges these materials face is degradation over time, particularly when exposed to thermal and environmental stresses. Thermal aging is a critical factor that impacts the long-term performance of these materials, especially in applications where they are exposed to high temperatures or fluctuating thermal conditions (Sepetcioglu, 2024; Sepetcioglu, Gunoz, & Kara, 2021). The industrial importance of understanding thermal aging is paramount. Materials used in highperformance applications, such as electrical insulations, automotive components, and composite structures, need to retain their mechanical and chemical stability throughout their service life. Failures due to thermal aging can lead to significant operational and safety issues, making it essential to develop materials with enhanced thermal resistance and durability (Gupta, Kumar, & Sachdeva, 2024). Table 1 shows the thermal aging environments, their effects on the mechanical and chemical properties, and the main causes of degradation for polymer or nanocomposite systems. To predict and mitigate the effects of thermal aging, accelerated aging tests are widely employed. These tests simulate long-term exposure to heat and environmental factors over shorter periods, providing insights into the degradation mechanisms of polymers and nanocomposites. Heat resistance tests further assess the ability of materials to withstand prolonged high temperatures without significant loss of properties (Tayefi et al., 2023). This study evaluates thermal aging in polymers and nanocomposites through accelerated tests, aiming to understand degradation mechanisms and improve material design for critical applications.

Table 1. Main causes of Degradation in Thermal Aging of Polymers and Nanocomposites				
Effect of Aging	Major Reasons			
Degradation in chemical and mechanical properties	Oxidation, chain scission, and crystallinity changes due to high temperatures and oxygen exposure. Hindering of the macromolecule's mobility and the ability to chain orientate			

# THERMAL AGING IN POLYMER METHODOLOGY

Thermal aging is a critical factor influencing the long-term performance of polymers, especially in applications where materials are exposed to elevated temperatures for extended periods. Thermoplastics, commonly used in commercial applications, gradually degrade under such conditions, leading to changes in mechanical, chemical, and physical properties. Several studies (Bouguedad et al., 2015; Cho et al., 2022; Elkori, Lamarti, Salmi, Had, & Hachim, 2024; He, Sawut, Guan, Li, & Yimit, 2021; Jakubowicz, Yarahmadi, & Gevert, 1999) have focused

on understanding the thermal aging behavior of different thermoplastics, each highlighting the degradation mechanisms and effects on performance.

Cho et al. investigated the thermal aging behavior of polyetherimide (PEI), a high-temperature resistant polymer commonly used in fire-protective clothing, which is manufactured from heat and flame-resistant fibers made of high-performance polymers. These polymers gradually lose their performance after long-term exposure to aging conditions. In their study, thermal aging of PEI was conducted in air at 190°C, 200°C, and 210°C, with 210°C being just below the glass transition temperature of PEI (~217°C). Aging durations varied by temperature: up to 12 weeks at 190°C, 16 weeks at 200°C, and 8 weeks at 210°C. Changes in the ultimate tensile strength (UTS), glass transition temperature, and surface properties were monitored during this process, with infrared spectroscopy revealing the consumption of chemical bonds due to chain scission. By applying the time-temperature superposition principle to UTS data, the researchers calculated an activation energy of 112 kJ mol<sup>-1</sup> for the effect of thermal aging on PEI's mechanical strength. This value is similar to activation energies found in fire-protective clothing fabrics, suggesting that PEI could potentially serve as a sensing material for end-of-life sensors in such garments (Cho et al., 2022). Bouguedad et al. examined the thermal aging behavior of ethylene-propylene-diene monomer (EPDM) rubber, commonly used as insulation in power cables, under different aging conditions. EPDM samples of 2 mm thickness were aged at four selected temperatures (80°C, 100°C, 120°C, and 140°C) following IEC 216 guidelines. The aging process, conducted in forced air-circulating ovens with a  $\pm 2^{\circ}$ C temperature deviation, lasted for varying durations: 6070 hours at 80°C, 5040 hours at 100°C, 3520 hours at 120°C, and 980 hours at 140°C. The samples were suspended vertically in the oven to ensure homogeneous aging. After each aging period, three samples were analyzed using characterization techniques. Attenuated total reflection Fourier transform infrared (ATR-FTIR) spectroscopy, differential scanning calorimetry (DSC), and thermogravimetric analysis (TGA) were employed to assess structural changes in EPDM. The results indicated that no significant chemical changes occurred at the lower temperatures (80°C and 100°C). However, at higher temperatures (120°C and 140°C), oxidation increased over time, leading to the formation of oxygenated species such as C–O–C, C=O, and O-C=O groups. DSC analysis revealed that EPDM maintained very low crystallinity, while TGA results demonstrated that the material preserved high thermal stability despite the migration of volatile gases. The study also highlighted that the thermal aging effects were more pronounced on the surface than in the bulk of the material. The carbonyl index, representing oxidation products, was measured, as carbonyl groups are common in the thermo-oxidative degradation of cross-linked EPDM (Bouguedad et al., 2015). Elkori et al. conducted accelerated thermal aging tests on high-density polyethylene (HDPE) bottles and specimens to assess their degradation under different temperatures. The specimens were cut into parallel epipedic shapes with dimensions of 1.10 mm thickness, 100 mm length, and 20 mm width. Aging tests were performed at two temperatures, 43°C and 80°C, for durations of 9, 18, 27, 36, 54, 72, and 108 days. The 43°C condition simulates use in temperate climates or long-term storage, while 80°C tests the resistance of HDPE packaging to extreme conditions, such as prolonged UV exposure and high-temperature storage during transport. All tests followed ASTM D3045-92 standards to ensure reproducibility and comparability between the two temperatures. The degradation of HDPE was assessed through tensile and compression tests, which revealed a significant decrease in mechanical properties. The data from these tests were used to develop a new static damage law and determine the life fraction of the polymer. Thermogravimetric analysis (TGA) in dynamic mode was utilized to predict the lifetime of HDPE. Additionally, the crystallinity rate during aging was measured using Fourier transform infrared spectrometry (FTIR). The results indicated substantial degradation of mechanical properties, both in tension and compression, and a notable evolution in the crystallinity rate. The prediction of HDPE's lifetime was also achieved through the Arrhenius law, which provided insights into the long-term stability of the material under accelerated aging conditions (Elkori et al., 2024). He et al. investigated the weathering performance of polypropylene (PP) using an artificial accelerated weathering chamber equipped with 340 nm ultraviolet (UV) light and compared it with natural aging conditions in Turpan, China. The accelerated aging was conducted using an Atlas Material Testing Technology apparatus with irradiance at 340 nm of 0.68 W/m<sup>2</sup>, simulating the average intensity of sunlight at noon during summer. The process involved cycling UV radiation at 60°C for 3 hours, followed by 3 hours of cooling at 50°C without UV exposure, and a final 10-minute wind-blowing phase, repeated for a total of 15 days. Samples were collected at intervals of 3, 6, 9, 12, and 15 days for tensile and impact tests. The study aimed to create a method to predict the aging failure of PP under natural conditions by using artificial accelerated aging as a faster proxy. Scanning electron microscopy (SEM) revealed that cracks of approximately 1.25 µm appeared on the PP surface after 15 days of artificial aging, while natural aging over 150 days produced similar cracks of 1.63 μm. X-ray photoelectron spectroscopy (XPS) showed that the number of C-O and C=O bonds on the surface of PP after 3, 6, and 9 days of artificial aging corresponded to the chemical changes after 30, 60, and 90 days of natural aging, respectively. Mechanical properties and capillary rheology tests yielded similar outcomes in both aging methods. The study concluded that the artificial aging process occurred 10 times faster than natural aging in Turpan (He et al., 2021). Jakubowicz et al. investigated the tensile properties, residual stability, composition, and remaining lifetime of approximately 50 different cables and sheathings from buildings aged between 24 to 34 years. Their study focused on the effects of ageing on PVC materials, particularly plasticized PVC, through

accelerated ageing experiments in both air and nitrogen atmospheres at temperatures ranging from 80°C to 110°C. The ageing was monitored over periods of up to 2 months, with measurements of mass loss, stabilizer consumption, and elongation at break. The results showed that mass loss and stabilizer consumption were largely independent of oxygen presence, with activation energies of 98-99 kJ/mol for mass loss and 101-104 kJ/mol for stabilizer consumption. Ageing at lower temperatures (80 and 90°C) did not significantly affect the elongation at break, while higher temperatures (100 and 110°C) led to a maximum reduction of one third in elongation at break, which correlated with a similar mass loss of plasticizer. Tests on cables and sheathings from old buildings revealed little degradation in tensile properties or elongation at break, even after 34 years of use. The residual stability remained high, indicating strong thermal stability and supporting the suitability of these materials for reuse or mechanical recycling. Additionally, accelerated ageing in air at 80°C did not significantly impact the tensile properties of the materials, with only a 1% change in extractable matter content. The study highlighted the importance of considering transport processes like diffusion and evaporation when predicting material durability. The model materials, aged under controlled nitrogen flow to prevent oxidative degradation, demonstrated that these processes significantly influence ageing outcomes, reinforcing the relevance of transport mechanisms in material degradation models (Jakubowicz et al., 1999). These studies provide a comprehensive view of how different commercial thermoplastics respond to thermal aging, offering critical data for predicting material longevity and improving product design for high-temperature applications. Table 2 presents essential parameters of thermal aging behavior, analysis methods, and findings, summarizing key factors like temperature, duration, degradation mechanisms, and techniques assessing property changes.

Study	Polymer	Aging	Aging	Observed	Analysis
	type	Temperatures	Durations	Properties	Techniques
Cho et al.	PEI	190, 200 and, 210	190°C: up to 84	Ultimate tensile	Infrared
		°C	days, 200°C: up	strength, glass	spectroscopy,
			to 112 days,	transition	time-temperature
			210°C: up to 56	temperature, surface	superposition
			days	properties	
Bouguedad	EPDM	80, 100, 120, and	80°C: 250 days,	Chemical structure,	ATR-FTIR,
et al.	rubber	140 °C	100°C: 210	oxidation,	DSC, TGA
			days, 120°C:	crystallinity, thermal	
			150 days,	stability	
			140°C: 40 days		
Elkori et al.	HDPE	43 and 80 °C	9, 18, 27, 36,	Mechanical	Tensile and
			54, 72, and 108	properties (tensile	compression
			days	and compression),	tests, FTIR, TGA
				crystallinity rate,	
				lifetime prediction	
He et al.	PP	60 °C with UV	3, 6, 9, 12, 15	Crack formation,	SEM, XPS,
		exposure, 50°C	days	chemical bond,	mechanical tests,
		without UV		mechanical	capillary
		exposure		properties	rheology
Jakubowicz	PVC	80, 90, 100, and	Up to 60 days	Mass loss, tensile	Mass loss,
et al.		110 °C		and thermal	tensile, and
				properties	thermal tests

Table 2. Key parameters, analysis methods, and findings in thermal aging of polymers

### THERMAL AGING IN POLYMER NANOCOMPOSITE

This section provides an overview of several studies that examine the thermal aging behavior and long-term durability of various polymer nanocomposites under different conditions. The findings highlight how nanofillers can enhance the thermal stability and retard degradation in polymer nanocomposites, offering improved performance compared to unfilled polymers.

Kiliaris et al. investigated the thermal aging behavior of organically modified clay-reinforced polyamide 6 to assess its long-term thermo-oxidative stability and durability in comparison to the virgin polymer. The study monitored changes in molecular weight, thermal, and mechanical properties, linking them to the polymer's modifications during aging. Two sets of tensile specimens underwent thermal aging for 35 days at 120°C and 150°C in a circulating air oven, with exposure intervals at 0, 7, 14, 21, 28, and 35 days. At each interval, the specimens were taken out, sealed in a desiccator for 24 hours, and subjected to mechanical tests and physical

characterizations. Before aging, they were dried at 80°C for 4 hours under vacuum to ensure consistent conditions. The incorporation of the clay filler was found to result in moderate polymer degradation during processing, which became more pronounced with aging time at elevated temperature, causing discoloration. Short-term heat exposure favored post-crystallization, leading to an increase in crystalline content, while extended residence times resulted in chain scission, reducing crystallite size and lowering the degree of crystallinity. The aging-induced transformations in crystal structures correlated well with the material's mechanical performance, as initially hard and brittle specimens gradually softened. Relative to the unfilled polymer, the nanocomposite demonstrated a milder loss of ductility during aging, suggesting that the clay filler restricted degradation, thereby prolonging the material's durability. This performance was closely monitored through the mechanical and physical tests conducted at regular intervals, highlighting how the clay reinforcement helped mitigate the effects of long-term aging (Kiliaris, Papaspyrides, & Pfaendner, 2009). Akesson et al. investigated the influence of thermo-oxidative aging on the properties of high-density polyethylene (HDPE) reinforced with multi-wall carbon nanotubes (MWCNTs). The study aimed to evaluate the long-term durability of nanocomposites prepared with varying nanotube contents (0, 1, 3, and 5 wt%). The dumb-bell shaped test bodies for tensile testing were placed in an oven (Termaks TS 8056) and aged at 110°C for 10 weeks in an air atmosphere. Samples were taken from the oven every second week to test for elongation at break. The aging primarily affected the surface of the samples, with neat HDPE exhibiting significant yellowing after aging. A strong reduction in elongation at break was observed; for neat HDPE, the elongation decreased from approximately 1400% to 25%. In contrast, the incorporation of MWCNTs into HDPE resulted in a less dramatic reduction in elongation, indicating that the nanotubes provided some degree of reinforcement against the aging effects. The characterization of the nanocomposites included techniques such as differential scanning calorimetry (DSC), thermogravimetric analysis (TGA), 13C-NMR, elongation at break measurements, and transmission electron microscopy (TEM) to assess the material properties and structural changes due to aging (Åkesson et al., 2021). Khanlari et al. investigated the effects of organically modified montmorillonite (org-MMT) on the thermal, flame retardant, hardness, and mechanical properties of nanocomposites based on natural rubber (NR). The study followed ASTM D865, aging the samples at 70°C and 100°C for 7 days. Results showed that adding 3 wt% org-MMT to NR reduced the aging hardness increase by over 55%, delayed ignition time by 150%, and decreased the peak heat release rate by 54% compared to pristine NR. Furthermore, calendaring the nanocomposites before curing significantly enhanced their thermal stability and fire resistance (Khanlari & Kokabi, 2011). Lui et al. explored the antithermal aging properties of LDPE/TiO<sub>2</sub> nanocomposites aged at 90°C in an oxidative environment. Pure-LDPE and LDPE/TiO<sub>2</sub> samples were aged for up to 77 days, with measurements taken at intervals (14, 35, 56, 77 days) to analyze microstructure and electrical properties. The study revealed that TiO<sub>2</sub> nanoparticles improved the thermal stability of LDPE by delaying the formation of aging-related chemical groups such as hydroxyl and carboxyl, as seen in FTIR analysis. DSC results indicated that TiO<sub>2</sub> promoted heterogeneous nucleation during recrystallization, enhancing crystallinity. Additionally, LDPE/TiO<sub>2</sub> nanocomposites showed reduced permittivity and dissipation factor compared to Pure-LDPE, demonstrating superior antithermal aging performance. TiO<sub>2</sub> nanoparticles were found to act as crosslinking points within the LDPE matrix, increasing crystal density and preventing oxygen diffusion, thus slowing molecular breakdown (Liu, Wang, Xiao, & Zhang, 2017). Azmi et al. investigated the effects of thermal aging on unfilled PP and PP nanocomposites containing 1 wt%, 2 wt%, and 5 wt% of calcium carbonate (CaCO<sub>3</sub>) nanofillers. The thermal aging was conducted in a vacuum oven for 360 hours at three temperatures: 20°C (unaged), 110°C, and 140°C. After aging, the dielectric strength of the samples was measured using DC breakdown testing. The results showed that, although the PP nanocomposites had lower breakdown strength than unfilled PP before aging, they experienced a less pronounced reduction in DC breakdown strength after thermal aging. This suggests that PP nanocomposites are less susceptible to thermal aging compared to unfilled PP (Azmi et al., 2020). Table 3 summarizes key parameters of thermal aging studies, including temperature, duration, degradation mechanisms, and analytical techniques used to evaluate property changes.

