ORIGINAL RESEARCH

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Impact of COVID-19 on the Indian ICT Industry

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Abstract

Due to the COVID-19 crisis, a continuation of business has become problematic. Most economic activities have shut down with huge losses. People at home, online businesses, video conferencing, movies on OTT platforms and e-learning, are the new normal. Seamless connectivity solutions are crucial. Living with COVID-19 has substantially reduced the movement of employees from homes to workplaces. Everyone needs telecommunication for business continuity, which has enhanced demand for telecom.

While most industries faced a slump, Information and Telecommunication (ICT) industry has taken off. The IT and telecom ecosystems have reached a new symbiotic high to meet the massive demand.

This paper discusses the impact of COVID-19 on the ICT industry and 'Data Consumption' concerning 'Average Revenue per User (ARPU)' and other indicators; it studies the impact of lockdown on Content Delivery Networks and their adaptation to higher usage; it predicts the impact of COVID-19 on the future of the ICT industry in India.

Keywords

Impact, COVID-19, Indian ICT industry, Data Consumption, Content Delivery Network

Imprint

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1. Introduction

In this unprecedented situation forced by the pandemic of COVID-19, it is crucial to maintain internet connectivity, since meeting in person has to be avoided as far as possible, which is further necessitated by the new trend of 'Work from Home,' which has put much pressure on the connectivity providers. The telecommunication sector has to step up and help everyone stay close even while staying away from one another. It is noteworthy that the sector emerged as a 'shining light' in the grim situation, as it supported business enterprises to maintain their continuity virtually. The world saw a significant surge in demand for 'Data.'

New player's marketing meeting and entertainment applications could reach out to new customers and gain significant market share. The Zoom Meetings, Skype, Go to Meeting were a few platforms that people have started using, helping maintain the business continuity.

'Content Delivery Networks' was another sector that took center stage. Providing continuous live streaming to such a large group of customers has put significant stress on them. The 'Entertainment' sector, where 'Over the Top (OTT) platforms have seen a significant rise in demand due to domestic entertainment for kids and young adults, has also contributed to the performance pressure. The closing of daily television shows added fuel to the fire. A very large, unprecedented, and significant proportion of the population thus created a huge demand.

The impact of the lockdown on the IT industry has also been significant. The 'Work from Home' culture has contributed significantly to the business continuity, but adverse contractual and new order developments of foreign clients have resulted in lower revenues. As stated by Mr. Mahalingam (CFO and Executive Director of Tata Consultancy Services) [12], India needs to improve the quality of software exported.

On this background, this paper conducts quantitative analysis to analyze whether there has been a significant increase in the consumption of data in urban circles. It also analyses the data consumption patterns to find out the variation after the start of lockdown. It uses statistical tests to analyze whether there has been a change in data consumption and further uses visualization techniques to analyze data consumption patterns.

This paper performs a qualitative analysis of IT industry experts' interviews to understand this situation. They are also major stakeholders in the ICT domain,

which will throw some light on their view in this situation and how the industry is adapting to the change.

This paper also extends its research to see the impact of lockdown on the Content Delivery Networks. These networks experienced a significant demand with a significant rise in content across platforms and live stream meetings. With content needed these days across age groups, it is vital to understand how they adapted in lockdown times.

This paper establishes how all these participants are aggregating the positive effect and how the ICT industry can absolve itself from the Coronavirus outbreak's negative impact.

2. Objective of Paper

This paper discusses the impact of COVID-19 and the consequent lockdown on the ICT industry. It studies the impact on 'Data Consumption' and its patterns across platforms, concerning 'Average Revenue per User (ARPU)' and other indicators. The paper will also study how there is an overall change in the IT industry which new work culture. Further, it extends its research to understand effects on Content Delivery Networks, and they have been adapting to higher usage in these Lockdown situations. It predicts the impact of COVID-19 on the future of the ICT industry in India.

3. Literature Review

Lockdown has led to varied responses in various sectors. As for the Information and Telecommunication (ICT) sector, a few positives and negatives have emerged.

3.1. Impact on Telecommunication Sector

In an era of 'Work from Home' and 'Social Distancing,' there have much stress on the telecom sector to achieve communication needs. The vast majority of work was done online in offices. Hence, the 'Work from Home' concept was well adapted in the IT industry, majorly catered by the Telecom Service Providers. To furnish this demand further, the 'Government of India' declared telecommunication as an 'Essential service' to allow seamless and hassle-free connectivity to implement this concept [1] successfully. It was also backed by a massive infrastructure of 5.93 lakhs telecommunication towers on air [8]. There was a tremendous need for high-speed data, which indicates that India's average broadband speed was about 36.17 Mbps, and Mobile download speed was 9.67Mbps [5]. There was an overall increase of 13% in data traffic. Few circles witnessed a jump of about 100% in data consumption [2]. Since a major chunk of the public was staying home, including the kids, the demand for entertainment also took a spike. The Content Delivery Networks asked the OTT companies to downgrade their streaming from 'High Definition' to 'Standard Definition'[1].

