



**SRI VENKATESWARA INTERNSHIP PROGRAM
FOR RESEARCH IN ACADEMICS
(SRI-VIPRA)**



Project
2023: SVP

SRI-VIPRA

Report of
– 2307

**“PERFORMANCE ANALYSIS OF MOBILE NETWORK OPERATORS
USING RANDOMISED BLOCK DESIGN”**

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SRIVIPRA PROJECT 2023

Title : “Performance Analysis of Mobile Network Operators using Randomised Block Design”

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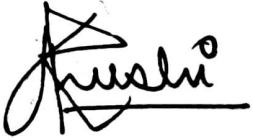


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Signature of Mentor

SRI-VIPRA

CERTIFICATE OF ORIGINALITY

This is to certify that the aforementioned students from Sri Venkateswara College have participated in the summer project SVP - 2307 titled “**Performance Analysis of Mobile Network Operators using Randomised Block Design**”. The participants have carried out the research project work under my guidance and supervision from 15 June, 2023 to 15th September 2023.

The work carried out is original and carried out in an offline mode.

A handwritten signature in black ink, consisting of a stylized initial 'S' followed by a horizontal line and a small flourish.

Signature of Mentor

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ACKNOWLEDGEMENT

We are very grateful to our mentor Prof. Veena Budhraj, Department of Statistics, Sri Venkateswara College, University of Delhi for guiding us and giving us valuable suggestions and ideas throughout the project.

We would also like to extend our deepest gratitude to our college Ag. Principal, Prof . K.C. Singh , for providing this platform to learn and skills under the guidance of our mentor.

PROJECT REPORT

INTRODUCTION

As the digital revolution surges forward, India stands at the cusp of a telecommunications transformation. With the 5th Generation Mobile Network – 5G – becoming a focal point in the global tech conversation, India is poised to further solidify its position as a digital powerhouse. This revolutionary technology aims to bridge divides, offering seamless integration of machines, objects, devices, and individuals. It was a watershed moment for India when Prime Minister Shri Narendra Modi flagged off the 5G journey on 1st October 2022 at the 6th India Mobile Congress (IMC).

Having carved a niche as the world's second-largest telecommunication market, India proudly boasts a staggering subscriber count of 1,170.75 million as of January 2023. Mobile Network Operators (MNOs) remain the backbone, facilitating incessant communication channels for this vast user base.

In this expansive ecosystem, the study zeroes in on three titans:

- **Bharti Airtel(Airtel)**: A communication behemoth, Airtel connects 500Mn patrons across 17 countries, offering a spectrum of services from streaming to IoT integrations.
- **Reliance Jio Infocomm Limited(RJIL)**: With unparalleled 4G and 4G+ outreach, RJIL has reshaped the telecommunications blueprint in India, championing affordability and expansive coverage.
- **Vodafone Idea Limited(VIL)**: A holistic GSM service provider, VIL curates a plethora of offerings ranging from 2G to VoWiFi, catering to a diverse Indian demographic parameters.

Our research framework delves deeper than mere internet speeds. We embark on a multifaceted assessment encompassing:

- **Network Availability**
- **Connection Establishment**
- **Connection Maintenance**
- **Voice Quality Analysis**
- **Point of Interconnection (POI) Congestion**
- **Customer Service Parameters**

To ensure that our analysis is robust and reflective of ground realities, we leverage the Randomised Block Design (RBD). Given the multitude of factors like location, technology infrastructure, and user demographics affecting MNO performance, our methodology segments data into coherent blocks. These blocks, defined by different states in India, will have various treatments (i.e., Mobile Network Operators) applied at random within each and replicated across all blocks. With RBD at the helm, our focus is on deciphering temporal nuances. This facilitates a meticulous examination of performance discrepancies among network service operators across distinct metrics.

Additionally, our study delves into understanding the pivotal factors that influence Customer Market Share relative to each MNO's Subscriber Base. Through Stepwise Regression Analysis for each operator, we pinpoint the statistically significant determinants in this dynamic.

Through this extensive exploration, our ambition is to decode the prowess of India's telecom leaders in the rapidly evolving 5G narrative.

STUDY OBJECTIVES

The research evaluates these MNOs' performance across India, examining metrics like network establishment and Customer services. The primary objective is to assess variations in the performance of MNOs across different states using Randomised Block Design (RBD) and determine the extent to which various parameters within our dataset influence the customer market share of these MNOs using Bidirectional Stepwise Regression.

The methodology is shaped by four key papers:

- **"A statistical comparative performance analysis of mobile network operators"(2020)**
Authors: Ahmet Yildirim, Engin Zeydan, Ibrahim Onuralp Yigit that focuses on KPIs influencing QoE and QoS with a confidence interval approach
- **"Performance Analysis of Wireless Mobile Network"(2016)**
Authors: Oboyerulu E. Agboje, Augustus E. Ibhaze, Olabode B. Idowu-Bismark that emphasizes network availability and base station downtime
- **"Measurement analysis and performance evaluation of mobile broadband cellular networks in a populated city"(2022)**
Authors: Ayman A. El-Saleh, Abdulraqeb Alhammadi , Ibraheem Shayea, Wan Haslina Hassan, Mohamed Shaik Honnurvali, Yousef Ibrahim Daradkeh assesses MNO performance in Cyberjaya(in Malaysia) based on signal and throughput KPIs
- **"Crowdsourcing Based Performance Analysis of Mobile User Heterogeneous Services"(2022)** Authors: Lamine Amour, Abdulhalim Dandoush utilize an index-based evaluation centered on the Mean Opinion Score (MOS).

