

Predicting the Post Covid-19 Trend of Indian GDP and Its Main Contributors

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Abstract –Forecasting is the process of estimating the future predictions based on the historical data. However, due to global pandemic it has become difficult to predict the GDP of India in the coming years based on the past data. This study has attempted to shed light on predicting the future GDP of India and has considered the factors that contribute to the Indian GDP like Unemployment Rate, Population and Labour Force Participation Rate. This paper also focuses on the individual sector contribution to the Indian GDP. These sectors include Agriculture, Industry and Service. Data on GDP has been collected from year 2008 to 2019 from various research websites such as statistics times and trading economics. Data on state-wise GDP of India has been collected from various publications of the Reserve Bank of India. The unemployment rate, Population and labour force participation rate data has been collected from the world bank. A multiple linear regression model has been fitted on data to determine the relationship between unemployment rate, population and labour force participation rate with Indian GDP. Results suggest that as the unemployment rate increases the Indian GDP decreases and as the population increases GDP also increases. Based on this model, further values of Indian GDP were forecasted for the coming years. A linear regression model was used to predict the contribution of three sectors i.e. agriculture, industry and service sector, and the state-wise GDP of top nine contributing states in India was predicted. We hope to assist the policy makers and businesses to formulate economic and business strategies in turn more precisely through the findings of our research. It will also help investors in decision making, as to whether or not to invest in a particular sector, and which sector needs investment to be stabilized or prevented from a drastic fall.

Keywords– COVID-19, GDP of India, Unemployment Rate, Population Rate, Agriculture Sector, Industry Sector, Services Sector, Multiple Regression, Linear Regression, Predictive Analysis, Labor Force Participation Rate, oxidation, peroxide value, polar compounds, polymerization, pyrolysis, rancidity, refractive index, smoke point.

I. INTRODUCTION

On the eve of 2020, cases of pneumonia started being reported in the Wuhan province of China. That is when it all started; the pandemic with the potential to bring many of the strongest economies of the world to a complete standstill. All countries have been largely affected by the onset of this pandemic. The United Nations (UN) expects the global economy in 2020 to shrink at least by 1 per cent as opposed to a previously forecasted growth in economy of 2.5 per cent[28]. The COVID-19 pandemic has been a major disruption in international trade[22] and the global supply chain. The international borders of over 100 countries have been closed since March 2020, which has led to tourism being ceased. Along with the tourism industry, almost all the countries in the world are facing a major unemployment crisis. In April 2020, the UN had forecasted cutbacks equivalent to 200 million full – time workers in the next three months. As of April 2020, the

global unemployment was already at 190 million. The UN also forecasted that even though the agriculture sector hasn't yet been impacted by the pandemic, it is expected to face the brunt in the future creating a major food crisis. Agriculture industry is single handedly the largest contributor to GDP in most developing countries.

One such country which has been affected greatly is India, the second most populous country in the world, after China. It is very difficult to contain the spread of the pandemic in a densely populated country like India. This has led to a devastating impact on employment in the country[30]. In India alone, the number of people left without jobs as of April, 2020 was 120 million. The country had been on a nation-wide lock down since March 2020, and with a large number of the population requiring to stay at home, many of them have been laid off. Informal workers have been the most affected due to this pandemic, as their working sectors, like construction, were the first to have been hit by the lock down.

India is a country with a population of one billion people. Most of India's population is concentrated in the age group of 15 to 64 years. A huge portion of this population is either formally or informally employed. This also means that, the percentage of people affected in this age group would be highest to have been affected by the pandemic and its effects on health. Due to the sheer density of population all over, it is very easy for the pandemic to be spread from person to person. Along with that, the healthcare system in India isn't equipped enough to deal with the large number of cases in the country. There is also a very high rate of comorbid conditions like diabetes and heart diseases in the country, which are contributing to a spike in the number of COVID-19 cases. On account of being the worst affected factors that have an impact on GDP, we wanted to see how Unemployment Rate, Labour Force Participation Rate and Population in the age group 15 to 64 years have affected India's GDP and the Gross State Domestic Product of its top contributing states.

For this, we considered nine states which largely contribute to India's GDP – Maharashtra, Tamil Nadu, Uttar Pradesh, Gujarat, West Bengal, Rajasthan, Andhra Pradesh, Telangana and Madhya Pradesh. Indian GDP growth rate has been on a fall since 2016, and with the advent of this pandemic, it is bound to continue to fall. India's GDP is made up of three main sectors – Agriculture, Industry and Services. Services and Industry sectors have already been terribly hit, and the UN has also predicted a severe blow to the agriculture sector globally. We also aim to see how badly the individual sectors will be affected in the years to come.