It can also be seen from this Figure 1 that in the Video on Demand section, viewership of 'Exclusive Web Series' content experienced an increase of 123%, and for movies, it was up by 56% [3].

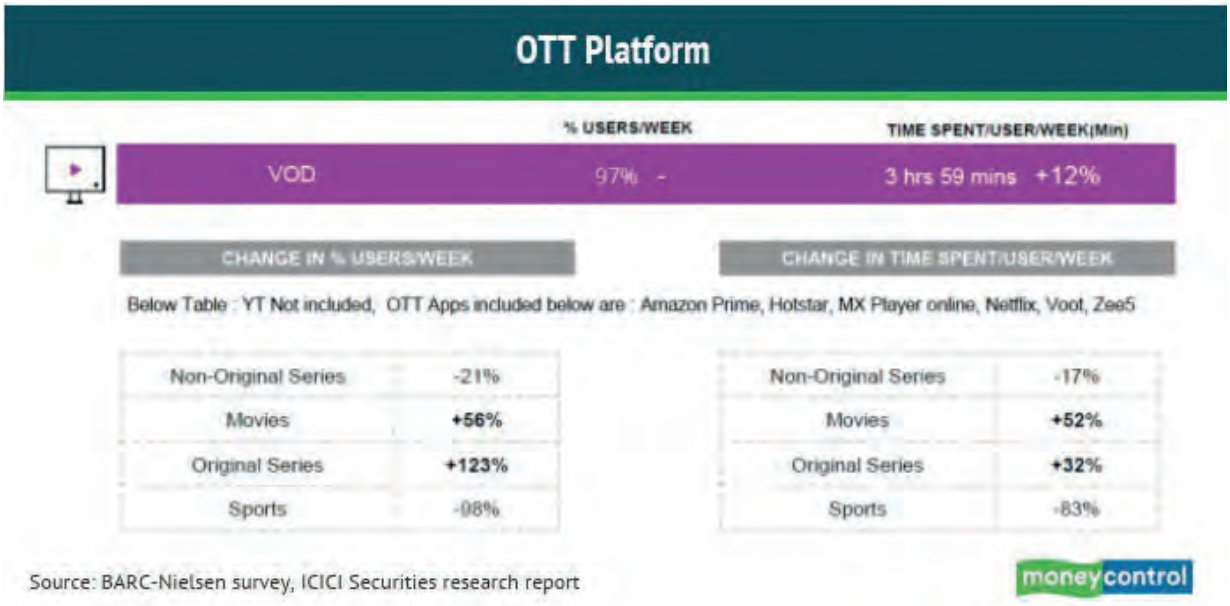

Figure1: Image indicating demand of OTT applications during the lockdown in India.
(Source-'BARC-Nielsen survey', 'ICICI Securities research report' via 'money control [3])

From the above image, we can infer that there has been a significant rise in the viewership of web-based content and, therefore, a larger need for telecom services to cater to this demand [9]. Hence, after such a significant demand for telecommunication, the Investment Information and Credit Rating Agency (ICRA) also said that the telecom sector would not experience a fall in demand, unlike other sectors [6]. A parameter where Telecom companies may not see a rise is the selling of new 4G SIM cards. The number of new SIM cards may not increase significantly, although we can say that there might not be a significant fall as well [4]. Telecom may also further delay the inevitable rolling out of 5G.

3.2. Impact on Information Technology Sector

Another sector that works closely with Communication Sector in this ICT world is Information Technology. With the successful implementation of the 'Work from Home' concept, the Information Technology industry adopted this situation very well. The fact is well acclaimed and is backed by the industry corporate-like Mr. Mahalingam (CFO and Executive Director, Tata Consultancy Services). He refers to the fact that there might not be any major impact on the IT industry.

He indicated that enhancing the quality of projects can be a differentiable factor [12]. He also welcomed the idea of 'Work from Home' as it provides employees much flexibility in their work without actually reducing the overall efficiency of working. Therefore, the organization plans to have only 25% staff in offices, said N. Ganapathy Subramanian (Chief Operating Officer, Tata Consultancy Services)[12].