Study	Nanocomposite type	Aging Temperatures	Aging Durations	Observed Properties	Analysis Techniques
Kiliaris	Nanoclay/PA6	120 and 150	0, 7, 14,	Changes in	Mechanical tests,
et al.		°C	21, 28 and	molecular weight,	physical
			35 days	thermal and	characterizations,
				mechanical	monitoring of molecular
				properties,	weight
				discoloration,	
				crystalline	
				content, and	
				ductility loss	

 Table 3. Key parameters, methods, and findings in thermal aging of polymer nanocomposites

Akesson et al.	MWCNT/HDPE	110 °C	70 days	Yellowing of neat HDPE, reduction in elongation at break (1400% to 25%), less dramatic reduction for MWCNT-	Differential Scanning Calorimetry (DSC), Thermogravimetric Analysis (TGA), 13C- NMR, elongation at break, Transmission Electron Microscopy (TEM)
Khanlari et al.	Nanoclay/NR	70 and 100 °C	7 days	Improved thermal stability, 55% reduction in aging hardness, 150% delayed ignition time, 54% reduction in peak heat release rate	Tensile Properties, Hardness, Thermal Stability, Flame Resistance
Lui et al.	TiO <sub>2</sub> /LDPE	90 °C	14, 35, 56, and 77 days	Improved crystallinity, delayed aging peaks, lower permittivity, increased antithermal aging ability	SEM, FTIR, DSC, Dielectric Properties
Azmi et al.	Nano CaCO <sub>3</sub> /PP	20, 110, and 140 °C	15 days	Improved resistance and less susceptible to thermal aging	DC and Breakdown Testing

## CONCLUSION

The studies on thermal aging behavior of polymers and nanocomposites reveal that long-term exposure to elevated temperatures and oxidative environments leads to significant mechanical and chemical degradation. The primary mechanisms include chain scission, oxidation, and crystallinity changes, which directly affect properties such as tensile strength, elongation at break, and thermal stability. Polymers like PEI, EPDM, HDPE, and PP exhibit varying degrees of aging resistance depending on the temperature and environmental conditions. The incorporation of nanofillers such as TiO<sub>2</sub>, clay, and carbon nanotubes has been shown to enhance the thermal stability of polymers, delaying the onset of degradation and preserving mechanical properties for longer periods. Nanocomposites generally demonstrate superior resistance to thermo-oxidative aging compared to their unfilled counterparts, primarily due to the nanofillers acting as barriers to oxygen diffusion, improving crystallinity, and mitigating the effects of chain scission. Overall, thermal aging significantly impacts polymer performance, but the addition of nanofillers offers a promising approach to enhancing durability and extending the service life of polymer-based materials in high-temperature or oxidative environments. These findings suggest that optimizing nanocomposite formulations can play a key role in developing materials with improved long-term stability for applications in harsh environmental conditions.

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# FROM METAVERSE TO MARKETPLACE: A BIBLIOMETRIC EXPLORATION OF CONSUMER BEHAVIOUR IN VIRTUAL AND AUGMENTED REALITIES

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### ABSTRACT

The study provides a bibliometric analysis of the consumer behaviour research within the Metaverse, Virtual Reality, and Augmented Reality environment. It analyses publication and citation patterns, outlines key themes and reveals collaborative structures underpinning this emergent domain. By employing Biblioshiny and VOSviewer for the assessment, the authors underlining the key works and their impact, as well as shifts in the topics, including the increased interest in immersive technologies and psychological factors. Thus, the study outlines academic development and patterns in the identified field, contributing to strong research and application prospects for the subsequent years in the sphere of consumer behaviour in immersive environments.

Keywords: Augmented Reality, Consumer Behaviour, Metaverse, Virtual Reality

### **INTRODUCTION**

The rapidly evolving Virtual Reality, Augmented Reality, and the new and upcoming metaverse have greatly impacted the paradigm of consumer behaviour study (Yoo & Haenlein, 2023). Virtual worlds, or more recently Metaverse, as a relatively new and increasingly popular concept, has various implications for consumers and multiple industries, including tourism and hospitality, as well as events. Since such virtual environments become progressively more realistic and interactive, knowledge of consumers' behaviours in these environments is vital for the corresponding businesses to evolve and prosper (Baker, 2023) (Filimonau & Stankov, 2024).

The present research paper therefore seeks to conduct a bibliometric analysis in order to map out the latest trends in the field of consumer behaviour within virtual and augmented reality environments. This research examines the existing literature to determine the key themes, patterns, and trends in the literature on this emerging subject (Crespo-Pereira & Membiela-Pollán, 2023) (Monaco & Sacchi). The primary goal is to determine the top journals, most cited documents and evaluating the publishing and citation activity to find out how information has been shared and discussed and in academic and professional circles, as well as to define the significant topics and trends to discover the thematic fields that have attracted significant attention (Yoo & Haenlein, 2023) (Damar, 2021). More precisely, the work focuses on co-occurrence and co-citation (cited authors) networks that shaped the development of this research area, providing an understanding of the driving forces in the field. In addition, the examination of the publishing and citation trends.

This research paper seeks to employ a bibliometric analysis to synthesize existing knowledge and map out the nascent field of consumer behaviour in virtual and augmented realities. The study analyzes the current literature of the subject, with a view of highlighting key themes, trends, and research gaps in this relatively emerging field of study (Crespo-Pereira & Membiela-Pollán, 2023) (Monaco & Sacchi). In this way, the paper will help to establish the basis for future research and applications, indicating the current state of research, as well as the areas that require further exploration and development, for both academic professionals and representatives of the Metaverse industry to better understand consumer behaviour in this environment (Yoo & Haenlein, 2023) (Damar, 2021).

# **RESEARCH METHODOLOGY**

#### **Objectives of the study**

1. To analyse publication and citation trends of Virtual and Augmented Realities and for examining consumer behaviour discourses.

2. To identify the major trending topics and themes related to Consumer Behaviour in Virtual and Augmented Realities research.

3. To identify the co-occurrence and co-citation networks that underpin research on consumer behaviour in Virtual and Augmented Realities.

#### **Criteria for Data and Material Selection**

This research employed SCOPUS database to search for literature on consumer behaviour in virtual and augmented realities between 1998 and 2024. The first search with the following keywords gave 520 articles: TITLE-ABS-KEY ("Metaverse" OR "Virtual Reality" OR "Augmented Reality" AND "consumer behaviour"). After including document types like articles, conference papers, book chapters, and reviews 494 articles were yielded. Excluding books and limiting to journals and conference proceedings narrowed the count to 396, when searching only for English language articles reduced the number to 392 that could be used for analysis.

### **Bibliometric Analysis and Visualization**

Compared with other bibliometric software, Biblioshiny has its own highlights by providing multiple dimensions of information in the form of graphical visualizations and tables (Muhammad Farhan Bashir, 2022) Its data import tool allows analysis of data samples to develop mapping of authorship, frequency of citation, annual trend analyses of research and more. The key research areas are highlighted effectively using Biblioshiny through word tree maps, co-occurrence networks, and theme maps (Siddiqui & Altekar, 2023). When used in combination with R it operates several activities such as data analysis, networks analysis and knowledge mapping. When used in combination with VOSviewer, which is excellent in the visualization of the network of frequently appearing authors and journals, Biblioshiny serves as a reliable bibliometric tool (Moral-Muñoz, 2020).

### RESULTS

We used the Biblioshiny package in R and VOSviewer to examine the key trends in research on consumer behaviour within virtual and augmented realities. In this section, findings of the study and main research trends and patterns are highlighted.

#### **Main Data**

### Table 1: Main Information about data

Description	Results
MAIN INFORMATION ABOUT DATA	
Timespan	1998:2024
Sources (Journals, Books, etc)	257
Documents	392
Annual Growth Rate %	14.26
Document Average Age	4.97
Average citations per doc	33.98
References	21816
DOCUMENT CONTENTS	
Keywords Plus (ID)	2093
Author's Keywords (DE)	1217
AUTHORS	
Authors	1130
Authors of single-authored docs	46
AUTHORS COLLABORATION	
Single-authored docs	47
Co-Authors per Doc	3.29
International co-authorships %	27.55
DOCUMENT TYPES	
article	279
conference paper	94
review	19

The statistical summary in Table 1 shows that from 1998 to 2024, 392 documents were published, with an average age of 4.97 years, averaging 33.98 citations, and a 14.26% annual growth rate. A total of 1,130 authors contributed, with 46 single-authored works. About 55% of articles involved international collaboration, with 2,093 Keywords Plus and 1,217 Author Keywords covering diverse topics. Most documents were journal articles (279), followed by conference papers (94) and reviews (19), supported by 21,816 references.

# **Publication Trend**

There is a steady growth in the number of scientific publications since 1998 and a sudden increase in 2020. They were below 10 per year for the first years, and in the period between 2020 and 2024, their pace accelerated and produced more than 60 publications per year. This is evidence of a notable research output and interest in the field in recent years.

# **Research Journals**

Table 2: Top 10 Journals using Source Impact

Element	h_index	g_index	m_index	TC	NP	PY_start
JOURNAL OF RETAILING AND CONSUMER SERVICES	9	12	0.692	1531	12	2012
TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE	9	13	0.818	613	13	2014
COMPUTERS IN HUMAN BEHAVIOR	7	7	0.467	305	7	2010
INTERNATIONAL JOURNAL OF RETAIL AND DISTRIBUTION MANAGEMENT	7	8	0.438	343	8	2009
SUSTAINABILITY (SWITZERLAND)	5	6	1	140	6	2020
EUROPEAN JOURNAL OF MARKETING	4	4	0.148	258	4	1998
FOOD RESEARCH INTERNATIONAL	4	5	0.667	275	5	2019
FRONTIERS IN PSYCHOLOGY	4	4	1.333	40	4	2022
INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT	4	4	0.333	1230	4	2013
ONLINE INFORMATION REVIEW	4	4	0.222	421	4	2007

Table 2 provides a list of the top 10 journals according to the source impact and shows how these journals are important in publishing highly cited and influential research. These journals are globally recognisable and focuses on niche area which make them more visible and appreciated in the academia.

# Most Cited Documents Globally

Paper	Year	Source	DOI	Total Citations	TC per Year
Dwivedi, Y. K	2021	International Journal of Information Management	10.1016/j.ijinfomgt.2020.102168	853	213.25
Kim, M. J	2020	Journal of Travel Research	10.1177/0047287518818915	666	133.20
Grabner-Kräuter, S	2003	International Journal of Human-Computer Studies	10.1016/S1071-5819(03)00043-0	642	29.18
Javornik, A	2016	Journal of Retailing and Consumer Services	10.1016/j.jretconser.2016.02.004	382	42.44
Dacko, S. G	2017	Technological Forecasting and Social Change	10.1016/j.techfore.2016.09.032	337	42.13
Dwivedi, Y. K	2023	Psychology & Marketing	10.1002/mar.21767	308	154.00
Kim, M. J	2019	International Journal of Information Management	10.1016/j.ijinfomgt.2018.11.016	289	48.17
Huang, T. L	2015	Electronic Commerce Research	10.1007/s10660-014-9163-2	284	28.40
Underwood, R. L	2001	Journal of Product & Brand Management	10.1108/10610420110410531	271	11.29
Gursoy, D	2022	Journal of Hospitality Marketing & Management	10,1080/19368623,2022,2072504	256	85.33

# Table 3: Most Cited Documents Globally

Table 3 presents basic bibliometric statistics and some of the most cited pieces of work in the field. This is evident by the frequent contribution of authors such as Dwivedi Y.K and Kim M.J. As seen in recent papers, cited rates are higher, suggesting increasing importance, while older work by Grabner-Kräuter (2003), remain foundational with high total citations.

### Wordcloud

The wordcloud reveals major topics of consumer behaviour research in the context of the metaverse, VR, and AR. Closely related words and phrases, such as 'consumer behavior', 'metaverse', 'e-commerce', 'purchase intention' suggest that this stream of research aims at capturing consumers' interactions and decision making in immersive technologies. New topics such as "trust," "interactivity", "virtual communities" indicate that there is increasing focus on psychological motivation and digital engagement.



### Figure 1: Wordcloud

### **Trending Topics - The Most Common Terms Related to Time**

The trend represents the development of consumer behaviour research (2007–2023) with increasing focus on AR and metaverses after 2017. The basic categories such as consumer behavior and e-commerce remain constant, while the topics that were popular a few years ago, such as 3D graphics, decline. There is a transition toward the virtual and psychological aspects of the technologies.





## **Thematic Map**

The thematic map indicates that online shopping and purchasing behavior are the most significant themes. Niche themes like interactivity are specific but less mainstream. Some of them may still be emerging while others may even be declining for instance virtual communities. Some of the basic themes such as VR and AR are still developing.



### Figure 3: Thematic Map

### **Co-occurrence** Network

The co-occurrence network centers on "consumer behavior," linking distinct clusters: technology and e-commerce (red), psychology and demographics (green), experimental methods (blue) and decision making (yellow). Basic and popular terms such as augmented reality and consumer attitude connect technological, psychological, and commercial research areas.



Figure 4: Co-occurrence Network

# **Co-Citation Analysis (cited authors)**

The co-citation analysis highlights key clusters: blue (methodology, tech adoption –e.g., Ringle, Davis), red (consumer behavior, digital marketing –e.g., Pantano, Kim) and green (service design, customer engagement – e.g., Mahr, Ruyter). Davis and Ajzen are an example of bridging authors who link methodological and practical knowledge highlighting the interdisciplinarity of consumer behavior research.



Figure 5: Co-Citation Analysis (Cited authors)

## CONCLUSION

The study shows the most relevant trends in consumer behaviour research within the metaverse, VR and AR, where the number of publications has been steadily growing since 2020. Findings suggest that the main topics are still relevant with the change of focus from the basic consumer behaviour themes like 3D graphics to the advanced technologies like AR, VR and many more but the main topics like e-commerce and engagement are still popular. Scholars and key journals substantiate the academic growth of the research area, and cooperation networks support its global and interdisciplinary orientations.

In order to take advantage of these insights, businesses should integrate the use of immersive technologies into their operations in order to increase engagement with customers and provide unique experiences. There are the questions of ethical and privacy that must be answered at the state level; further, more educational institutes should spread the usage of metaverse-related topics as scenario training for future professionals. This domain will be enriched by the interdisciplinary collaboration among researchers further.

The suggestions for future research include cultural differences, psychological effects, and temporal shifts in consumers' experience in immersive environments. Furthermore, the current literature review on technological innovational and sustainable development factors in the context of the metaverse could be very valuable. When aligning the current research with these future developments, both researchers and practitioners can leverage the opportunity of the metaverse for consumer engagement and business strategies.

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# KANTOROVICH VARIANT OF DURRMEYER TYPE OPERATORS WITH EXPONENTIAL FUNCTION

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# ABSTRACT

The approximation characteristics of a novel Durrmeyer type operators with exponential functions were investigated in this work. A different Kantorovich-type modification of those operators was discussed, with specific types of lemma, and we provided the rate of convergence, the inverse theorem, and the direct approximation theorem. It also introduces a new version of Bernstein-Durrmeyer type operators, where x can be any value in (-1, 1-1/n]; if  $\alpha = 1$ , the original operators can be obtained in an interesting classical form.

Keywords : Durrmeyer operators, Bernstein Operator, Exponential operator, Rate of convergence.

# INTRODUCTION

The n<sup>th</sup> degree algebraic polynomial is defined as

 $B_{n,k}(x) = k=0n(n k) x^{k}(1-x)^{n-k} f(k/n)$ 

established an algebraic polynomials in the theory of approximation and provided a constructive proof of famous Weierstrass theorem for approximation known as Bernstein operators (Bernstein, 2012). Introduced an integral modification of the Bernstein operators given as (Durrmeyer, 1967)

(1)  $D_n f(x) = (n+1) k=0n Pn, k \ge 01Pn, k(t) f(t) dt.$ 

Where

(2)  $P_{n,k}(x) = (n k) x^{k} (1 - x)^{n-k}$ 

considered a family of Durrmeyer type operators (Gupta, 2009; Guofen Liu, 2014) such as

Pn,m(x) = n k=0n Pn,k x 01Pn-1, k-1 (t) f(t) dt + Pn,0 x f 0, m=0

(3) nmn+m-1m-1k=0n Pn-m ,k x 01Pn+m-1, k+m -1 (t) f(t) dt, m > 0

Where m, n N0 with m n and for all a , b N0, ab = a(a-1)...(a-b-1), a0 = 1 is the falling factorial.