RBD is a statistical method where subjects are grouped into blocks, and treatments (e.g., mobile network operators) are randomly assigned within each block. In this study, each Indian state is treated as a Block, acknowledging variations in network performance due to factors like terrain and infrastructure. A mathematical model is formulated to capture these effects, with assumptions ensuring randomness, independence, homogeneity of variances, additivity, and normality. An ANOVA table further breaks down the variance sources

Stepwise Regression is an iterative technique for variable selection in regression analysis, aiming to find the most relevant predictors for a dependent variable. Using methods like Forward selection, Backward elimination, and Bidirectional elimination, it optimizes variable inclusion based on chosen criteria. In the context of analyzing market share data for MNOs, Bidirectional Stepwise Regression was applied to discern which metrics significantly influenced Customer Market Share. The method alternates between adding and removing variables to ensure model accuracy, with the goal of avoiding overfitting while identifying key predictors.

STUDY AND DISCUSSION

- **Data Source:** Data comes from TRAI's Official Website, specifically from the Indian Telecom Services Performance Indicator Report, October-December 2022, published on 31st May 2023.
- **Regions Studied:** Andhra Pradesh, Maharashtra, Assam, Bihar, Delhi, Gujarat, and others, totalling 22 States and Union Territories.
- **Metrics:** The metrics have been divided into 2 categories :
 - o **Network Related Parameters:** Measures network availability, connection establishment, connection maintenance, and Point of Interconnection (POI) congestion.
 - o **Customer Service Quality Parameters:** Covers Billing Credibility for both Post-paid and Prepaid users, resolution of complaints, response time for customer assistance, and metrics related to service termination and deposit refunds.
- **Main Metrics Discussed:**
 - o **Network Availability:** Base Station downtime and affected Base Stations due to downtime.
 - o **Connection Establishment:** Call Set-Up Success Rate and Session Establishment Rate, Channel and Resource Congestion.
 - o **Connection Maintenance:** Metrics like Downlink Call Retention Spatial and Temporal distribution.
 - o **Customer Service:** Accuracy of billing for Post-paid and Prepaid users, Resolution times for Billing complaints, and Response times for customer inquiries.

Metrics with consistent or redundant values across MNOs were excluded. Selected metrics were standardized by subtracting from 100%. Highly correlated connection metrics were merged into 'Channel and Resource Congestion' for clarity. Metrics are weighted based on their impact on Network Performance and Customer Experience. The Key weightages include Network Availability (23%), Connection Establishment (22%), Retainability (30%), and Customer Service Quality (25%).

Column-wise scores standardize data using benchmarks and a scale factor, relative to the maximum and minimum value in the column. It reflects data point position relative to a range and includes a penalty if benchmarks are exceeded. Final composite scores are calculated using weighted averages.

In sifting through the data, it was intriguing to see that a **lower score actually signalled a better performance** for an MNO, that implies MNO performance is inversely proportional to its score. Analysis using RBD evaluates the variance in performance across States and MNOs.

Using RBD, the performance of MNOs was assessed across states, **ANOVA** analysis revealed significant performance differences among MNOs. Paired t-tests further confirmed these disparities, indicating statistically significant variations between all operator pairs. A subsequent stepwise regression model was applied for each operator with the aim to pinpoint significant factors influencing each MNO's telecommunication service.

A residual analysis is conducted between Observed , Fitted and Residual values to check if the Regression model is a good fit and presence of outliers are also identified in this step. A Q-Q plot suggests Normal data distribution, although it displays potential outliers in the right tail. Outliers are unexpected data points that can skew results. In analyzing MNOs, significant outliers were found in various states for specific operators. These outliers were removed to maintain the design's integrity. This removal notably altered the p-values related to states, emphasizing the outliers' influence.

CONCLUSION

- **Airtel** demonstrates a strong fit, indicating a good match, with Downtime, Call Set-up Failure rate, Network Quality of Service (QoS), and Packet Drop Rates (both Downlink and Uplink) emerging as key influencers. In the residual analysis of Airtel, a good model fit was indicated by uniform clustering observed in the observed vs. fitted plot, with no observed relationship found between residuals and observed values. Furthermore, curvilinear patterns or outliers were not identified. The data was suggested to be mostly normally distributed based on the Q-Q plot. This underscores the importance of addressing downtime and enhancing network quality to improve Airtel's service.
- **Reliance Jio (RJIL)** exhibits a reasonable fit, with Network QoS, Packet Drop Rates, and Customer Care accessibility as significant influencers, emphasizing the need for attention to these aspects to enhance their performance. Clustering of points within a specific range was observed in the observed vs. fitted plot, and although no relationship was found between Residuals and Observed values, outliers were detected, particularly on the right tail of the Q-Q plot.
- **Vodafone (VIL)** shows a strong fit, suggesting a strong relationship with its key influencers, including Call Set-up Failure Rate, Network QoS, Packet Drop Rates (Uplink), Billing Credibility, and Call Centre Accessibility. This underscores the importance of addressing Call Failure Rates, Network Quality, Billing Credibility, and Call Centre Accessibility to optimize Vodafone's service performance. A close connection was noted between observed and predicted values, and there was no apparent relationship between residuals and observed values. Nevertheless, some outliers were detected, particularly evident in the Q-Q plot.

Moreover, an outlier analysis was conducted, demonstrating that the removal of outliers led to improvements in the models for both Reliance Jio and Vodafone Idea. This resulted in **higher R-squared** and **adjusted R-squared values**, underlining the significance of addressing outliers during the modelling process to enhance accuracy.

Each provider's unique set of influencing factors suggests the need for tailored strategies for optimization and improvement in the telecommunications industry. This in-depth review painted a vivid picture of where each MNO stands in India's telecom arena.

Using the RBD and Bidirectional Stepwise Regression, two main revelations stood out:

- MNOs performed consistently across different regions, but strikingly varied when compared to each other.
- There was a tangible link between an MNO's service quality and its stronghold in the market.