3.3. Impact on Content Delivery Network

With a massive investment in Content Delivery Network, all the countries have robust Delivery Networks, which has helped the OTT platforms with the entertainment sector and the for-Web Meeting providing live meetings [7], which was helpful as Mumbai Internet Exchange had hit peak traffic of about 2.45 Tbps as compared to 772.6 Gbps the same time last year. Hence, it helped the OTT platforms as they operate majorly on the public internet [7].

Figure 2 refers to the fact that to cater to such a massive increase in demand for content; the content delivery networks need to strive further to cater to this demand. Akamai CEO Tom Leighton has said that

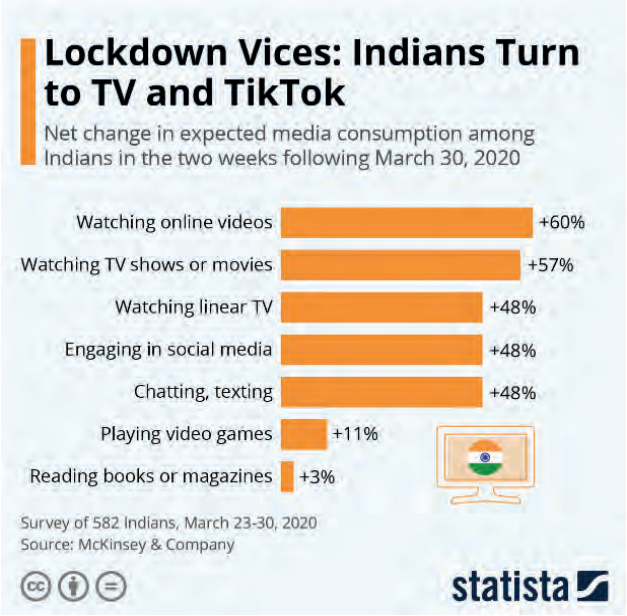

Figure 2: Image indicating demand of web-based content during the lockdown in India.
(Source- 'Statist a' [10])

there has been a rise of about 30% increase in their traffic (Akamai (n.d.). They also touched peak traffic of 167 Tbps during the lockdown times [10].

3.4. Impact on Revenues of Telecom sector

With such a vital role to play in this crisis, it is speculated that the telecom sector might be contributing about 30-35% in lockdown duration other than 6% direct contribution, which is also as a result of generating higher revenues as BhartiAirtel is expected its rise is ARPU to the range of 200-300 as said by Gopal-Vitthal (Managing Director and Chief Executive Officer, BhartiAirtel) [8]. Also, there is a difference between the increase in Base Transceiver Station (BTS) malfunctioning from 800 to 70 due to coordination due to proper coordination between the Department of Telecommunication (DoT) and local authorities to improve overall efficiency for better service.

4. Research Methodology

4.1. To Study Impact of Lockdown on Telecom Sector

To analyze the impact of lockdown on telecom, we selected two parameters as our study areas: 'Data Consumption' and 'Average Revenue per User. A quantitative approach was used to accomplish this task. Data consumption was used as a parameter for this study as; from Literature Review, we can see that there is a significant impact on data consumption during the

lockdown. Further, Average Revenue per User is used because it is a Key Performance Indicator (KPI) for the industry. Hence, the above parameters were selected as the area of study [11].

A small survey was carried out to understand the variation of their data consumption due to lockdown. People across various age groups filled the survey, and different service providers' subscribers were approached to get details about how the lockdown has impacted their data consumption. It is enquired about variation in tariff before lockdown and post lockdown.

A small research was conducted to get people's responses on their average data consumption before the lockdown and post lockdown had happened. Also, we tried to predict whether the increase or decrease in data consumption impacted their revenues. A total of 182 responses were recorded. To check where there has been an increase in consumption, Wilcoxon signed ranked test was carried out to check whether there is a significant variation in data consumption or not.

Wilcoxon Signed Rank Test is a non-parametric test that uses both variables for the analysis of variables. It is analogous to paired sample t-test for normal distribution.

A simple linear regression was done to predict its increase concerning the increase in data consumption to predict whether there has been an increase in the Average Revenue per User also since most other factors like adding new customers, new products, and new services that reflect as an increase in revenues were unchanged. Therefore, the only major reason for the increase in revenues is due to increased data consumption. Therefore, an increase in data consumption is considered an 'independent variable.' An increased data plan during lockdown is taken as a 'dependent variable' for this analysis.

4.2. To Study Impact on Information Technology Sector

Another vital element of the Information and Communication Technology (ICT) industry is the Information Technology element of it. It majorly worked online; it was one of the industries that adapted the best to this situation. Thereby, developing a new 'Work from Home' culture imparts the values of 'social distancing' and 'stay at home without even reducing the work process's overall efficiency.