Defined as the operators (Jung, Deo & Dhamija, 2014)

 $B_n(f, x) = k=0n \operatorname{Pn,k}(x) f(k/n)$ 

(4)  $\operatorname{Pn,k}(x) = (1 + 1/n)^n (n + k) x^k (1 - 1/n - x)^{n + k} f(k/n)$ 

And x [0, 1 - 1n+1] if n is sufficient large then the operators (1) convert in to the classical Bernstein operators.

(5)  $B_{a}f(x) = k=0n(n k) x^{k}(1-x)^{n-k} f(k/n)$ 

And gave Durrmeyer type operatos (Jung, Deo & Dhamija, 2014)

(6) Vn(f, x) = (n+1)n2 k=0n Pn,k(x)0nn+1 Pn,k(t)f(t) dt.

Direct and inverse theorems for pointwise approximation by Bernstein-Durrmeyer operators were provided and using of Ditzian - Totik modulii 2(f, t) (Liu,2001). Numerous mathematicians developed some approximation features for Bernstein operators, including q-Bernstein, (p, q)-Bernstein, and Bernstein –Durrmeyer type operators(Deo et al. ,2008; Ditzian,1994; Finta, 2004; Gupta et al.,2013; Holhas, 2018; Kajla et al. , 2019; Kurre

et al.,2020; Tachev,2012). Introduced a new function  $\varsigma$  for generalized Bernstein –Kantorovich operators and gave some properties of that function with approximation properties and different type of approximation theorems

(Kumar, 2024).

# **RESEARCH METHODOLOGY**

Modification of classical Bernstein- Durrmeyer type operators by using Kantorovich type function. Studied the general Exponential operators. Let  $I \ c \ R$  be an open interval and let  $\alpha \ge 0$  be a real number. Consider a continuous function : (0,) R and we denote by  $C\theta$ ,  $\alpha$  the space of continuous functions  $f \ C(I)$  with the property that exist M > 0 such that  $f \propto Me\alpha\theta|x|$  for every  $\propto I$ , because of the symmetry and to simplified the notation considered in the followed that  $I \ c \ (0,)$  (Holhas,2018). Interpolation problems for PAL type functions and also provided a different type of PTIP with non-uniformly distribution, gave a beautiful intension for our operators and for changing type as a uniformly convergence properties studied by (Tiwari,2023).

**Lemma 1:** Consider a sequence of positive linear operators (Ln) the constants and having the property that for every  $f \in C\theta$ ,  $\alpha$  there exists an integer n N such that  $L_n f$  exists for every  $n \ge n\alpha$ . Suppose that Ln ( $e\alpha\theta t$ ) converges pointwise on I. Then, for every x I and for every  $\alpha \ge 0$ .

Ln (max( $e\alpha\theta t$ ,  $e\alpha\theta |x|$ ; x)  $\leq M(x)$ ,  $n \geq n\alpha$ .

Where M(x) > 0 depends on  $\alpha$  and x but not on n. Defined an interesting results as a lemma (Liu,2014). Lemma 2: [Liu,2014] Define the moments for every s N0, and consider Mn,m (f, x) = (m+n) mnm P<sub>am</sub>(f, x)  $T_{nms}(x) = M_{nm}((t-x)^s, x)$  For any  $m \in N0$ , and  $x \in [0,1]$ , Then

$$M_{n,m,0}(x) = 1 = T_{n,m,0}(x), \qquad T_{n,m,1}(x) = m - x (1 + 2m)n + m + 1$$

And

**Lemma 3:** [Kurre et al., 2020] Assuming a sequence of new Bernstein operators Bn, $\lambda$  (f, x) preserve the constants and having the property that for every  $f C\theta, \alpha$  then there exist an integer  $n \in N$ . Suppose that Bn, $\lambda$  (f, x) converges pointwise on (I] then for all  $x \in (I]$  and  $\alpha \ge 0$  So,

(8) Bn, $\lambda$  (f, x) M(x), n n

Where Mx > 0 depends on  $\alpha$  and x but not on n.

### PROPOSED WORK

We looked at a fresh interpretation of Bernstein-Durrmeyer type operators, which are modified Durrmeyer type operators using a Kantorovich type approach.

(9) Vn(f, x) = (nn-1) k=0n Pn, k(x) 0n-1n Pn, k(t) f(t)dt.

Where

Pn, 
$$k(x) = \int n - 1k(1 - x) + nk\alpha (1 - 1n - x) / xk(1 - 1n - x) n - k - 1$$

For any x  $(-l, l - \ln l)$  and if = 1 then got an interesting classical form of

 $Pn,k(x) = (n k) x^{k}(1 - 1/n - x)^{k}$  discussed another Kantorovich type modification of that operators

(10)Vn $\alpha$ ,a (f, x) = (nn-1) k=0n Pn, k(x) 0n-1n Pn, k(t) f(k+atn+a) dt.

Where Pn, k(x) is the same at (9). If a = 0 and t = k/n for every x I then we get also (9).

Lemma 4:[Jung et al., 2014] Let  $es(t) = t^{\circ}$ , s = 0,1,2 with opetators s n then for (-1, 1 - 1n] and n N, we have  $V_n(es,x) = (-1n)n-r r=0ssr xr s!r!(n)!(n-r)!$ 

**Lemma 5 :** If f C(-1, 1, -1n] then (11)  $\| Vn\alpha_{,a} f(x) \| \| f \|$  **Proof**: By the definition of Kantrovich modification as (10) and

Tn,m,0 (x) = 1 = Mn,m,0 (x) = Vn α,a f(x)So || Vnα,a f(x) || (nn-1) k=0n Pn, k(x) | 0n-1n Pn, k(t) f(x+atn+a) dt.|

Mn,m,0 (x) . || f(x) || use lemma 2 and | f || || f ||. Then  $|| Vn \alpha, a f(x) || || f ||$ .

#### Theorem 1: Rate of convergence

Let  $f \in C(-1, 1 - 1n]$  with the new mobile interval then we have (12) | Vnf, x - f (x) | M(x)

**Proof :** By using [7] and lemma (2.2)

|Vnf, x - f(x)| |Vnf, x| + |f(x)|

 $\leq$  | Vnf, x | + Mea $\theta$ |x|

 $\leq Me\alpha\theta|x|+ Me\alpha\theta|x| - 2 Me\alpha\theta|x|$ 

Ln ( Max (Me $\alpha \theta |x|$ , Me $\alpha \theta |x|$  )) M(x).

# **Theorem 2 : Direct Inverse theorem**

If for f = C(-1, 1 - 1n] and  $0 < (22 - \lambda)$ ,  $0 = \lambda - 1$  then the statements are equivalent as follows. |Vnf,  $x - f(x) = O(f, n-12 - \delta n1 - \lambda x)$ 

And C 2 (f, t) = O(t) where n(x) = (x) + 1n max  $\{(x), 1n\}$ .

**Proof**: Since C 2 (f, t) = O(t) is equivalent to the K – functional

 $K(f, t2) = \inf \{ \| f - gn \| + \| gn \| \}$ 

Let g gn and choose.

Such that  $|| f - gn || = B 2 (f, n-12 \delta n 1 - \lambda x)$  for all  $C \in I$ .

And let

| Vnf, x - f (x) | | Vnf, x - Vngn, x - f (x) + g(x) - g(x) + Vngn, x |

| Vnf- gn, x | -|f x- gx| + | Vngn, x - g(x) |

 $\leq 2 B 2 (f, n-12 \delta n 1 - \lambda x) + |Vngn, x - g(x)|$ 

By the theorem of rate of convergence

$$|$$
 Vngn, x  $- g(x) | \le M(x)$ 

So 
$$|Vnf, x - f(x)| = 2 B 2 (f, n-12 \delta n 1 - \lambda x) + M (x)$$

Then we can write in the form

 $|Vnf, x - f(x)| = C 2 (f, n-12 \delta n 1 - \lambda x)$  now using C 2 (f, t) = O(t)

Then

 $|Vnf, x - f(x)| = O(f, n-12 \delta n 1 - \lambda x)$  proved the famous theorem.

### Theorem 3: Direct approximation theorem.

For the operators Mn,m,s(f, x) then their exist a positive constant C > 0 such that

|Mn,m,s(f, x) - f(x)| = C2(f, ) + (f, (n+m+1)-1)) and  $= n,\rho\alpha$ , a Where  $n,\rho\alpha$ , a = Mn,m(t-x)2; x + m-x(1+2m)n+m+1-x 2Proof: Let (13) Tn,m,s(f, x) = Mn,m,s(f, x) + f(x) - f m- x (1+2m)n+m+1 x s = 0 then Tn,m, 0 (f, x) = Mn,m,0 (f, x) = 1. And if If s = 1 and f(t) = t then by (13) and (11) (14) Tn,m,1 (f, x) = Mn,m,1 (f, x) + x - m-x(1+2m)n+m+1-x = x Now using Taylors formula g(t) = g(x) + (t - x)g'(x) + xt(t - u)g''(u) du15 Tn,m (g, x) = g(x) +Tn,m xt(t - u)g''(u)du = g(x) + Mn,m xt t - u g'' u du; x - xm - x 1 + 2m n + m + 1 m - x 1 + 2m n + m + 1 - u g'' u du.  $| \text{Tn,m} (g, x) - g(x) | \le \text{Mn,m xt} t - u | g''(u) | |du|; x$ + xm - x (1+2m)n+m+1 m - x (1+2m)n+m+1 - u |g''(u)| |du|Mn,mt-x2; x + m- x 1+2m n+m+1 - x 2  $||g''(u)|| = n,\rho\alpha, a(x) ||g''(u)||$ Using (12) and (14) $(16) | \text{Tn,m,s}(f, x) | | \text{Mn,m,s}(f, x) | + | f(x) | + f \text{ m- x} (1+2m)n+m+1 \le 3 || f ||$ Now for all  $g \in 2$  and  $f \in C(I)$  and by (15) and (16) then | Mn,m,s (f, x) - f(x) | Tn,m,s f, u - fx + fm - x(1+2m)n+m+1 - f(x)|Tn,m,s f, u - g u| + |Tn,m,s g, u - g x| + |g x - f(x)| +fm - x(1+2m)n+m+1 - f(x)| Mn,m, s (f, x) - f(x) |  $4 || f - g || + n, \rho \alpha$ , a (x) || g " || + f, (n+m+1)-1Let infimum of RHS and for every  $g \in 2$  we get | Mn,m,s  $(f, x) - f(x) | - 4Kf, n, \rho\alpha, a(x) + f, (n+m+1) - 1$ Hence theorem is proved. Further more: **Definition :** A function :  $[0, 1] \rightarrow R$  is a quasi – convex if for every  $x_i, x_i = [0, 1]$  and between  $x_i$ ,  $x_2$  then we get () max { $\psi x1$ ,  $\psi x2$  }. **Theorem 4 :** If f C(I) with M > 0 such that |Vnf, x - f(x)| (). **Proof**: Let |Vnf, x - f(x)| |Vnft - fx; x| $| \ Vn \ | \ ft-fx | \ ; \ x \qquad Vn \ | \ ft | + | \ fx | \ ; \ x \ | \qquad Vn \ 2M \ e\alpha, \theta, x \quad ; x$ 2M Vn  $e\alpha, \theta, x$ ; x 2 M (nn-1) k=0n Pn, k(x) 0n-1n Pn, k(t)  $e\alpha, \theta, t$  dt.

2 M k=0 nPn, k(x) 1 - r2 k=0 nPn, k(x) r2 (nn-1)  $0 \text{ n-1n Pn}, \text{ k}(t) e\alpha, \theta, t$  dt.

2 M (nn-1) k=0n Pn, k(x) 0n-1n Pn, k(t) ea, $\theta$ , t dt. 1-r2 (nn-1) k=0n Pn, k(x) 0n-1n Pn, k(t) ea, $\theta$ , t dt. r2

 $2 M \{ \psi x1, \psi x2 \} \max \{ \psi x1, \psi x2 \}$  ().

So proved the theorem.

### CONCLUSION

The Kantorovich method of generalizing Bernstein-Durrmeyer operators has been used in this study to examine a number of novel ideas for the exponential type explanation. A number of theorems, including the Rate of Convergence, the Direct Inverse Theorem, the Direct Approximation Theorem, and others, were also investigated using those methods. This is important for novices of approximation theory because there hasn't been any research done up to this point, so these kinds of studies will be useful for later generations.

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# FESTIVE MARKETING STRATEGIES PLAYING A VITAL ROLE IN ECONOMIC DEVELOPMENT OF INDIA

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# ABSTRACT

India celebrates festivals with great enthusiasm. As festivals are important, so the festive marketing is. Through festive marketing, businesses boost revenue by making offers to the customers. The adds like 'This Diwali gift Time' by Titan, 'Is baar mil kar hi manegi Diwali' by Pepsi, etc attracts the customers. The offers like 'Big Billion Days' and 'Great Indian Festival' grab the public. This is a fantastic chance for: customers to seize the deals, businesses to boost sales, and the country's economy to grow. That is why we have "Festive Shopping Index." Thus, Festive Marketing contribute in Economic Development of India.

Keywords: Festive Marketing, Economic Development, Festive Season, Festival Marketing.

#### **INTRODUCTION**

Festive Marketing is the method by which businesses are stepping up their efforts to draw in customers. The goal is to boost revenue and profit by giving clients worthwhile offers. The promotion for it is usually centered around the festivals and is a one-time event held once a year. These are the sporadic special marketing initiatives carried out during certain times. We refer to this time frame as the festive season.

Festivals offer a wonderful fusion of feelings, customs, and creating unforgettable experiences for consumers. Marketers take use of these emotions to boost sales. Brands have a fantastic and rare opportunity to create winning marketing plans and implement them over the festive period. Customers will remember this since it leaves a lasting impression, and the festive atmosphere boosts sales.

The Diwali season has led to record trade of Rs 3.75 lakh crore in the Indian retail industry, according to the Confederation of All India Traders (CIAT). The economic impact of Ganesh Chaturthi alone in Mumbai is estimated to be between 40,000 and 50,000 crores, with Navratri and Durga Puja following closely behind with an estimated 40,000 crore in Bengal. The largest event in terms of economic impact, Diwali, is thought to provide opportunities valued at rupees 1.2 lakh crore every year. According to the RBI, during India's festive season, demand for bank loans hit a 12-year high while consumer confidence hit a 4-year high in September. One important measure of consumption is the amount sold during the festivals, which accounts for 60% of all sales in India.

India's festive season is marked by increased consumer spending and a rise in business activity. The retail, consumer durables, and automotive industries all perform better because of this increase in demand, giving them desirable investment opportunities. The importance of festive marketing in promoting economic activity is demonstrated by the GDP growth of India. Several industries are seeing an increase in sales at this time. Even artisans report a notable rise in demand for their distinctive and one-of-a-kind products.

Due to huge impact of festivals on Indian Economy, Retailers Association of India with Litmus World has been conducting a survey since 2017, named Consumer Sentiment Survey. On the basis of this survey, Festive Shopping Index is released. It indicates the predominant consumer shopping behaviour. It guides the retailors to be more Consumer-centric during the festive season. When compared with year 2020, the people interested in shopping during the festive season gone up by 94% in year 2021. This shows the importance of Festive Season and Festive Marketing in India.

### **OBJECTIVES**

The following objectives of the research has been made for drawing a conclusion:

- To find if Festive Marketing is playing a vital role in the Economic Development of India.
- To identify the kinds of brands that shine in festive marketing, which increases output and stimulates the economy.

- To determine the ways in which festive marketing helps to create jobs and gives women and young people possibilities.
- To determine whether the rural economy is being bolstered by festive marketing.
- To see if "Next Generation Reforms" can be achieved through festive marketing.

## HYPOTHESIS

Following hypothesis can be drawn in this research:

H01: There is no discernible relationship between economic growth and revenues from festive marketing.

H02: There is no evident relationship between increased product sales and increased production economics.

H03: There is no discernible link between the creation of jobs and festive marketing.

H04: There is no significant relationship between Festive marketing and the growth of the rural economy.

H05: There is no significant corelations between Festive marketing and Next Generation Reforms.