This culture was a major success, and hence, it was of the industries to face a lower blip than other industries that require on-site presence like manufacturing. There are quite a few reasons why the industry adapted so well to this extent and the challenges they might face during these times. Hence, for this analysis, we decided to approach a qualitative way. Therefore, interviews of industry experts were conducted to get a view of the situation. Detailed questions were asked to get an in-depth view of this situation of industry the situation. General patterns that emerged from the data collected from interviewees emerged as the areas of study.

For Content Delivery Network (CDN), a qualitative study was carried out. The interview was carried out, and results were formulated based on the answers of the respondents. Secondary research would also be done to get precise analysis for the research work.

5. Hypothesis Formation

5.1. Hypothesis Formulation to Analyze Variation in Data Consumption before Lockdown and Post Lockdown

Since the quantitative approach of analysis is used to study telecom's impact, it is important to pre-define their hypothesis to draw our conclusion based on these results. To check the variation in data consumption before and post lockdown, Wilcoxon Signed-Rank Test is used. This test is used to compare medians of both the analysis variables. Here, H_0 would be used to define 'Null Hypothesis,' and H_1 would be used to define the 'Alternate Hypothesis' Hence, the hypothesis would be as follows:

H_0: Median of data consumption before lockdown = Median of data consumption post lockdown.

H_1: Median of data consumption before lockdown ≠ Median of data consumption post lockdown.

Descriptive Statistics of each would be done as a Post-Hoc test to conclude changes in data consumption patterns. From Descriptive Statistics, we can formulate the increase or decrease in data consumption before the lockdown and post lockdown had happened. This test would be performed in Statistical Package for Social Sciences (SPSS) for the analysis.

5.2. Hypothesis Formulation to Predict Increase in Average Revenue per User Due To Increase in Data Consumption

A simple linear regression technique is used to calculate the impact of lockdown on Average Revenue per User. It is seen that increase in data consumption is one of the factors for the rise in revenues of the company,

and hence, 'increase in data consumption is selected as the independent variable, and 'additional tariff' is taken as the dependent variable for this regression.

For this analysis, H_0 would define 'Null Hypothesis' and H_2 to define the 'Alternate Hypothesis.' In regression, β is used to define the slope of the regression curve. Hence, the hypothesis would be as follows:

H_0: β=0; there is no relationship between 'increase in data consumption and 'additional tariff.'

H_2: β≠0; there exists a relationship between 'increase in data consumption and 'additional tariff.'

Since Simple Linear Regression is used as a tool for Predictive Analytics hence; the regression model would be used to predict the increase in the companies' revenue post lockdown, which would allow us to understand the impact of lockdown on the increase/decrease in their Average Revenue per User. Since it is a Key Performance Indicator for the industry, it can be used to examine the industry's health during the period of lockdown. The test would be performed in MS Excel.

6. Results and Analysis

6.1. Respondent Profile of the Survey Conducted

Responses from people across all age groups and of different subscribers were done. Most of the respondents were from the age group of 20-30. MS Excel was used to generate the graphs to follow. The below graphs indicate the profile of respondents. The Figure 3 bar graph indicates the distribution of respondents across various Telecom Service Providers. Following this, Figure 4 shows a bar graph in the age-group chart, which shows respondents' distribution across various age groups.

6.2. Data Analysis of Data Consumption before and Post Lockdown

To analyze data consumption patterns before the lockdown and post lockdown, 'Descriptive Statistics' for both the variables were calculated using MS Excel is shown in Table 1.

From Table 1, we can see that there is a significant variation in data consumption patterns before the lockdown and post lockdown. There is a significant rise in the mean level of data consumed by over 600 MB per user. That is, we can see that there is about a 60% increase in usage of data. Further, the medians have also experienced a significant rise of 66% throughout lockdown. The study is largely focused on

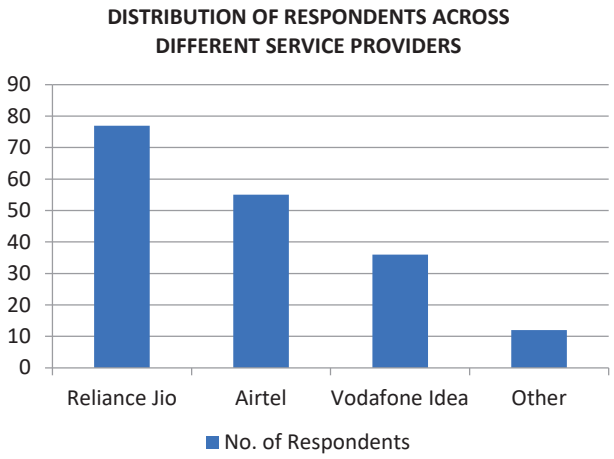

Figure 3: Service Provider, wise distribution of Respondents.

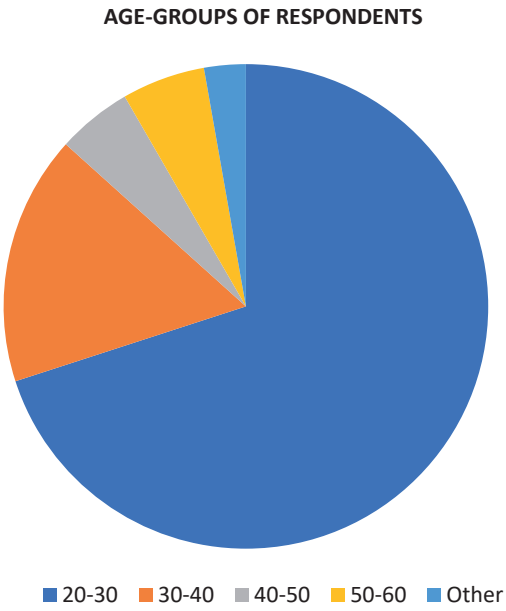

Figure 4: Age Group-wise distribution of respondents

the age-groups of 20-60 years old, the major working population. It was observed that they were forced to stay home and 'Work from Home,' which meant many of their activities shifted online, meaning an increase in data consumption, which is quite clearly visible from the above descriptive statistics.

From the descriptive statistics, it can also be concluded that the numbers of Skewness and Kurtosis are quite large, and hence, the distribution is not a Normal Distribution. Hence, to analyze such data, we use a non-parametric test. The test which can help us in this scenario is the 'Wilcoxon Signed Rank Test.'

6.3. Data Analysis of Data Consumption before Lockdown and Post Lockdown using Wilcoxon Signed-Rank Test

Wilcoxon Signed-Rank Test is a non-parametric test for the analysis of two variable groups. It is a

Table 1

Descriptive Statistics of Data Consumption Prior and Post Lockdown.

Data Consumption Pre-Lockdown		Data Consumption Post-Lockdown	
Mean	962.3179191	Mean	1584.300578
Standard Error	56.13004708	Standard Error	87.24518027
Median	900	Median	1500
Mode	500	Mode	2000
Standard Deviation	738.2755028	Standard Deviation	1147.531183
Sample Variance	545050.7181	Sample Variance	1316827.816
Kurtosis	9.400559608	Kurtosis	5.443541711
Skewness	2.354151651	Skewness	1.674632389
Range	4990	Range	7950
Minimum	10	Minimum	50
Maximum	5000	Maximum	8000
Sum	166481	Sum	274084
Count	173	Count	173

non-parametric test and hence uses the median as a basis of hypothesis testing. It is an analogous test to the paired sample t-test, which is used for normal distribution. Here, H_0 would be used to define 'Null Hypothesis,' and H_1 would be used to define the 'Alternate Hypothesis' Hence, the hypothesis would be as follows:

H_0: Median of data consumption before lockdown = Median of data consumption post lockdown.

H_1: Median of data consumption before lockdown ≠ Median of data consumption post lockdown.

Based on the above hypothesis, we performed the Wilcoxon Signed Rank Test and the results obtained are shown in Table 2.

Table 3 test statistics analysis shows that significance value (2-tailed)< 0.05, and hence, we reject our Null Hypothesis H0 and accept our Alternate Hypothesis H1. There we conclude that the data consumption post lockdown has varied significantly.

As a Post-Hoc measure, we perform the descriptive statistics for this test. From the results of Table 1, we can see that Post-Lockdown, there is a tremendous rise in data demand.

6.4. Predicting Increase in Average Revenue per User using Regression Analysis

For Regression Analysis, we have taken the following hypothesis:

Table 2

Ranks. Wilcoxon Signed Ranks Test

		N	Mean Rank	Sum of Ranks
Average Data Consumption post lockdown (per day in MB) - Average Data consumption pre lockdown (per day in MB)	Negative Ranks	6	51.17	307.00
	Positive Ranks	137	72.91	9989.00
	Ties	30		
	Total	173		

Table 3

Test Statistics

	Average Data Consumption post lockdown (per day in MB) - Average Data consumption pre lockdown (per day in MB)
Z	-9.767
Asymp. Sig. (2-tailed)	.000

H_0: β=0; there is no relationship between 'increase in data consumption and 'additional tariff.'

H_2: β≠0; there exists a relationship between 'increase in data consumption and 'additional tariff.'

where H_0 is the 'Null Hypothesis' and H_2 is the 'Alternate Hypothesis.' The simple Linear Regression technique was used to determine between the variables. The tests were performed in a Microsoft Excel sheet. The results obtained were shown in Table 4.