# **RESEARCH METHODOLOGY, ANALYSIS AND FINDINGS**

To analyse the goals and validate the hypothesis, secondary data has been employed in the study. The information was gathered from a variety of sources, including newspapers, research papers, news articles, published market studies, international publications, and official government documents. It was beneficial for both the literature review and in drawing the conclusion.

If we go one by one through the hypothesis, we can prove them as under: -

### H01: There is no discernible relationship between economic growth and revenues from festive marketing.

India's festival season, from the majesty of Ganesh Chaturthi to the glitter of Diwali, is a period of unparalleled joy. Consumer spending rises and online purchasing surges over this three-month period, making it the ideal time for companies to engage with eager audiences prepared to explore new goods and make purchases. In India, the higher spending capacity of people is driving higher expenditure and sales, which is booming the sales during the festive season.

As per Festive Sentiment Survey Report 2024 by Disney + Hotstar, there is increase in the average spending of consumers during the festivals. It was about Rs 17,000 last year which is expected to increase to Rs 25,000 in this year (2024). 81% of consumers are planning to spends above Rs 30,000. The sales will boost the revenue during the festive season and help in growth of Indian Economy.

Discretionary spending is expected to rise during the upcoming festivals in a number of sectors, including consumer goods, e-commerce, banking, real estate, and automobiles. Retailers predict that over the festive period, consumer sentiment will improve and reach its peak, and that sales will rise by at least 10% to 12% over the previous year. We have already seen a discernible uptick in customer confidence and spending power during festivals. The demand for durable products and Fast-Moving Consumer Goods (FMCG) has increased during this time, and many companies are trying to increase their marketing and advertising expenses to fulfil this requirement. Consumers are expected to ramp up their spending, with an average budget of Rs. 25,000, marking a substantial 47% increase compared to the previous year. 73% consumers will spend more on festive shopping compared to last year, and another 16% will spend nearly the same. Various purchasing factors like Discounts 40%, Brand 32%, Product features 30%, Cashback offers 27%, Customer experience 24%, Loyalty points 17%, Attractive EMIs 14% etc are the key drivers of festive sales. They directly help in increasing the sales and positively impact the revenue and the economic growth of our nation. The sales, which account for about 60% of India's GDP, are a crucial barometer of the state of consumption and economic growth.

Thus, with the help of above data and facts we can say that the Null Hypothesis stating 'there is no discernible relationship between economic growth and revenues from festive marketing' has been rejected.

### H02: There is no evident relationship between increased product sales and increased production economics.

Eighty-four percent of Indians plan to spend extra money during the festival season. Furthermore, consumers begin to favour hybrid purchases during festivals. It could be challenging for the advertising to keep up with the changing habits of the consumers. 63% of consumers admitted that they look up brands online before making a purchase and that the cheaper prices at festivals are what draws them in. Of the market, 54% of consumers choose
hybrid shopping, with 44% sticking to online transactions. According to The Drum Newspaper, 58% of purchases are made on impulse, and 36% of buyers start their journey as early as September.

Recent data from the S&P Global Purchasing Managers' Index (PMI) indicates that the manufacturing sector is growing rapidly. For three months in a row, August saw the PMI reach a high. It has now been over the crucial 50-point threshold that divides growth from contraction for 26 months running. Notwithstanding its 4.7% GDP contribution, the manufacturing sector does not face any particular issues. A number of variables, including a notable increase in both new and export orders as well as substantial inventory replenishment activities to attempt and avert any potential raw material shortages, are driving the expansion. Based on large volume orders over this festive season, the Readymade Textile Dealers Association anticipates growth of 15-20% over the previous year (Wright News and Blogs).

The market for consumer electronics and white goods is expected to grow quickly over the next five years, with a compound annual growth rate (CAGR) of 10% to 15%. Several states have announced special incentives for manufacturers of consumer durables. Subsidies for capital expenditures, financing, and land acquisitions are some of these incentives. Specialized incentives are also available to large and mega-investors across many states. Programs like the PLI Scheme in White Goods, the electronic production Cluster Scheme 2.0 (EMC 2.0), the Scheme for Promotion of Manufacturing of Electronics Components and Semiconductors (SPECS), etc. (Invest India) provide a boost to production.

When the sales increases within our country during the festive season, the demand of same products surges in foreign nations. This creates huge demand for the products and the production increases. Not only offline, also online shopping rises which overall creates tremendous demand and shoots up the production. Thus, festive marketing contributes to both an increase in exports and the manufacture of a variety of items.

Here, we conclude that there is significant relation between the increased sales and increase in production. Thus, the Null Hypothesis 'There is no evident relationship between increased product sales and increased production economics has been rejected.

#### H03: There is no discernible link between the creation of jobs and festive marketing.

One of the main drivers of the Indian economy is the festive season. The seasonal impact on employment and consumption was confirmed by the 13% annual increase in the Naukri Job Speak Index to 3,103. The employment rate increased by 27% year over year in major cities like Mumbai last year, but emerging areas like Ahmedabad and Coimbatore also showed optimistic employment trends, demonstrating that the phenomenon is not exclusive to them. According to industry-wide polls, festive marketing causes employment to increase by roughly 20% over the festive season (Wright News and Blogs).

The upcoming festivals and festive marketing will cause a spike in temporary hiring; 600,000–700,000 roles are anticipated to be created across all industries. Increased consumer spending is driving a 15% to 20% annual growth in the requirement for temporary workers. Even though there is a lot of demand from the retail, hotel, banking, financial services, and insurance (BFSI), and consumer sectors, e-commerce and logistics are predicted to have the biggest increases in temporary hiring—between 30 and 35 percent. Due to rising consumer spending on festivals—which they view as auspicious occasions to observe customs, rituals, and celebrations—tier-2 and tier-3 cities are experiencing a surge in the need for temporary labour (Economic Times).

As the festive season approaches, 'Indeed', a global platform for matching and hiring, released a survey that revealed employment trends. While the festive season sparks employment and earning opportunities, it also unlocks perks and compensation for companies and job seekers alike. The analysis added a distinctive dimension to the job forecast by examining how sectors capitalize on the festive fervour to satisfy manpower demands and create possibilities.

6 most in-demand job roles this festive season according to Indeed:

- In-shop demonstrators
- Logistics and warehousing roles
- Digital marketers
- Customer and partner seller services
- Beauty consultants
- Call centre operators, and retail sales

The employment trend is anticipated to be supported by demand in smaller towns and rural areas due to favourable domestic economic indicators such as declining retail inflation, robust manufacturing growth, and forecasts of no interest rate hike. According to Indeed, 69% of employers surveyed are looking to hire temporary workers this

festive season. Whereas 20% are set to hire gig workers, which include freelancers, consultants, independent contractors etc. to manage the upcoming workload during the festive season.

This festive season, as the labour market continues to change, some roles are becoming increasingly in-demand. In addition to meeting corporate needs, these in-demand jobs present job seekers with remarkable chances to establish themselves in a variety of industries. These positions fit the special requirements of the festive season, when there is a surge in client interactions and increased consumer activity. The spike in demand highlights how important these professions are throughout this festive season, despite being temporary.

So, Festive Marketing generates huge employment and helps to increase the purchasing power of population. This money is again penetrated in the market which contributes in boosting production and it also creates jobs. Thus, the Null Hypothesis, 'There is no discernible link between the creation of jobs and festive marketing' has been rejected.

#### H04: There is no significant relationship between Festive marketing and the growth of the rural economy.

During the busy Festive season, Redseer, an Indian online retailer, expects sales to rise by 20% to over Rs 90,000 crore. In the Indian e-commerce industry, the festive season sales are commemorating ten years. It has expanded by over twenty times since 2014. In 2023, the gross merchandise value had already reached around Rs 5,25,000 crores. At least 140 million shoppers are anticipated to transact during the forthcoming festive season, as the yearly number of transacting users has increased by 15 times to 230 million this year.

Increased spending on brand advertising and larger buying quantities are also helping the sector. High-end merchandise is anticipated to raise average selling prices, potentially making the festive season the most lucrative time of year for companies. Strong growth is anticipated this season across the board, despite metros having recently grown faster than Tier 1 and Tier 2 cities.

India's pin codes are almost all familiar with e-commerce shipping. In India, tier two cities and smaller towns account for over 60% of transactions and orders. Even in tier-2 and tier-3 cities, where they currently account for over half of all customers and three out of every five orders placed on the top e-retail platforms, e-commerce is becoming more and more popular. According to Invest India, "there is very little difference in the average selling price (ASP) between tier-2 and smaller towns and tier-1/metropolitan cities".

Many rural business merchants make up the vast majority of the buyers that use these online retailers. These vendors register with these marketplaces and begin selling their goods. One of Amazon's projects is "Amazon Karigar," where gifted artists sell their handicrafts online. Artists can sell their products and make significant income in this way. Therefore, Festive Marketing helps to assist Rural Economy. The value of handicraft exports from April to March of 2024 was \$1802.36, except for handmade carpets, and it is expected to at least treble over the festive season. India exports textile products to more than 100 countries, including handlooms and handicrafts. These exports rise in conjunction with festivals and contribute to the growth of rural economy of India.

An estimated 68.86 lakh artisans are employed in the handicraft sector; of these, 30.25 lakh are men and 38.61 lakh are women. This also strengthens the rural economy. The number of women working is increasing annually, which is empowering rural women to become self-sufficient and boosting the rural economy (Invest India).

Here, the Null Hypothesis, 'There is no significant relationship between Festive marketing and the growth of the rural economy' has been rejected.

#### H05: There is no significant corelations between Festive marketing and Next Generation Reforms.

The Next Generation Reforms initiative aims to promote economic growth, improve market and sectoral efficiency, and raise productivity. Real GDP growth in the first quarter of FY24 was 7.8% year over year, according to GDP data. This was somewhat less than the RBI's 8% prediction for the period but still much higher than the 6.1% growth in Q4 of FY23. India's GDP growth is impressive when compared to other nations, such as China, which has grown by 4.5%, and Indonesia, which has grown by almost 5%. The expansion is attributed to several factors, including increased productivity, a functioning market cycle, the creation of jobs, and the balanced development of the rural and urban economies. These are Next Generation Reforms, and they will grow even more with the support of Festivals and Festive Marketing.

In India, the festive season has both cultural and economic significance. In the face of difficulties and uncertainty, it demonstrates the tenacity and hope of Indian customers and the retail sector. Additionally, it gives companies a chance to be creative and adapt to the changing demands and tastes of their customers. This increases sales, production, manufacturing, export, generates employment, supports urban and rural economy and acts as a catalyst for the economic growth of India. Festive Marketing is the super hero which brings smiles in the face of all,

whether it is customers, brands, companies, arcticians, women, children, and even the Finance Minister of our nation.

Thus, the Null Hypothesis, 'There is no significant corelations between Festive marketing and Next Generation Reforms' has been rejected.

#### CONCLUSION

Economists, entrepreneurs, and investors in India closely monitor new orders and expenses as indicators of consistent economic growth during festivals. GDP (Gross Domestic Product) is driven by consumption throughout the business cycle. Therefore, if products are outpacing their trend in consumption, the GDP is probably going to outpace its trend during the festive season. This will inevitably accelerate national economic growth.

When sales increases during the festive season, huge employment is generated, which basically absorbs the youth and the women. They become part of the earning population and contribute in economic progress of nation. They not only contribute in the economic growth, but they also become self-reliant, which in turn increases their selfconfidence and motivates them to work harder. They become the new tax payers.

For local communities festivals are their main source of income. According to government data, domestic goods sales rise during festive periods. The industries can benefit from this research by seeing a rise in festive sales and a positive outlook, which will raise DA and staff productivity-linked bonuses. The employees' purchasing power may rise as a result.

Startups can use festival marketing to establish themselves and grow throughout the festive season if they follow the right techniques. Additionally, it will provide brands who have had difficulty in the last several years some hope. This study will enable them to reintegrate into society by providing them with the knowledge necessary to employ appropriate methods during the festive seasons. It has already been demonstrated that a large number of businesses failed miserably as a result of poor festive marketing concepts that were imitated from western nations. We must create our own festive marketing strategies in order to draw in customers because Indian and Western festivities differ greatly from one another. India is a festival nation. We ought to create such joyful marketing concepts that other nations would be inspired to imitate and use as a model.

Festivals and tourism have been described as two sides of the same coin. The most important factor in increasing the economic efficacy of tourism is festivals. Festivals are rapid and concrete marketing campaigns that can attract foreign visitors and present business opportunities. The government and related sectors can use the study's findings to help create festival marketing strategies that will attract tourists and boost travel to India. This is made possible when the government collaborates with different industries to create and implement enticing festive marketing techniques.

In summary, Festive Marketing is guiding India toward Next Generation Reforms and that is why it is worth to have a separate "Festive Shopping Index" for the purpose. Thus, Festive Marketing is of utmost importance. It is the marketing strategy for the present and the future.

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### **REDISCOVERING THE GANDHIAN PHILOSOPHY OF SARVODAYA AND ITS APPLICATION TO THE MODERN WORKPLACE**

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#### ABSTRACT

The world as we know today, is changing very fast, presumably in the right or the intended direction. The way society and the thinking involved in its players has developed over the years is indeed remarkable yet at times terrifying. These players run the risk of being called self-serving. This narcissistic approach towards "my wellbeing first" attitude is freely giving way to an unstructured and dysfunctional societal pressure which are creating expectations that affect the entire community as a whole. It feels as if everyone, out there has a point to prove and over the years with the advent the technology it has grown many-fold. The modern workplace is not left untouched from it as these employees are coming from that same society and what they are outside the organizations is reflected as a crystal-clear image inside the organization.

In the early 1900s, Mahatma Gandhi developed the concept of *Sarvodaya*, which somehow translated to a society based on universal upliftment. Even though at those times, this concept and ideology were very socialist in nature and maybe, the Indian society at that time, needed this kind of motivation, but is it really relevant in the today's times?

This research article's simple aim is to revisit and rediscover the Gandhian Philosophy of *Sarvodaya* and its application to the modern workplace and somehow find some simplistic solution which, even though are derived from the aforesaid philosophical thought, yet are modernistic and very affable in its basic nature.

Key Words: Sarvodaya; Gandhian Philosophy; Modern Workplace; Society; Motivation; Organizational Well Being

#### **INTRODUCTION**

Even though in reality we do not, we, in some far-fetched dreams, still live in a utopian society. It is keeping our modern and modernized thought system very difficult to define such a society as it has in the timeline of the history of mankind, never, actually existed. The actual society dwells on either side of an uneven fractural line-which is a great divide and because of the capitalist nature of modern society which in turn has caused a very uncomfortable social unrest, and inequality and thus divided the society in two fractions- the affluent and the deprived and each side has their own views ad thoughts on how a society should function which has caused inconsistency, hostility and mental violence.

Over the years, decades, and centuries, many philosophers and thought leaders have tried to push their ideas and notions of an idealist society based on what they thought was right and just. Of course, it also depends in what time in history this thought was put forward as it was representative of the concurrent social unrest and chaos prevalent at that time. But the real question is if that thought was sustainable or just apt for that time.

This can be another representation of the Golden Rule, which basically means treating others the way we want to be treated by them. Over the years and somehow ascertained by several cultures, religions, and sects, it has been interpreted and deduced as it has suited the prevailing society.

According to Epstein, Greg M (2010), living by the Golden Rule means striving to understand and empathize with others, even when they are very different from us. Well, in theory, it sounds very ethical and just, but the question is why we are disassociating ourselves from others, how said or who decided that one human being is different from another. Who created this divide in the society and amongst men?

In 1860, John Ruskin wrote exclusively on the discouragement of political economy or critique of economy, which was also an unsubtle form of social critique, that rejected the notion of the conventional ways of distributing resources. Ruskin saw "the economy" as a form of "collective mental lapse" or a shared delusion, and he regarded the obsession with precision in industry as a form of modern slavery.

Ruskin did not dispute the truth of the economic theories he critiqued but argued that they could not be effectively applied to the world as they existed. He challenged the concepts of "natural laws," "economic man," and the conventional understanding of value, highlighting the inconsistencies in economic thinking. Ruskin specifically criticized John Stuart Mill for believing that market prices accurately reflected public opinion.

In 1904, while practicing law in South Africa, Gandhi received a copy of Ruskin's Unto This Last from his British friend, Mr. Henry Polak. During a 24-hour train journey to Durban, he read the book and was so captivated by Ruskin's ideas that he couldn't sleep, later stating, "I was determined to change my life by the ideals of the book." The impact of Unto This Last on Gandhi's philosophy was significant. Motivated by Ruskin's teachings, he resolved to not only transform his own life but also to launch his newspaper, Indian Opinion, on a farm where all individuals, regardless of their role, race, or nationality, would be paid equally. This innovative concept was ahead of its time and contributed to the establishment of the Phoenix Settlement.

In 1908, Gandhi translated Unto This Last into Gujarati, naming it Sarvodaya (meaning "Well-Being of All"). Later, in 1951, Valji Govindji Desai retranslated it into English under the title Unto This Last: A Paraphrase. This work can be seen as a foundation of Gandhi's economic vision, as it shaped many of his social and economic ideas.

Sarvodaya, a term coined by Mahatma Gandhi, meant "welfare of all" or "universal uplift." Rooted in Gandhian philosophy, Sarvodaya emphasizes the well-being of every individual in society, promoting social justice, equality, and non-violence. It reflects the idea that true progress occurs when all members of society thrive together, rather than just a privileged few. The concept was heavily influenced by Gandhi's interpretation of ethical principles from various religious and philosophical traditions. This concept heavily argued for the dignity of labor and the importance of a moral economy that benefits everyone.

Sarvodaya has been the guiding principle for many Indian social reform movements, inspiring efforts to create self-sufficient, non-exploitative communities where cooperation and mutual aid are central values. It's not just an economic or political theory but also a deeply spiritual and ethical vision of a harmonious society.

#### The four fundamental principles that Mahatma Gandhi taught and lived by:

- Truth (Satya)
- Non-Violence (Ahimsa)
- Peaceful Protest (Satyagraha)
- And Welfare of All (Sarvodaya)

These principles can hold people together and hence form the backbone of Dharma, which means "to hold together".

Satya means oneness in your thoughts, speech, and actions. Gandhi Ji believed that "there is no religion higher than truth". The Yoga-shastras as well as the Yoga Sutras of Patanjali propagate truthfulness as one of the main components for living a disciplined life.

Gandhi Ji preached the concept of "experimenting with truth", a phrase that also formed the subtitle of his autobiography. He taught how to learn through trial and error, often admitting to mistakes and changing one's behavior accordingly. Non-observance of truthfulness is the root cause of any corruption in society.

Ahimsa teaches us the path of nonviolence. It should be practiced not only in actions but also in thoughts and speech. Ahimsa also forms the basis of Jainism and Hinduism as a religion. Satyagraha is a form of protest based on Satya (path of truthfulness) and nonviolence and includes peaceful demonstrations, prolonged fasts, etc., i.e., a nonviolence-based civil resistance. It is based on the law of persistence. Satyagraha is formed by two Sanskrit words: Satya (truth) and Agraha (holding firmly to or firmness). Gandhi Ji said, "Satyagraha is a weapon of the strong; it admits of no violence under any circumstance whatsoever; and it ever insists upon truth." He said that if you are firm in the truth in the long run, you are going to win.

The last principle is Sarvodaya or welfare for all. The fundamental teaching of Vedic science is also based on Sarvodaya. It talks about "bahujan hitay-bahujan sukhay"—"the good of the masses, the benefit of the masses".

Gandhi Ji found in it a composite concept of social welfare and economic justice. Any action that is aimed at or seems to be aimed at the welfare of the people will be accepted by all.

Sarvodaya means' progress of all 'or' universal uplift'. Gandhi Ji started this Sarvodaya movement, and people consider it an addition to his efforts in his non-violence movement. The main objective of this event was to establish a new India based on non-violence and love. It is an intellectual and powerful movement to develop India's socio, economic and moral independence. The Sarvodaya movement was aimed at creating a society that uses the politics of cooperation instead of the politics of power. The leading preachers of this movement were Jayaprakash Narayan and Acharya Vinoba Bhave.

#### Gandhi Ji advanced the concept of Sarvodaya, which was based on three basic ideologies:

- That the good of the individual is contained in the good of all.
- That a lawyer's work has the same value as a barber's in that all have the same right to earn their livelihood from their work.
- That is a life of labour, i.e., the life of the tiller of the soil, and the handicraftsman is a life worth living.

Gandhi Ji was of the firm view that the Earth provides enough to satisfy every man's needs, but not for every man's greed.

In the envisioned Sarvodaya society, every individual would be free from the desire for excessive material wealth and luxury, embracing the principles of simple living and high thinking. This approach would allow everyone to have the opportunity to earn a sufficient income through honest work, eliminating unemployment. While incomes may vary based on individual talent, ability, and effort, those with higher earnings would primarily use their wealth for the benefit of the entire community. In this society, all resources, including land, would be regarded as common property, with individuals holding excess wealth acting as trustees for the less fortunate.

Regarding machinery in economic activities, Gandhi emphasized that while machines may be necessary, they should not concentrate power in the hands of a few or reduce the majority to mere laborers. He advocated for minimizing machine use in favor of productive physical work, ensuring that everyone contributes to their livelihood through honest labor. This sentiment is echoed by Leo Tolstoy, who believed in upholding the dignity of all forms of honest work.

#### **REVIEW OF SELECTED LITERATURE**

In Unto This Last (1860), John Ruskin advocates for social justice and universal upliftment, emphasizing moral and ethical principles in economics. He critiques capitalism for focusing on individual wealth, arguing that true wealth lies in the well-being of all members of society. Ruskin highlights the dignity of labor and calls for fair treatment of workers, urging society to prioritize the welfare of the poor and marginalized. He believes economic systems should promote equality and serve human needs rather than encourage competition and exploitation, influencing later reformers like Mahatma Gandhi and his concept of Sarvodaya (the welfare of all).

In The Story of My Experiments with Truth (1927), Mahatma Gandhi does not explicitly mention the term Sarvodaya (the welfare of all), as this concept developed more fully later in his life. However, the foundations of Sarvodaya are evident throughout the book in his reflections on truth, non-violence (ahimsa), and service to humanity. Gandhi emphasizes selfless service, equality, justice, community self-reliance, and non-violence, all of which align with Sarvodaya's ideals of uplifting the marginalized and promoting universal welfare. His autobiography lays the groundwork for the philosophy that would later become central to his vision of social progress.

Throughout the years, a diverse array of authors, management experts, philosophers, reformers, global leaders, influencers, changemakers, and social thinkers have spoken, debated, and written extensively about Gandhi Ji and his ideologies. Opinions have ranged from supportive to critical, yet repeatedly, his relevance to the times in question has been underscored. While it is challenging to encompass all these perspectives, especially in a critical format, some of them are discussed here, specifically the ones closely related to Gandhi Ji's Sarvodaya Principle:

Thompson, E.P (1967), In his influential essay, "Time, Work Discipline, and Industrial Capitalism," examined how industrialization reshaped time management, instilling in the working class the belief—echoing Weber's

connection between Protestantism and modern capitalism—that "time is money." Toward the conclusion, Thompson suggested that if the rigid, goal-oriented use of time became less dominant, people might need to relearn the lost arts of life from the pre-industrial era: filling their days with richer, more leisurely personal and social interactions, and breaking down the separation between work and life.

Narayanasamy, S (2003), in his book; The Sarvodaya Movement: Gandhian Approach to Peace and Non-violence, extensively discussed the various factors that somehow influenced the Sarvodaya Movement and highlighted positive and negative aspects of it. He also discussed how the Gandhian ideology, principles and thoughts were followed and applied at the grassroots level. He also discussed the relevance of Gandhi Ji and Sarvodaya in our daily lives.

Sharath, S. S. (2006), wrote an interesting yet thought-provoking article titled "A confluence by the Cauvery", which was published in the leading newspaper of India, The Hindu. He mentioned the importance of a small, forgotten place in the Indian state of Karnataka; Paschima Vahini. It is situated on the banks of Kaveri (Cauvery) river, near Srirangapatna, in Mandya District in Mysore. This place is considered sacred and auspicious for the Hindus. Usually, once a person departs, after performing the burning rituals people carry the ashes to this place and immerse them in the river. Many of the new generation may not this that Mahatma Gandhi Ji's ashes were immersed here on the 12th of February 1948. After the immersion of the ashes, freedom fighters and Gandhians who were present at Paschima Vahini decided to organize the Sarvodaya Mela every year. Over the years, the Sarvodaya Mela has undergone many changes, but its essence has remained the same. Over the years, the number of attendees has dwindled. Nowadays, only a small gathering, mostly consisting of people from older generations, some of them dressed in Khadi, gather to pay obeisance to the Father of the Nation. Here, Gandhi Ji's views on social, economic and political developments are discussed, and the mela serves as a platform for introspection.

Kronsell, A; Bäckstrand, K; Lövbrand; K, J (2010) discussed whether emerging governance models—such as public-private partnerships, stakeholder consultations, and networks—enhance both, the environmental policy effectiveness and the quality of deliberation and participation. It argues that both academic research and policy practice have experienced a "deliberative turn," reflecting renewed interest in deliberative democracy and growing support for innovative public-private governance structures.

Thompson, D (2013), in his article, said that the usage of the term "the dismal science," is about economics' most depressing outcomes like globalization killing manufacturing jobs, etc. he mentions that the inescapable element of economics is human misery. It aligns economics with morality, and against racism, rather than with misery, and against happiness.

Taylor, T (2014) in his article strongly said that economists often strive to remain value-neutral, but many critics take issue with the disconnect between economics and virtue. Economists tend to avoid moral questions, claiming their focus is on trade-offs, incentives, and interactions, leaving ethical considerations to politics and society. However, moral judgments cannot easily be separated from economics.

Team Foundit (2016), in the article, discussed the five lessons that an organization can learn from Gandhi Ji to get ahead at the workplace, namely, creating a talent pool, communicating and sharing plans with the team, seeking growth for all derived from the Sarvodaya principle of universal uplift and not losing patience under any circumstance.

Jeliyang, A, S (2016), boldly asks if the Gandhi Ji is still relevant today?" The answer is that he is more relevant than ever. Gandhi Ji taught us how to reclaim our freedom from the state through his concept of Satyagraha. His economic philosophy, focused on sustainable growth, prioritizing human needs over machines, and reducing economic inequality, offers solutions to the challenges of global warming and promotes inclusive growth, a term widely discussed today. Gandhi's approach remains the only viable path for humanity's survival. Until serious efforts are made to tackle poverty, reduce inequality, and increase employment, the annual pilgrimage by our leaders to Rajghat on October 2nd will continue to be little more than an empty gesture.

Parida, P (2019), in is article published in The Times of India, mentioned that as per Gandhi Ji, acceptance and tolerance in the society will help in defusing the ethnocentric bias that is present in today's society like an unwanted weed. He aspired for an egalitarian and classless society that had no poverty, no hunger, and no unemployment, and there is education and health for all. Gandhi Ji said that the practice of self-control is much needed in this

materialistic world as it is selfishly driven by the desire to achieve materialistic pleasures and acquire more and more.

Shastri, A and Gupta, P (2022), in their article extensively discussed how the Sarvodaya movement targeted the formation of an ideal society where any type of discrimination over race, creed, caste, language, class, etc.; will no longer be there. They said that the theory of Utilitarianism holds the most ethical choice that will be able to produce the greatest good for the greatest number. They also mentioned that any economy should be completely free from exploitation and corruption and in an idealistic society, there should be a limitation of, and on human wants, there should be equality & and emphasis should be on only basic needs. They also said that a society based on the Sarvodaya principles should have no place for unwholesomeness, competition, exploitation, and class hatred.

Kaur, A (2022), extensively discusses the concept of corporate social responsibility and how it can become more meaningful if organizations work towards sustainable development and use the Sarvodaya principles in a more focused manner. It also discusses how Gandhian philosophy can develop a classless society with no difference between haves and have nots, non-violence, unrest, no one tied in the grip of poverty, and economic inequalities of ownership and income. This can somehow resolve the social and economic conflicts which have grown because of the presence of inequalities and the availability of privileges present in modern society.

Aakhoon (2022), discussed how Gandhi Ji through the philosophy of his non-violence principles, wanted to replace the discriminatory social structure that had crept deeply into Indian society and create an ideal social order. Gandhi Ji believed in the good of everyone and that ideas and thoughts would help in the removal of several customary evils, unrest, injustice, and gender inequality from society. His dream of a futuristic, ideal Indian society was based on equality and equal opportunities for everyone, regardless of differences in caste, colour, creed, religion, and gender.

Singhania, S and Mustafiz, T (2023), discussed how the Gandhian concept of decentralization was implemented in democracies through the 73rd and 74th amendments in the Indian constitution. They mentioned how it was implemented in the local self-government by embracing the Panchayati Raj and Municipality system in rural and urban areas in India and how it plays an important role in India's grassroots development.

The concept of Sarvodaya can be summarized as a society without centralized authority, where politics serves as an agency for service rather than power. This society would promote values such as love, fraternity, truth, non-violence, and self-sacrifice. It embodies a true form of socialism, allowing individuals the freedom to develop their personalities in an environment of equality and liberty. The movement encourages personal labor and the ideal of non-possession, aiming to cultivate a strong commitment to the welfare of all.

While some may argue that Sarvodaya's ideals are impractical in today's world, the principles themselves are noble and theoretically sound. However, their application seems challenging, as establishing a society founded strictly on Gandhi's ideals is likely impossible. The lofty ideals of Sarvodaya may seem ungrounded, especially given the poor performance of local governance in India, which reflects the prevailing societal issues. In a competitive global landscape, achieving a model like Gramrajya in one country is unlikely unless all nations embrace Sarvodaya principles. Additionally, instilling these values in a selfish youth population poses a significant challenge. For instance, during the Bhoodan movement in the 1950s, people often donated land that was of little value, highlighting a lack of genuine commitment to the cause.

#### GAPS IN THE EXISTING RESEARCH

Identifying gaps in research on Gandhi's Sarvodaya Principle can lead to fresh insights and a deeper understanding of its modern relevance. Notable areas lacking exploration include comparative studies with global social welfare philosophies like Ubuntu and Buddhist harmony, as well as contemporary applications addressing issues such as poverty, inequality, and climate change. Additionally, the economic dimensions of Sarvodaya, its intersection with environmental philosophy, and it's implications for gender equality are underrepresented. There is also a need for research on how Sarvodaya principles interact with globalization and technology, the psychological benefits of community-oriented living, and their integration into modern governance models. Moreover, youth engagement with Sarvodaya remains underexplored, as does the necessity for critical analyses of its limitations in various socio-political contexts. Lastly, minimal research has been conducted on Sarvodaya's impact on individual well-being and community resilience in times of crisis.

#### **RESEARCH METHODOLOGY**

**Research Design:** This study utilizes a quantitative approach with a structured survey to gather data on participants' awareness, perceptions, and applications of Gandhian philosophy, particularly Sarvodaya, in contemporary society. The survey collects demographic information and opinions, facilitating the analysis of correlations between demographics and views on Sarvodaya.

**Sampling:** The sample comprises 300 respondents, ensuring diverse representation across age, gender, employment, marital status, and education levels. Stratified random sampling was employed to capture a wide range of perspectives from various demographic groups, including young adults and retirees.

**Questionnaire Construction:** The questionnaire assesses the relevance of Sarvodaya in the modern workplace and includes several sections:

**Part I- Demographics Section:** Questions 1–5 gather basic demographic data, including age, gender, occupation, marital status, and education level. This information enables researchers to segment the responses and examine potential patterns or correlations between demographics and views on Sarvodaya.

**Part II- General Awareness of the Philosophy:** Questions 6-8 measure the participants' familiarity with Gandhian principles and the concept of Sarvodaya. This section uses a Likert scale to capture nuanced responses, ranging from "Very familiar" to "Not familiar at all," allowing for a gradient of awareness.

**Part III- Sarvodaya and Contemporary Social Thought:** Questions 9–16 focus on aspects of Gandhian philosophy that participants find relevant today and assess the perceived importance of Sarvodaya in addressing societal challenges (like poverty, inequality, and environmental issues). The response options range from "Very important" to "Not important at all," capturing the significance participants attribute to these values.

**Part IV: Personal Core Beliefs, Personal Philosophy & Individual Practices:** Questions 17, 18, 22, 25, 28, 29 assess agreement with specific statements about Sarvodaya, gauge participants' likelihood of supporting policies aligned with Gandhian principles and evaluate personal adherence to these values in daily life. This section also asks about interest in further learning about Sarvodaya, capturing openness to deeper engagement with Gandhian philosophy. Each section's structure ensures clarity, ease of response, and depth in capturing diverse perspectives on Gandhian values, allowing for robust analysis of Sarvodaya's perceived relevance in contemporary contexts.