Since, the 'Significance level < 0.05', we 'reject' the 'Null Hypothesis. Hence, we can conclude a relationship between the independent variable 'Data Consumption' and dependent variable 'Increase in Tariff.' Further, the difference between 'R square' and 'adjusted R square' is less than 10%, which is another correct analysis indicator. We can see that R square's value is very small as the points overlapping the regression curve are few. The reason for this is that Data Consumption is different for all people. Hence, the accurate overlapping of these points is very less on the regression line. Table 5 shows the relation between dependent and independent variables.

As the Significance Level < 0.05, which confers to the fact that the Null Hypothesis is rejected and thereby accepts the Alternate Hypothesis, it confers a relationship between the variables. Hence, we try and establish the relationship between the variables. For this task, a Line-Fit plot is plotted.

From Table 3, we can find the Increase in Data consumption value and the intercept value to obtain the regression curve. The increase in tariff plan would be the average value of increase during the lockdown period; hence, it would increase or decrease in Average Revenue per User during the lockdown period. The slope 'β' and the intercept of this regression curve would be obtained from Table 1. The difference between the mean of Data Consumption Post- Lockdown to Pre-Lockdown is '621.9827,' which would be used as the average increase in Data Consumption due to lockdown. To equation will give the increased Average Revenue per User, which is as follows:

Increase in Average Revenue per User = β*Increase in Data Consumption+ Intercept = 0.028668293 * 621.9827 + 23.3573947 = ₹ 41.18858

Therefore, Figure 5 shows the Line Fit Plot for Increase in Data Consumption and Increase in Tariff Plan; the Telecom companies can expect an increase in Average Revenue per User of about ₹ 41.18858 due to lockdown. A positive Average Revenue per User also indicates that the industry's health state is quite good even though there has been a lockdown.

6.5. Analysis for Impact on Lockdown on Information Technology Industry

Profile of Respondents of the interviewees:

Table 4

Regression Statistics and ANOVA results

Regression Statistics					
Multiple R	0.230620714				
R Square	0.053185914				
Adjusted R Square	0.047550115				
Standard Error	89.26184371				
Observations	170				
ANOVA					
	df	SS	MS	F	Significance F
Regression	1	75192.21886	75192.22	9.437157	0.002481122
Residual	168	1338569.693	7967.677		
Total	169	1413761.911,			

Table 5

Relationship between Dependent and Independent Variable

	Coefficients	Standard Error	t Stat	P-value
Intercept	23.3573947	8.935746753	2.613928	0.009764
Data Consumption	0.028668293	0.00933214	3.071996	0.002481

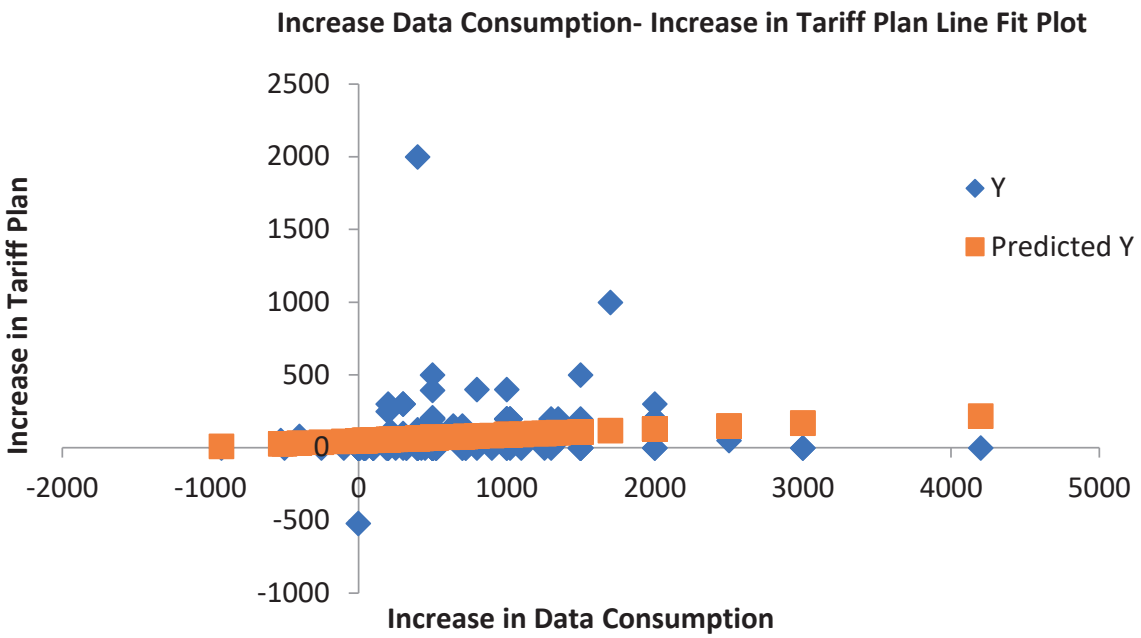

Figure 5: Line Fit Plot for Increase in Data Consumption and Increase in Tariff Plan

An interview was conducted with renowned persons of the industry, who have aplenty experience of the industry. They provided deep insights into how the industry has changed in the due duration of lockdown. Various aspects have changed during this tenure, and the interviewees were quite capable of throwing light on these aspects, which were quite valuable as far as the research is concerned. They shared their experiences, how the industry has progressed, and the challenges decision-makers face during these times. The main inferences that can be drawn from interviewees reply are:

- **Positive Trends that have emerged for the industry from this situation:**
  - Many companies have changed their working environment from office cubicle based to 'Work from Home' based culture as these were required considering health safety purpose as it maintains 'Social Distancing.' What made this initiative successful was that it was implemented without reducing the efficiency of the process. Hence, there was no major decrease in output process and delivery of projects as well.
  - Massive surge in demand for IT infrastructure has been the highlight of this situation as not only the IT industries have shifted online, but also various other sectors like supply chain, educational institutions, financial industries, government, and public sector, pharmaceuticals are in need for IT infrastructure for their business continuity.
  - Also, there has been a new concept emerging that is 'Bring Your Device.' Companies are bringing such a concept to manage the reduction of cost in the procurement of these assets.
  - The 'Work from Home' concept will also help reduce fixed assets by the company. The cost of land, offices, and machinery will reduce significantly as fewer fixed assets would be required.
  - Something on the non-professional front that has emerged is the time with family. Since parents are staying home, they can spend much time with their families.
  - The Business Support activities shifting online were a major change. The activities which form a major part not significant for the business process also started shifting online.
  - Virtual Sales and Virtual Contract signing are seen as the new normal. As the industry is doing its significant work online, this has been a new way to close out of deals and acquire customers.
- **Negative Trends that have emerged for the industry from this situation:**
  - Time for communication has picked up significantly. From a direct verbal conversation face-to-face now, this time has increased substantially. The concept of 'Everything is a meeting' has substantially picked up.
  - Technical infrastructure management faced challenges in the early part when there was

a drastic change of work from home and increased demand for data.
    - Service Level Agreement (SLA) Management became crucial. As initially due to lockdown lot of work went in the pending zone has to accomplish the tasks in time. The timelines deferred, and hence, management of these dates became a vital task.
    - Large projects that incur one-time costs were put on hold as client businesses' capital expenditures varied. The revenue-based projects did not differ significantly, as it was a small sum. Hence, the large and small rental-based IT companies are likely to flourish and gain significant demand in this tenure.
    - As an initiative of working-capital management, there is a very small laying-off and less acquiring of staff.
- **What are the areas in the industry that are likely to grow due to this situation?**
    - The areas of industry that will witness growth are Cloud Infrastructure and Content Delivery Networks.
    - The need for applications like Video Meetings and Online Entertainment Content Delivery Networks has experienced a rise in massive demand. Also, many delivery networks deliver through a network of private and public clouds; hence, in the era of massive need demand for data, this area will also experience a significant rise.
    - Another reason for the rise in demand for cloud infrastructure is that most companies are moving for cloud-based infrastructure, thereby decreasing the need for fixed assets and permanent hardware.
    - With the advent of 5G, the core infrastructure would be moving virtual, and hence, there would be more demand for 'Virtual Machines' and 'Cloud-based Core' networks.
- **Niche Category that was explored during this tenure:**
- Since the Business Support activities also shifted online, an application such as Human Resource Management, Project Management, and Document Sharing application has gained significant demand.
- **Strengths and Opportunities that have emerged from this situation:**
    - The biggest possible strength that has emerged is the 'Work from Home' culture. The employees have been able to stay home to work effectively, which is the single biggest reason why the work has not hampered significantly.
    - An opportunistic trend that has emerged during this period is 'Gig Work,' also called 'Freelancing.' Since many companies may face financial, instead of hiring a permanent workforce, many freelancers may be acquired as they are not on the company payroll. Thereby reducing the financial liability of a permanent employee on the company.
    - Another positive aspect this industry handled well is contingency planning. To enable all employees to Work from Home, the companies had started to plan this contingency well before tackling this situation.
    - Since the people are working from home; therefore, they can spend much more time with their family, hence abiding by their social responsibilities.
- **Weaknesses and Threats that have emerged from this situation:**
- There has been a significant decrease in the demand for a manual workforce in this industry.
- The interviewees feel that once this situation settles down to normal, the industry might increase attrition rates.
- Dropping out of projects from US-based clients.
- Due to foreign clients' regulatory issues, there might be an increase in India's unemployment figures.