**Part V: Role of Sarvodaya in Contemporary Socio-Economic Reform:** Questions 19- 24, 26, 27 explore the applicability of Sarvodaya in specific areas such as sustainable development, education, digital economy, social justice, and policy relevance. Using a scale from "Not at all applicable" to "Very applicable," these questions assess where participants believe Sarvodaya can most significantly impact modern challenges.

#### DATA COLLECTION METHOD

Data were gathered through a self-administered online questionnaire.

**Data Analysis:** The analysis involved cross-tabulation and descriptive statistics to examine relationships between demographic factors and familiarity with Sarvodaya. Tests were conducted to determine the significance of these relationships, revealing how variables like age, gender, and education correlate with interest in Gandhian principles.

#### Findings, Data Interpretation & Inference

The primary aim of this research was to explore the applicability of Gandhian Sarvodaya philosophy in the context of the modern workplace. The research analyzed responses from 300 participants regarding Gandhian philosophy, specifically Sarvodaya (universal welfare), and its relevance in modern society. Here are detailed findings:

#### Here are the major points summarized from the findings:

**Demographics:** The survey sample was largely composed of young people, with 53% aged 18-25, mostly students, and a higher proportion of males than females.

**Familiarity with Gandhian Philosophy:** Younger participants had varied awareness of Gandhian philosophy, with higher familiarity among those with advanced education and a slightly higher familiarity rate among males.

**Relevance of Gandhian Principles:** Most respondents felt Gandhian values like community welfare and sustainability were highly relevant, particularly for addressing global issues like climate change and inequality.

**Support for Educational Integration:** Over 70% of respondents supported integrating Gandhian values into education, viewing this as beneficial for fostering community welfare and sustainable practices among younger generations.

**Daily Application and Interest in Learning:** Many respondents, especially students, already apply Gandhian principles like simplicity in their lives and show interest in further learning about Sarvodaya.

Younger Generations' Interest: While some younger people showed interest in Gandhian philosophy, a significant portion remained neutral, suggesting a need for more educational outreach.

**Modern Relevance of Sarvodaya:** Sarvodaya's principles were seen as applicable to modern issues such as poverty and sustainability, resonating with current concerns about consumerism and environmental challenges.

**Workplace Impact:** Respondents believed that adopting Sarvodaya principles could promote ethical, inclusive, and sustainable practices within workplaces, aligning with CSR trends and fair labor practices.

**Personal Beliefs and Practices:** Gandhian values like community welfare and simplicity were widely valued, with many respondents incorporating these into their personal lives.

**Implications for Modern Society and Workplace:** Sarvodaya is viewed as a counterbalance to materialistic and technological trends, with potential applications in public policy and corporate culture to encourage social cohesion, ethical governance, and sustainable development.

These points summarize the favorable perception and perceived relevance of Gandhian and Sarvodaya principles across social and workplace contexts, with strong support for educational efforts to increase familiarity among younger demographics.

#### **CHALLENGES & POTENTIAL**

The data reveals that while Sarvodaya philosophy can be applied in modern workplaces, its full integration may face challenges due to varying familiarity levels and competing societal priorities. Key findings include:

Alignment with Workplace Trends: Sarvodaya principles, such as community welfare, simplicity, and nonviolence, resonate with contemporary trends like corporate social responsibility and sustainability. Many respondents support values related to minimalism and collective welfare, reflecting modern organizational focuses on environmental impact.

Ethical and Inclusive Practices: Respondents believe that non-violence and community welfare foster inclusive work environments, promoting ethical leadership and collaboration, especially in diverse and global teams.

Simplicity and Minimalism: The emphasis on simplicity in Sarvodaya aligns with the current shift toward lean operations and sustainable practices, appealing to businesses aiming to reduce costs and enhance their brand image.

Interest in Self-Sufficiency: Sarvodaya's self-sufficiency principle resonates with the desire for organizational resilience, encouraging investments in local resources and sustainable supply chains, particularly among self-employed individuals.

**Workplace Culture Transformation:** The focus on universal welfare could shift workplace success metrics from individual achievements to collective well-being, promoting employee-centric policies that enhance mental health and social connections.

**Challenges to Integration:** Despite these alignments, awareness of Sarvodaya principles is limited among younger demographics, which may hinder adoption. Respondents perceive its relevance as overshadowed by technological and economic priorities.

Overall, there is broad interest in Gandhian philosophy, particularly its emphasis on community welfare and sustainability, with a strong call for its integration into educational policies. However, increasing awareness and education, especially among younger workers, is essential for effective implementation. While respondents generally view Sarvodaya as relevant for addressing social issues like inequality and environmental concerns, competing societal values may impact its future influence. There is significant alignment with Gandhian ideals, indicating the potential for these principles to guide personal growth and social impact.

#### CONCLUSION

In conclusion, the research highlights that Gandhian philosophy, particularly the principles of Sarvodaya, holds significant potential for fostering ethical, inclusive, and sustainable practices in the modern workplace. Despite challenges such as limited familiarity among younger demographics and competing priorities like technology and materialism, there is a clear alignment between Sarvodaya's values—community welfare, simplicity, and non-violence—and contemporary workplace trends centered on corporate social responsibility and environmental consciousness. Integrating Gandhian ideals into educational and organizational frameworks can promote awareness, encouraging a cultural shift towards collective well-being and ethical leadership. This approach can serve as a counterbalance to the prevailing materialistic and individualistic tendencies, supporting a workplace culture focused on social cohesion, fairness, and sustainable development.

So, how can we adopt the principle of Sarvodaya in our daily lives? Connecting the principles of Sarvodaya with other principles of Satya, Ahimsa, and Satyagraha we can adopt and create our own doctrines or basic rules that will not only affect us positively but also influence and inspire future generations. These are the same things we learned as children, taught to us by our parents or teachers, but we chose to forget them as we grew older. When we were children, life, of course, was much easier, without any prejudices or complexities that we feel surround us today. And believe me, we were much happier. How we apply these principles is all up to us. It is our interpretation. We are not perfect; none of us are, but we are all "work-in-progress", and we think that is the most important thing. What matters most is the journey we choose to take, the path we tread.

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## LOST IN TRANSLATION: ANALYZING COMMUNICATION BREAKDOWNS BETWEEN DEVELOPERS AND STAKEHOLDERS

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#### ABSTRACT

This research addresses the persistent challenges of communication gaps between developers and stakeholders in projects development. Through a mixed-methods approach, we analyzed communication breakdowns, their impacts, and potential solutions. Our research involved 300 participants across various roles, employing surveys, interviews, and case studies. We introduced targeted interventions, including standardized technical glossaries, cross-functional meetings, and improved requirements templates. Results showed significant improvements: the Communication Effectiveness Index by 50%, Project Risk due to Miscommunication decreased by 54%, and on-time project delivery rates improved by 37%. The Integrated Communication Improvement Score rose by 41.4%, including substantial overall enhancement. These findings demonstrate that structured communication strategies can dramatically improve project outcomes, stakeholder satisfaction, and technical-business alignment. This research provides actionable insights for organizations seeking to bridge the developer-stakeholder communication gap and enhances success rates.

**Keywords:** Communication Effectiveness, Projects Management, Developer-Stakeholder alignment, Technical Business Gap, Communication Breakdowns

#### INTRODUCTION

Getting developers and stakeholders to communicate effectively remains a significant in modern projects development industry (Schmidt & Meures, 2016). The common communication challenges that develop in projects are what we address in this paper, aiming to understand why they happen, how they affect projects, and what we can do to fix them. When we create a project, we require expert developers to collaborate with non-tech stakeholders (Ebisuya et al., 2021), where each group has its own method of thinking and discussing topics. Developers who spend their days dealing with code frequently struggle to convey sophisticated technical concepts in simple words (Tena et al., 2012). Stakeholders, on the other hand, are more concerned with business goals and what users want, and often struggle to explain their requirements in a way that the tech team can understand.

When these two groups are unable to interact effectively, a variety of difficulties arise. They may misinterpret the project's purpose, have divergent expectations, or fail to see the boundaries of what is achievable (Rauf & AlGhafees 2015). This frequently results in projects being delayed, or overbudget that does not perform as intended. These challenges have an impact on more than just the present project; they can harm client relationships and annoy team members. People have studied this problem before and found several reasons for these communication gaps. These include using too much tech jargon, not having enough background information, not updating each other often enough, and not having standard ways to communicate (Miclea & Irimias, 2023). Even though we know about these issues, finding good solutions that cover all aspects of the problem has been tough. Our research tries to tackle this by looking closely at how these communication breakdowns happen and what they do to projects. We also came up with some new ideas to help developers and stakeholders communicate better, and we tested these ideas to see if they work. We used different ways to study this problem. We sent out surveys, talked to people in interviews, and looked at real-life examples in detail. This gave us a well-rounded view of what is going on. We also created some new ways to measure how well people are communicating. These include what we call the Communication Effectiveness Index, a way to measure how risky miscommunication is for a project, and a score that shows how well the tech side and business side understand each other. To try and fix these problems, we came up with some new strategies. We made a list of technical terms with simple explanations to help with jargon. We started regular meetings where both tech and non-tech people could talk things through. We created a new template for writing down what the project needs to be done, in a way that makes sense to everyone. And we set up a system to get feedback and keep improving how people communicate. We tested these ideas in different projects and companies to see if they help. Our goal was to find practical advice that development teams and project managers can really use. We believe that our research will help individuals understand how to communicate more effectively in projects, resulting in more successful projects, happier stakeholders, and a better fit between what the tech team can achieve and what the business requires. In the rest of this article, will describe how we conducted our research, what we discovered, and what it all implies for developers.



Fig 2. Simple Illustration of Communication Gap

This section offers a comprehensive, tabular analysis of the methods that have been explored thus far in the same field in 2023 and 2024.

 Table 1. 2023/2024 Existing Methods

	Reference	Challenge Addressed	Proposed Solution	<b>Results Achieved</b>
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(Anne et al. 2024)	Communication between university and high school students	Qualitative methods: project case study, document analysis, in- depth interviews	Improved understanding of effective communication in education projects
(Alvin et. al. 2024)	Barriers in virtual project team communication	Proactive communication practices, use of communication technologies	Enhanced collaboration in remote work settings

(Kelemen et al., 2024)	Communication management in construction projects	Evaluation using EFA- Maximum Likelihood and Spearman's rank order correlation	Identified key factors influencing project success
(Abdul-Fatawu et al., 2024)	Cross-cultural communication in global IT rollout projects	Interpretative phenomenological approach, expert interviews	Revealed six key sources of intercultural problems
(Gideon Oluseyi et al., 2024)	Effective communication in Ghanaian construction projects	Survey of professionals, analysis of communication methods and channels	Identified hindrances to effective communication and their impacts
(Hiranrat et al., 2023)	Communication barriers in multinational energy projects	Systematic review of existing research and case studies	Proposed integrated strategies for effective communication
(Horstmann et al., 2024)	Developing communication skills in software engineering students	Project-based learning framework, self- efficacy questionnaire	Significant increase in students' communication self-efficacy
(Lić et al., 2023)	Communication gap between software developers and privacy experts	Qualitative semi- structured interviews	Uncovered reasons for struggle in implementing privacy requirements
(Rauf & AlGhafee, 2015)	Digital marketing communication management	Multilinear regression analysis of digital platforms	Ranked digital platforms for advertising in Serbian market

Looking at the studies we have reviewed, we can see that researchers have been tackling communication problems in many different areas, from schools to construction sites to global energy projects. They have used various methods to figure out what is causing communication breakdowns and have come up with some ideas to fix these issues, with that, we have noticed some common themes, like how cultural differences can cause misunderstandings, why it is crucial to have clear ways to share information, and how important it is to use the right communication tools but there are some gaps in what's been done so far. Many of these studies only look at one specific industry or situation, which means their findings might not work everywhere, and also, while they are good at pointing out problems and suggesting general solutions, they often don not give specific, measurable ways to actually make things better. Our paper tries to fill in these gaps because we are looking at communication problems between developers and stakeholders across different industries, not just in one specific area. We have come up with some new ways to measure how well people are communicating. We are not just identifying problems – we are testing out real solutions, like creating a dictionary of technical terms everyone can understand and setting up regular meetings between different teams. By mixing real-world insights with these measurable tools and practical solutions, our study offers a more complete approach to improving communication in projects. Our method builds on what others have done, but it goes a step further by providing a framework that can be

adapted to different types of projects. This fills an important gap in what we currently know about communication in projects development.

#### **RESEARCH METHODOLOGY**

This section outlines the methods used to analyze communication breakdowns between developers and stakeholders in projects. We employed a mixed-methods approach, combining quantitative surveys, qualitative interviews, and case study analyses. Our methodology aims to identify, categorize, and measure the impact of communication gaps, as well as evaluate potential solutions.

A. Data Collection and Analysis Process



#### Fig 2. Data Collection and Analysis Process Chart

This flow chart visually represents our step-by-step approach to gathering and analyzing data. It shows how we move from initial data collection through various stages of analysis to reach our conclusions. This chart is crucial because it:

- · Provides a clear overview of our research process
- Demonstrates the logical progression of our study
- · Helps readers understand how we arrived at our findings
- Ensures transparency and reproducibility of our research methods

B. Communication Breakdown Identification Framework

**Fig.3** illustrates our systematic approach to identifying and categorizing communication breakdowns in development of projects. It is important because it shows the structured process, we use to analyze communication issues, helps standardize our approach across different projects or teams, provides a tool that other researchers or practitioners can adapt and use, and demonstrates how we link observed problems to potential solutions.



Fig 3. Communication Breakdown Identification Framework

These flow charts are essential to our methodology as they offer visual representations of complex processes, making our methods more accessible, ensure consistency in our approach across different aspects of the study, and provide a framework that others can follow or adapt in future research.

 Table 2. Participants Demographics

<u>Role</u>	Number	<u>Average Experience (years)</u>
Developers	100	7.5
Project	50	10.2
Managers		
Stakeholders	100	12.8

**Table 2** provides an overview of our study participants, showing the distribution across different roles and their average experience. This information is significant for understanding the context of our data and ensuring that our study includes a representative sample of software development project stakeholders.

Table 5. Communication Breakdown Categories						
<u>Category</u>	<b>Description</b>	Frequency (%)				
<b>Technical Jargon</b>	Use of complex	35%				
	technical terms					
Unclear	Ambiguous Project	28%				
Requirements	Specs					
Misaligned	Differing Project	22%				
Expectations	Goals					
Infrequent	Lack of regular	15%				
Updates	communication					

Table 3. Communication Breakdown Categories

**Table 3** categorizes the types of communication breakdowns we observed in our study. It helps us identify the most frequent issues, allowing us to focus our interventions on the most critical areas. The frequency percentages give us a baseline against which we can measure the effectiveness of our proposed solutions.



#### Fig 4. Communication Breakdowns

**Fig.4** shows a pie chart that illustrates the distribution of different types of communication breakdowns identified in our study. Technical jargon misunderstandings account for the largest portion (35%), followed by unclear requirements (28%), misaligned expectations (22%), and infrequent updates (15%).

C. Mathematical Formulas

The formulas presented here serve specific purposes in our research:

1. Communication Effectiveness Index (CEI):

#### METRIC **PRE-INTERVENTION** POST-**IMPROVEMENTS INTERVENTION** 50% Communication 5.2 7.8 Effectiveness Index (CEI) Project Risk due to 0.68 0.31 54% Reduction Miscommunication (PRM) Stakeholder 6.1 8.3 36% Satisfaction Score **On-time Project Delivery** 62% 85% 37% Increase Rate

CEI = (C \* w1) + (F \* w2) + (R \* w3) + (FB \* w4)

Table 4. Summary of Key Findings

Where: C = Clarity (1-10 scale) F = Frequency (1-10 scale) R = Relevance (1-10 scale) FB = Feedback quality (1-10 scale) w1, w2, w3, w4 are weights assigned to each factor

*Purpose:* This formula quantifies the overall effectiveness of communication in a project. By assigning weights to different aspects of communication (clarity, frequency, relevance, and feedback quality), we

can measure and compare communication effectiveness across different projects or teams. This allows us to objectively assess the impact of our interventions on communication quality.

#### 2. Project Risk due to Miscommunication (PRM):

#### $\mathbf{PRM} = \Sigma(\mathbf{Ii} * \mathbf{Pi})$

Where: Ii = Impact of miscommunication type i (1-10 scale) Pi = Probability of miscommunication type i occurring (0-1)

**Purpose:** This second formula helps us quantify the risk associated with communication breakdowns. By considering both the impact and probability of different types of miscommunications, we can prioritize which communication issues to address first and measure how our interventions reduce overall project risk. IV. ANALYSIS AND RESULTS

This section presents the findings from our study on communication breakdowns between developers and stakeholders in projects development. We analyze the data collected through surveys, interviews, and case studies to identify patterns, quantify impacts, and evaluate the effectiveness of our proposed solutions. The results are presented in both tabular and narrative formats, with accompanying technical explanations and formulas to illustrate our analytical approach.

<b>Budget Adherence Rate</b>	58%	79%	36% Increase
<b>Requirement Clarity Score</b>	5.8	8.2	41%
Technical-Business	5.5	7.9	44%
Alignment Score			

**Detailed Technical Explanation with Formulas** 

Our analysis focused on quantifying the impact of communication breakdowns and evaluating the effectiveness of our proposed interventions. We used several key metrics and formulas to achieve this:

a) Communication Effectiveness Index (CEI):

CEI = (C \* 0.3) + (F \* 0.25) + (R \* 0.25) + (FB \* 0.2) Where:

C = Clarity (1-10 scale) F = Frequency (1-10 scale) R = Relevance (1-10 scale)

FB = Feedback quality (1-10 scale). The weights (0.3, 0.25, 0.25, 0.2) were determined through factor analysis of survey responses. The CEI improved from 5.2 to 7.8 after implementing our proposed solutions, indicating a significant enhancement in overall communication quality.

#### b) Project Risk due to Miscommunication (PRM):

 $PRM = \Sigma(Ii * Pi)$  Where: Ii = Impact of miscommunication type i (1-10 scale) Pi = Probability of miscommunication type i occurring (0-1)

We observed a 54% reduction in PRM (from 0.68 to 0.31), suggesting that our interventions substantially mitigated communication-related project risks.

#### c) Stakeholder Satisfaction Score (SSS):

SSS = (U \* 0.4) + (I \* 0.3) + (EA \* 0.3) Where: U = Understanding of project progress and challenges (1-10 scale) I = Involvement in decision-making processes (1-10 scale) EA = Expectation alignment with project outcomes (1-10 scale). The SSS improved by 36%, from 6.1 to 8.3, indicating enhanced stakeholder engagement and satisfaction.

#### d) Technical-Business Alignment Score (TBAS):

TBAS = (CS \* 0.5) + (BP \* 0.3) + (IR \* 0.2) Where: CS = Shared understanding of technical constraints (1-10 scale) BP = Alignment of business priorities with technical solutions (1-10 scale)

IR = Integration of business requirements into technical specifications (1-10 scale)

The TBAS increased from 5.5 to 7.9, demonstrating improved alignment between technical and business perspectives.

e) Requirement Clarity Index (RCI): RCI = (D \* 0.4) + (C \* 0.3) + (T \* 0.3) Where: D = Detail level of requirements (1-10 scale)

C = Consistency across requirement documents (1-10 scale) T = Traceability of requirements to business needs (1-10 scale). The RCI improved from 5.8 to 8.2, indicating clearer and more comprehensive requirement documentation.

#### **PROPOSED WORK**

#### Implementing the Formulas for Organizational Use

Organizations can use these formulas to measure and improve communication in their specific projects. For the Communication Effectiveness Index (CEI), rate Clarity, Frequency, Relevance, and Feedback quality from 1 (very poor) to 10 (excellent). For example, a Clarity score of 2 might mean frequent misunderstandings, while 8 indicates clear communication. Use surveys, peer evaluations, or stakeholder feedback to determine these scores. For the Project Risk due to Miscommunication (PRM) formula, identify common communication problems and rate their impact (1-10) and likelihood (0-1). An impact of 3 might mean a small delay, while 9 could indicate project failure. A likelihood of 0.1 means it rarely happens, while 0.9 means it's almost certain. Base these on past experiences or expert opinions. And similarly for all other formulas presented. By regularly using these formulas, organizations can track communication trends, identify areas for improvement, and measure the effectiveness of their communication strategies over time.

Our proposed solution addressed communication breakdowns through several key interventions:

- Implementation of a standardized technical glossary to reduce jargon-related misunderstandings.
- Introduction of regular cross-functional meetings to improve alignment and information flow.
- Development of a requirements template that bridges technical and business perspectives.
- Establishment of a feedback loop system to continuously refine communication processes.

The effectiveness of these interventions is evidenced by the significant improvements across all measured metrics. The increase in on-time project delivery (from 62% to 85%) and budget adherence (from 58% to 79%) demonstrates the tangible business impact of enhanced communication. To quantify the overall impact of our solution, we developed an Integrated Communication Improvement Score (ICIS): ICIS = (CEI \* 0.3) + (1-PRM) \* 0.2 + (SSS \* 0.2) + (TBAS \* 0.15) + (RCI \* 0.15). The ICIS improved from 5.63 to 7.96, representing a 41.4% overall enhancement in communication effectiveness and its related outcomes in software development projects. These results suggest that our proposed solution effectively addresses the critical issues in projects development

communication, leading to improved project outcomes, higher stakeholder satisfaction, and better alignment between technical and business objectives.

#### **CONCLUSION AND FUTURE DIRECTION**

This study highlighted the importance of excellent communication in bridging the gap between developers and stakeholders in projects development initiatives. Our extensive research found considerable improvements in key parameters following the adoption of specific procedures. The Communication Effectiveness Index saw a 50% increase, while Project Risk due to Miscommunication decreased by 54%. Stakeholder satisfaction and on-time project delivery rates improved by 36% and 37% respectively. These gains, coupled with a 36% increase in budget adherence, underscore the tangible benefits of enhanced communication practices. Our proposed solutions, including standardized technical glossaries, cross-functional meetings, improved requirements templates, and continuous feedback loops, proved effective in addressing persistent communication challenges. The Technical-Business Alignment Score's 44% improvement highlights the success in reconciling technical and business perspectives. The Integrated Communication Improvement Score, encompassing multiple facets of project communication, showed a remarkable 41.4% enhancement. This holistic improvement suggests that our interventions not only addressed surface-level communication issues but also fostered a more collaborative and aligned project environment. While these results are promising, future research should explore long-term sustainability of these improvements and their applicability across diverse project types and organizational cultures. Nonetheless, this study provides a solid foundation for organizations seeking to enhance their software development processes through improved communication strategies, ultimately leading to more successful project outcomes and stronger developer stakeholder relationships.

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## MARKETING MIX FACTORS INFLUENCING THE DECISION TO PURCHASE A XIAOMI PHONE IN THAILAND

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#### ABSTRACT

This study aimed to examine marketing mix factors in purchasing Xiaomi phones in Thailand and their influence on purchasing decisions. Data from 400 respondents were collected using questionnaires and analyzed with percentage, mean, One-Way ANOVA, and Multiple Regression Analysis. Most respondents were male, aged 30–55, held a bachelor's degree, and were company/store employees earning 35,001 baht or more monthly. The marketing mix factors were deemed very important and significantly influenced the decision to purchase Xiaomi phones in Thailand, with statistical significance at the 0.05 level.

Keywords: Marketing mix, decision-making, Xiaomi phone.

#### INTRODUCTION

Communica3tytion is an essential process necessary for our daily lives, as we use it as a tool to carry out various tasks and connect with others in society. Therefore, communication is important to humans at every level (Anonymous, 2013). Tools and communication devices are continuously evolving to facilitate seamless and borderless communication. Nowadays, anyone with a mobile phone is likely to use it for activities such as making calls, answering calls, listening to music, playing games, or at least one of these. Some people spend more than half of their day on their phone screens, talking with friends or partners, updating their status, watching others' stories, following the news, or discussing homework. Others may spend almost their entire day on their phone, using it for business communication, financial transactions, coordination, and more. A single small mobile phone provides immense convenience in areas such as social interactions, business, education, and entertainment. However, the extent to which individuals use their mobile phones in each area varies greatly. (Yi Xin, 2021)

Market research company Canalys announced smartphone sales for the entire year of 2022. The results showed that Samsung ranked first with 257.9 million units sold, a decrease of 6.0%, and a market share of 22%. Apple ranked second with 232.2 million units sold, an increase of 1%, and a market share of 19%. Xiaomi ranked third with 152.7 million units sold, a decrease of 20%, and a market share of 13%. Oppo ranked fourth with 113.4 million units sold, a decrease of 22%, and a market share of 10%. Vivo ranked fifth with 101.9 million units sold, a decrease of 22%, and a market share of 10%. Vivo ranked fifth with 101.9 million units sold, a decrease of 22%, and exceeded the market share of 22%, and a market share of 9% (Report, 2023). The report also showed that smartphones from the Republic of China, which have only recently entered the market, have received significant attention from consumers.

(https://www.mreport.co.th/news/statistic-and-ranking/201-Smartphone-Global-Sales-2022)

Based on the above information, the researcher is interested in studying the marketing mix factors that influence the decision to purchase a Xiaomi phone in Thailand. The goal is to use this study as a guideline to plan improvements on the factors influencing decision-making, in order to better match Xiaomi consumers' demands and increase Xiaomi sales in Thailand.

#### **RESEARCH METHODOLOGY**

Data were collected using 400 questionnaires and analyzed using percentage, mean, One-Way ANOVA, and Multiple Regression Analysis.

#### **Objective of the research**

- 1. To examine the marketing mix factors involved in purchasing a Xiaomi phone in Thailand
- 2. To study the marketing mix factors influencing the purchasing decision for a Xiaomi phone in Thailand

#### **Research hypothesis**

Marketing mix factors influence the decision to purchase a Xiaomi phone in Thailand



#### LITERATURE REVIEW

Marketing mix refers to the variables or tools that businesses use to achieve their target marketing objectives and meet customer satisfaction. Traditionally, the marketing mix consisted of only four variables (the 4Ps): product, price, place, and promotion.

Product refers to what a business offers for sale to meet customer needs and contribute to their satisfaction.

Price refers to the amount of money exchanged to obtain a product, good, or service, as agreed upon by both the buyer and the seller.

Place refers to the structure of channels, which consists of institutions and activities used to move products and services from the organization to the market. The institutions that bring products to the target market are called marketing institutions. The activities that help distribute products include transportation, warehousing, and storage.

Promotion refers to the promotional tools businesses use to build connections with customers, persuading them to see value and establish a relationship.

### **DECISION THEORY**

There are five stages in the decision-making process.



#### **DATA RESEARCH RESULTS**

From the study, it was found that there were 400 respondents. The majority of respondent were male, aged 30–55, held a bachelor's degree, and were company/store employees with a monthly income of 35,001 baht or more.

1. Marketing Mix Factors in Purchasing Xiaomi Phones in Thailand

Table 1 indicating the importance level of marketing mix factors in purchasing Xiaomi phones in Thailand

No.	Marketing mix factors	Mean	S.D.	Test results
1	Product	4.08	.610	high
2	Price	4.05	.554	high
3	Place	3.90	.767	high
4	Promotion	4.03	.581	high
	Total	4.01	.562	high

From Table 1, the overall average of the marketing mix factors in purchasing Xiaomi phone in Thailand is at a high level ( $\overline{x}|_{\overline{X}}$ = 4.01, S.D. = .610) When considering each aspect individually, it was found that the product aspect ( $\overline{x}$  = 4.08, S.D. = .610) ranked first, followed by the price aspect ( $\overline{x}$  = 4.05, S.D. = .554), the promotion aspect ( $\overline{x}$  = 4.03, S.D. = .581), and the place aspect ( $\overline{x}$  = 3.90, S.D. = .767) respectively.

2. Marketing mix factors influencing the decision to purchase Xiaomi phones in Thailand From the analysis of the marketing mix factors influencing the decision to purchase Xiaomi phones in Thailand, the findings can be summarized as follows:

Table 2 shows the analysis results of marketing mix factors influencing the decision to purchase Xiaomi phones in Thailand

Marketing mix factors	В	Std. Error	Beta	t	Sig	Test results
(Constant)	.031	.140		.220	.826	
Product .482		.050	.0454	9.609	.000*	yes
Price	.429	.058	.368	7.455	.000*	yes
Place	.231	.037	.0274	6.232	.000*	yes
Promotion	.199	.064	.179	3.127	.002*	yes

\* Statistically significant at the .05 level

From Table 2, the analysis results of marketing mix factors influencing the decision to purchase Xiaomi phones in Thailand revealed that the product aspect, price aspect, place aspect, and promotion aspect significantly influenced the decision to purchase Xiaomi phones at the 0.05 significance level. *Conclusion* 

#### Information on marketing mix factors influencing the purchase of Xiaomi phones in Thailand

From the study on the importance level of marketing mix factors influencing the purchase of Xiaomi phones in Thailand, it was found that the product aspect, price aspect, distribution channel aspect, and promotion aspect were, overall, rated at a very high level of importance. The details are as follows:

Product aspect: The study revealed that the overall average for the product aspect was rated at the highest level of importance. The details of its significance are as follows: eight items were rated at a very high level of importance, including ease of use, standard product quality, diverse functionalities, modern operating systems, good design, a variety of color options, reliable warranties, and high-performance cameras, respectively.

Price aspect: The study found that the overall average for the price aspect was rated at a very high level of importance. The detailed significance includes five items rated as very important: prices appropriate to the product quality e.g., using high-quality hardware materials, a variety of price ranges to choose from, reasonable maintenance costs, stable and consistent pricing, and installment payment options, respectively.

Promotion aspect: The study showed that the overall average rating for the promotion aspect was at a very high level of importance. The details include five items: providing giveaways such as phone cases and screen protectors, advertising through social media, offering phone discounts, promotions for special occasions such as New Year's Eve and Valentine's Day, and providing discount packages.

Place aspect: The study showed that the overall average rating for the promotion aspect was at a very high level of importance. The detail includes four items: the distribution center is modernly decorated, and its services meet standard quality requirements.

#### Information on the Decision to Purchase Xiaomi Phones in Thailand

The study of opinion levels regarding the decision to purchase Xiaomi phones in Thailand revealed that need recognition, information search, evaluation of alternatives, purchase decision, post-purchase behavior. Overall, the decision-making process had an average rating at a high level of agreement, with the details as follows:

**Need recognition**: The results of the study showed that the overall average was at a high level of agreement. The key details, rated at a high level of agreement, include the following five items:

- 1. Consideration of phones that suit user needs and are easy to use.
- 2. Availability of multiple colors and designs.
- 3. Focus on quick problem resolution
- 4. Attentive customer service in case of issues.
- 5. Xiaomi has an extensive network of service centers.

**Information search**: The results of the study showed that the overall average was at a high level of agreement. The key details, rated at a high level of agreement, include the following two items:

- 1. Comparing Xiaomi phones with other brands.
- 2. Advertising through websites and the internet.

Items rated at a moderate level of agreement include the following two:

- 1. Advertising through print media.
- 2. Inquiring about information from acquaintances, close contacts, or trade representatives.

**Evaluation of alternatives**: The results of the study showed that the overall average was at a high level of agreement. The details, rated at a high level of agreement, include the following five items:

- 1. Deciding to choose a phone based on financial liquidity.
- 2. Deciding to choose a phone based on personal experience and expertise.
- 3. Deciding to choose a phone based on Xiaomi's reputation and reliability.
- 4. Deciding to choose a phone based on improvements made to plans whenever issues arise.
- 5. Deciding to choose a phone based on competitive bidding.

**Purchase decision**: The results of the study showed that the overall average was at a high level of agreement. The details, rated at a high level of agreement, include the following three items:

- 1. Purchasing a Xiaomi phone after comparing it with other brands.
- 2. Believing that the Xiaomi phone is good enough to recommend to others.
- 3. If purchasing a new phone, they would return to buy a Xiaomi phone.
- 4. The warranty for Xiaomi phones leads to the belief that the decision to purchase a Xiaomi phone was the right one.
- 5. They are committed to choosing Xiaomi smartphones exclusively, even though other brands may offer phones with better features.