6.6. Analysis for Impact on Lockdown on Content Delivery Networks

The content delivery networks also have had a massive impact due to lockdown. There is a tremendous increase in the need for data. There is a significant rise in the need for entertainment and live meeting segment. The Content Delivery Network has nonchalantly catered to this demand. Zoom the video conferencing has been the highest used app over applications like WhatsApp and YouTube during the lockdown times. It goes to show how much stress this has impacted as a result of lockdown. Hence, it was vital to understand their role during this lockdown as well.

Respondent Profile:

An interview was conducted with industry personnel who have prior industry experience and can share deep insights into how the industry has changed

during this time. They also put-up challenges faced by them during this time. Major inferences draw from the answers of interviewees responses are:

- **The major impact of this situation:**
  - There was significant demand for data to cater to the demand from OTT applications. It was important to manage the load.
  - The outreach was unaffected as the service had already reached major locations where demand was already significant and where the rise took place.
  - Demand for live streaming was significantly high due to the massive rise in video conferencing meetings.
  - Ad-content delivery saw a massive rise as a move of the massive increase in digital marketing initiatives [13].
- **How did the industry adapt to this situation?**
  - The industry adapted well to this situation as some platforms were requested to downgrade their streaming experience to manage the load.
  - Through a network of private and public clouds, the network resources were shared to avoid public internet data.
  - Installing backup server pre-hand before the situation arises so that we can supply the demand of data that arose due to lockdown.
- **Positive Trends emerged during this situation:**
  - Catering to this significant demand with ease. Though small concerns have emerged like cybersecurity from Zoom and the downgrading of streaming for OTT, major demand is well catered.
  - Unaffected supply of demand of data
  - Generating alternative routes like the generation of private and public clouds to cater to demand.
  - Alternative backup servers for uninterrupted supply before the lockdown itself so that its large demand of data can be catered to whenever the situation arises.
- **Negative Trends that came out of this situation:**
  - Cybersecurity issues like DDoS attacks may arise due to large-scale demands.
  - Unable to suffice full-fledged streaming service [14].

7. Managerial Implications of Study

This paper studies the changes that have taken place during the lockdown due to COVID-19. It shows the quantitative impact on the Indian telecommunication industry of its major impact variable during lockdown - 'Data Consumption.' It also indicates the possible impact of the increase in data consumption on one of the industry's key performance indicators, increasing Average Revenue per User (ARPU). An increase in ARPU is an indicator of the better health of the industry. Further, this paper also analyses the reasons for the resultant change experienced by both variables.

This paper also analyzes the impact of lockdown on another vital component of the ICT industry - the IT industry. Qualitative research was conducted by interviewing industrial experts to analyze the impact of COVID-19. Analysis of the interviews is useful to understand how the industry adapted so well to this situation. It highlights the key decisions taken to deal with this contingency and the industry's positive changes during this period.

The paper further extended its research to look into the impact of Content Delivery Networks on lockdown. With a massive increase in demand, the providers also had to adapt to cater to this demand. Thereby, we tried to understand the decisions they took to cater to the end-user [15].

8. Limitations of Research

- The survey conducted for this research was only limited to the urban sector. Since major workforce using telecom lies in this region.
- The timeline of this research was very short. Hence, it is possible that in the long term, these effects may vary.
- The qualitative analysis is based on the personal responses of the interviewees.

9. Conclusions

From the above research, we have established the following conclusions:

- From the Wilcoxon Signed Rank test, we conclude that there has been a significant rise in the need for data. Hence, there has been a tremendous increase in 'Data Consumption' post lockdown.
- From the simple linear regression analysis, we conclude that the telecom industry might experience increased revenue of about ₹41.19 due to lockdown, which shows that the industry is in good health and positively impacts.
- The IT industry also did not have any significant loss due to lockdown. It transformed itself well to adapt to this situation.
- The Content Delivery Networks have adapted well to cater to the rise of demand despite such a massive surge.

- Some guidelines may be more applicable to the form of supply chain disruption, but the above-mentioned recommendations should be used to monitor the effects of supply chain disturbances in general.
- Managers have a difficult time making decisions after a disruption. As a result, during a pandemic, researchers could recommend an adequate decision-making process. How to assess the success of supply chains during a pandemic is another uncharted territory.

Conflict of interest

None declared.

Author contributions

The authors read the ICMJE criteria for authorship and approved the final manuscript.

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