Post-purchase behavior: The results of the study showed that the overall average was at a high level of agreement. The details, rated at a high level of agreement, include the following three items:

- 1. The value of Xiaomi phones in relation to the cost paid
- 2. Recommending them to others
- 3. Future Xiaomi phone purchases (if any)

#### The comparison of purchase decision on Xiaomi phone in Thailand categorize by personal data

Different personal demographic factors influence the decision to purchase Xiaomi phones in Thailand in varying ways. The study found that gender, education level, average monthly income, and occupation significantly affect the decision to purchase Xiaomi phones in Thailand. However, age differences do not significantly impact the decision to purchase Xiaomi phones.

#### Marketing mix factors influencing the decision to purchase Xiaomi phones in Thailand

The results showed that product, price, place, and promotion significantly affect the decision to purchase Xiaomi phones in Thailand, with statistical significance at the .05 level.

#### DISCUSSION

Information about the importance level of marketing mix factors in the decision to purchase Xiaomi phones in Thailand revealed that the average rating was at a very high level of importance. This finding is consistent with the research of Nathabamrung et al. (2020), which examined marketing mix factors affecting consumers' decisions to buy smartphones in Minburi metropolis. Their study showed that, overall, respondents rated the marketing mix factors as very important, with an overall average at a very high level.

The marketing mix factor related to the product aspect was found to be at a very high level of importance. This finding aligns with the research of Thongsiri, S. (2018), which studied marketing mix factors affecting the decisions to purchase mobile phones of customers in Amphoe Mueang, Ratchaburi Province. It revealed that the product aspect was rated at a high level.

The marketing mix factor related to the price aspect was found to be at a very high level of importance. This finding aligns with the research of Nilpuang, S. (2013), which examined marketing mix factors affecting decision of buying behavior of mobile phone in the municipality of Kanchanaburi and revealed that the price aspect was rated at a high level.

The marketing mix factor related to the place aspect was found to be at a very high level of importance, consistent with the research of Thongsiri, S. (2018), which studied marketing mix factors affecting the decisions to purchase mobile phones of customers in Amphoe Mueang, Ratchaburi Province. The study revealed that the marketing mix for mobile phones in terms of the place aspect was rated at a high level.

The marketing mix factor related to the promotion aspect was found to be at a very high level of importance, this finding aligns with the research of Thongsiri, S. (2018), which examined marketing mix factors affecting the decisions to purchase mobile phones of customers in Amphoe Mueang, Ratchaburi Province. The finding showed that the promotion aspect was rated as a high level.

Different personal factors influence the decision to purchase Xiaomi phones in Thailand. The study found that gender, education level, average monthly income, and occupation significantly affect the decision to purchase Xiaomi phones in Thailand. This finding aligns with the research of Nathabumrung et al. (2020), which examined marketing mix factors affecting consumers' decisions to buy smartphones in Minburi metropolis. Their study revealed that differences in gender, average monthly income, current occupation, and education level significantly influenced consumers' decisions to purchase smartphones in Minburi at a significance level of 0.01.

The marketing mix factors influence the decision to purchase Xiaomi phones in Thailand. The study found that the product aspect, price aspect, place aspect, and promotion aspect significantly affect the decision to buy Xiaomi phones in Thailand, with statistical significance at the 0.05 level. This is in line with the research of Nathabamrung et al. (2020), which examined marketing mix factors affecting consumers' decisions to buy smartphones in Minburi metropolis. It was found that the 4P's marketing mix factors, including the product aspect, price aspect, place aspect, and promotion aspect, significantly influence consumers' decisions to buy smartphones in Minburi metropolis, with statistical significance at the 0.01 and 0.05 levels.

#### SUGGESTION FROM THE STUDY

Product aspect: Mobile phone companies should prioritize product quality control, create innovations to make products more unique, reduce the complexity of the mobile phone's working processes, and develop phones to be more diversified in order to meet the needs of various groups.

Price aspect: Distribution should set prices that are appropriate for the quality and maintain a standard, offering a variety of price ranges to choose from, convenient payment methods for consumers, as well as installment options.

Place aspect: Distributors should present products in retail centers or shopping malls with aesthetically pleasing store displays, ensure convenient access, offer multiple branches, and provide contact channels to facilitate consumers.

Promotion aspect: Distributors should organize engaging product introduction activities to motivate customers' purchase decisions, advertise through social media or influencers, offer marketing discounts during various occasion, and provide value-added gifts such as phone cases or screen protectors. Additionally, they should offer promotional packages with discounts and phone call credits.

#### THE SUGGESTION FOR FUTURE STUDIES

Future studies should study about behavior of mobile phone usage among working professionals to apply the findings in developing functions that align with users' needs.

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## MARKETING MIX FACTORS THAT AFFECT THE DECISION TO PURCHASE HOMEMADE BROWNIES IN SAI MAI DISTRICT

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#### ABSTRACT

The study aimed to 1) compare decisions to purchase homemade brownies in Sai Mai district by personal information and 2) examine marketing mix factors affecting these decisions. Data were collected from 400 respondents and analyzed using percentage, mean, One-Way ANOVA, and Multiple Regression Analysis. Most respondents were single males, aged 21-30, holding a bachelor's degree, and earning 10,001-20,000 baht monthly. Marketing mix factors were rated very important, and purchasing decisions were highly agreed upon. Personal information such as age, education, and income had no effect, but price and promotion significantly influenced decisions at the 0.05 significance level.

Keywords: Marketing mix factors, Decision-making, Homemade brownies.

#### INTRODUCTION

Brownies are one of the most popular baked goods enjoyed by many people. With their rich, fragrant, and creamy chocolate taste, along with a soft and chewy texture that melts in your mouth, brownies are a favorite dessert for chocolate lovers. In some books, brownies are categorized as a type of cookie called 'Sheet Cookies,' which resemble dense cakes. They are typically baked in rectangular trays and cut into square shapes, sometimes topped with chocolate or sprinkled with nuts, such as cashews, to enhance flavor and make them more appetizing. According to food historians, this dessert originated in the United States in the late 19<sup>th</sup> century. It is said that a baker was making a chocolate cake but forgot to add baking powder, causing the cake to turn out flat. This accident led to the creation of a new dessert with a firm, brown texture, which eventually became known as the 'Brownie.' The texture of brownies can be categorized into three types: 1) Brownie cake, 2) Fudge brownie, and 3) Chewy brownie.

Nowadays, brownies remain popular as they are enjoyed by people of all ages and genders. Brownies pair well with many drinks, such as tea and coffee, and can also serve as a birthday cake or a gift for various occasions. Currently, the bakery business is popular among teenagers, middle-aged individuals, and students, especially those offering a variety of desserts, good locations, and beautiful décor, making it the perfect place to relax. In Thailand, most bakery shops continue to be popular. People of all ages and genders are increasingly interested in consuming bakery products, leading to a growing trend in choosing baked goods. The number of bakery shops has increased in response to rising customer demand. The most essential thing for a bakery owner is to keep the business running successfully. The owner should be attentive to maintaining product quality, implementing measures to ensure consistent service, expanding and improving the product, and building the brand. This includes using attractive packaging, adding an element of fun to make the product livelier, and offering services that leave a lasting impression. The ability to create a lasting impression and maintain product quality is crucial, regardless of whether the business is small or large. These businesses can operate sustainably in the economy. Bakery products are considered a form of art that requires a high level of skill in their preparation. Nowadays, progress depends not only on the baker's expertise but also on the equipment used in the production process, as well as the quality of the ingredients. These factors contribute to the continuous growth of the industry. Running a bakery business is popular nowadays because teenagers have a strong preference for eating desserts. The main consumer market primarily focuses on teenagers. The bakery offers a variety of flavors and sizes without the need to be expensive, providing options for both dine-in and take-home.

Bakery items are viewed as a type of art that demands a significant level of expertise in their creation. Nowadays, the advancement of bakery making does not depend solely on the baker but also on the equipment used in production, as well as the development of ingredient quality, which contributes to the continuous growth of this industry. Brownies are baked goods that come in a variety of recipes, each offering different textures and flavors.

Many people are interested in making them for sale as a primary or secondary career. However, to achieve success, it is important to understand consumer behavior in order to create brownies that meet their needs.

Based on the background provided, the researcher is interested in studying the marketing mix factors that affect the decision to purchase homemade brownies in Sai Mai District. The purpose of this study is to serve as a guideline for developing a marketing plan aimed at improving products and services in harmony with consumer requirements.

#### **RESEARCH METHODOLOGY**

Data were gathered through 400 questionnaires and analyzed using percentages, means, One-Way ANOVA, and Multiple Regression Analysis.

#### **Objective of the Research**

- 1. To compare the decision to purchase homemade brownies in the Sai Mai District, classified by personal information
- 2. To study marketing mix factors affecting the decision to purchase homemade brownies in the Sai Mai District.

**Independent Variables** 

#### **Research Hypothesis**

- 1. Different Personal information making a decision to purchase homemade brownies in Sai Mai District. Different
- 2. Marketing mix factors affecting the decision to purchase homemade brownies in Sai Mai District.



dependent Variables

#### LITERATURE REVIEW

Marketing mix refers to the variables or tools that businesses use to achieve their target marketing objectives and meet customer satisfaction. Traditionally, the marketing mix consisted of only four variables (the 4Ps): product, price, place, and promotion.

Product refers to what a business offers for sale to meet customer needs and contribute to their satisfaction. Price refers to the amount of money exchanged to obtain a product, good, or service, as agreed upon by both the buyer and the seller. Place refers to the structure of channels, which consists of institutions and activities used to move products and services from the organization to the market. The institutions that bring products to the target market are called marketing institutions. The activities that help distribute products include transportation, warehousing, and storage.

Promotion refers to the promotional tools businesses use to build connections with customers, persuading them to see value and establish a relationship.

#### **DECISION THEORY**

The consumer buying decision process represents the process of decision-making in which consumers consider various alternatives, compare those choices, and make a purchase in order to successfully achieve the goals they set for themselves.

The theory of consumer buying behavior by Philip Kotler can be analyzed through five distinct stages, starting with the situation before purchasing a product and continuing to the situation after the purchase. These stages consist of need recognition, information search, evaluation of alternatives, purchase decision, and post-purchase behavior

#### DATA RESEARCH RESULTS

The majority of respondents are male students aged between 21 and 30, who are single, hold a bachelor's degree, and have a monthly income of 10,001 to 20,000 baht.

The information about purchasing decisions for homemade brownies in Sai Mai District is classified by personal information.

- 1. Different personal information influences a decision to purchase homemade brownies in Sai Mai District. Different. It was found that variation in gender, age, family status, level of education, monthly income, and occupation do not affect the decision to purchase homemade brownies in Sai Mai District.
- 2. Marketing mix factors that influence the decision to purchase homemade brownies in Sai Mai District.

Table 1 analysis result of marketing mix factors that influence the decision to purchase homemade brownies in Sai Mai District

Marketing mix factors	В	Std.	Beta	Т	Sig	Test results
		Error				
(Constants)	2.732	.394		6.936	.000	
Product	.071	.122	.044	.580	.562	no
Price	.240	.110	.152	2.172	.030*	yes
Place	.142	.105	.104	1.348	.178	no
Promotion	.191	.081	.166	2.354	.019*	yes

\* Statistically significant at the .05 level

From Table 1, the marketing mix factors that influence the decision to purchase homemade brownies in Sai Mai District are shown. It indicates that price and promotion affect the decision to purchase homemade brownies in Sai Mai District at the 0.05 significance level.

#### CONCLUSION

## Information about marketing mix factors on the decision to purchase homemade brownies in Sai Mai district

From the study on the significance levels of marketing mix factors influencing the purchase of homemade brownies in the Sai Mai district, it was found that the marketing mix factors include the following aspects: product, price, place, and promotion. Overall, these factors were rated as highly significant, with the details as follows:

For the product aspect, the study revealed that the overall level of opinions on the product-related marketing mix factors was rated as highly significant. Upon further consideration, the top three most important factors were as

follows: brownies with a delicious taste, fresh brownies, and high-quality ingredients used in making the brownies. Additionally, two other highly significant factors included clear labeling of the brownies' expiration dates and the introduction of new brownie varieties.

For the price aspect, the study found that the overall level of opinions regarding the price-related marketing mix factors was rated as highly significant. The most significant factor was the reasonableness of the brownie price in relation to its quality. Additionally, four other highly significant factors included clear price labeling, appropriateness of the price relative to packaging size, and price variety for brownies.

For the place aspect, the study revealed that the overall level of opinions on the place-related marketing mix factors was rated as highly significant. Five key factors included clear specification of opening and closing hours, easily recognizable store locations, convenient accessibility, availability of delivery services, and the ability to purchase products online.

For the promotion aspect, the study indicated that the overall level of opinions on marketing promotion-related factors was highly significant. The top five factors included promotional activities during various festivals, weekly discounts, free gifts with purchases above a specified amount, product recommendations by staff, including taste tests before purchase, and consistent advertising across different media platforms.

#### Information on the decision to purchase homemade brownies in Sai Mai district

The study of opinion levels regarding the decision to purchase homemade brownies in the Sai Mai district showed that the overall level of agreement on decision-making factors was rated as "highly agreeable." Among these, two factors received the highest level of agreement: deciding to purchase from a nearby homemade brownie shop and enjoying the purchase of homemade brownies. Three factors were rated as "moderately agreeable": purchasing based on social media information about shops in the Sai Mai area, choosing shops with flavors that match personal preferences, and reviewing favorite homemade brownie shops to share with others.

# The comparison of purchase decision on homemade brownies in Sai Mai district categorize by personal data

Differences in personal demographics were found to have no significant effect on the decision to purchase homemade brownies in the Sai Mai district. Factors such as gender, age, marital status, education level, average monthly income, and occupation showed no significant differences in influencing the decision to purchase homemade brownies in the area.

#### Marketing mix factors influencing the decision to purchase Xiaomi phones in Thailand

The study showed that price and promotion significantly influence the decision to purchase homemade brownies in the Sai Mai district at a statistical significance level of .05.

#### DISCUSSION

A study showed that marketing mix factors were, on average, considered very important, consistent with the research by Pongpunnakul, N. (2015), which studied factors influencing online bakery buying decision. The results revealed that the average score for each aspect of the marketing mix factors was at a high level.

Marketing mix factors affecting the decision to purchase homemade brownies in Sai Mai District were studied. The findings indicated that consumers prioritized the product as their first consideration, consistent with the research of Narintrangkul Na Ayudhaya, C. & Srikanlayaniwart, S. (2019), which examined behavior and marketing mix factors affecting a decision making on purchasing brownie riceberry almonds of consumers in Phitsanulok. Their study also revealed that consumers placed the highest priority on the product.

Marketing mix factors related to promotion that affect the decision to purchase homemade brownies in Sai Mai District were found to be significant at the .05 level, consistent with the research of Sripipatporngul, P. & Papattha, C. (2017). Their study, which examined factors affecting consumers' decision to buy bakery in Nakhon Pathom Province, revealed that promotion had a positive effect on the purchasing decision at the .05 significance level.

The decision to purchase homemade brownies in Sai Mai District was studied. The research revealed that the overall average opinion was considered very important, consistent with the findings of Tanglamlert, S. (2019),

which examined factors affecting consumers' decision to buy healthy snacks in Bangkok. That research indicated that overall decision-making was at a high level, aligning with the study by Sripipatporngul, P. & Papattha, C. (2017), which investigated factors affecting consumers' decision to buy bakery in Nakhon Pathom Province. Their study also showed that consumer decision-making in Nakhon Pathom was at a high level.

#### SUGGESTION FROM THE STUDY

#### Learner has suggestions for manufacturer as follows:

For the product, business owners should prioritize using high-quality ingredients to make the brownies delicious and fresh, ensure they suit customers' tastes, and clearly specify the expiry date.

For pricing, business owners should set appropriate prices that match the quality, clearly display the prices, and offer a wide range of prices to choose from.

For place, the opening and closing times should be clearly specified, and store locations should be convenient for easy access. Additionally, offering brownie delivery services is essential.

For promotion, business owners should organize promotional activities for special occasions and offer discount promotions every week. Staff should introduce the products by offering samples for tasting before purchase.

#### THE SUGGESTION FOR FUTURE STUDIES

Future studies should examine the behavior of brownie consumers in the Sai Mai district through online channels.

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