II. LITERATURE REVIEW

According to Investopedia, Gross Domestic Product of a nation is "the total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period" (Gross Domestic Product, June 1, 2020). GDP can rise and fall depending on a lot of factors. One such cause in recent times is the ongoing COVID-19 pandemic. While there is abundant research on the effects of COVID-19 on GDP, there is very little research identifying its effects on the GDP of India. Here, all the factors that have been affected by COVID-19 are considered individually. However, the cumulative effect they would have on the GDP of India is not considered. Furthermore, the impact of this change in GDP on the component sectors and the Gross State Domestic Product of Indian states is not looked into. We are using this opportunity as a research gap to provide substantial contribution to this area of research.

Section 1: COVID-19 and impact on GDP

In 2012, Maity and Chatterjee conducted a research to forecast the trends of growth of India's GDP up to the

year 2021. They used the ARIMA model whose parameters were estimated using time-series data for a single variable, in this case a macroeconomic variable i.e. India's GDP. They forecasted an increasing trend in the actual value of GDP, with a declining trend in the growth rate of the GDP. Another study was conducted by Bhattacharya, Chakravarti and Mundle in 2018. They used the Time Varying Parameter Regression model to understand how the growth of GDP in India is driven by structural shocks.

However, all of this changed due to the onset of COVID-19 which has greatly affected the Indian economy. It has been forecasted by the world economic forecasting model that the global output is going to decrease by 0.9 per cent. This would be highly dependent on the demand shocks faced by the countries, and economic activities affected by this pandemic. Recent studies (Maliszewska et al., 2020; McKibbin and Fernando, 2020) have examined the impact of the financial shocks that have come with COVID-19 and the macroeconomic outcomes using a standard CGE model. The results from these studies have predicted a fall of 2 per cent in the baseline global GDP, with a 1.8 per cent fall for developed countries and 2.5 per cent fall for developing countries.

Another study conducted by Dev and Sengupta in 2020 talks about how the adverse effects of COVID-19 on demand and supply chains in the country are going to further put a strain on the already precarious state of the Indian economy.

Due to the country wide lock down, the magnitude of the impact on the economy can only truly be determined based on how the situation unfolds when lock down is lifted although the eventual damage is predicted to be more adverse than current estimates.

Section 2: COVID-19 and impact on factors affecting GDP

Since January 30th, 2020, the quantity of COVID 19 cases within the country has been continuously rising with 22,010 cases as of 27th April 2020. As a result, the government of India took a choice of nation-wide lockdown on 25th March 2020 so as to forestall the spread of the pandemic. The imposing of lockdown on all educational institutions and business activities has led to an impression within the number of cases but has affected employment on an outsized scale. It is estimated by the International Labor Organization (ILO) that globally over 25 million jobs would be threatened because of the spread of coronavirus. Moreover, it's been estimated that 81 per cent of the people within the worldwide workforce of three billion face the brunt of the consequences that COVID-19 has had on their workplaces by requiring full or partial workplace closure. As mentioned in the report of Centre for Monitoring Indian Economy (CMIE), only a bit over one-fourth (27.7%) of the whole working

population (from ages 15-59 years) out of 1003 million, i.e. 285 million people still continued visiting add the lock down's first week. However, before the initiation of the nationwide lock down, this number was about 404 million. About 119 million workers ended up losing their jobs between the week before and after lock down. As mentioned in the report by CMIE, a notable rise within the rate of unemployment and a downfall within the amount of obtainable (kept) jobs was expected in March, 2020. The per centum stands at 8.7% in March 2020, which is far above the govt. unemployment estimate at a 45-year high of 6.1% in 2017-18. This is the highest percentage since September 2016 (Balwant Mehta, April 13 2020). Thus, it's understood that COVID 19 had an enormous impact on employment. With 29,887 deaths within the country as per ministry of health and family welfare, the population rate of India has also gone down and currently it's down by 0.99%. Senior citizens and folks with underlying health conditions are at higher risk of developing severe symptoms of COVID 19 (WHO, 16 June 2020). The existence of other comorbid conditions like diabetes and heart diseases, together with other chronic illnesses can increase the complications of health because of the virus, also making the individual more liable to being infected.

However, the worst affected region is the state of Maharashtra which shows that the people with the highest number of the corona virus disease is between 31 and 40 years as per state government's data (Meenakshi Ray, June 13 2020). This shows that COVID 19 has largely affected the class of the population which comprises a large portion of the Indian population.

Based on all the literature that we referred to in the process of our research, the general consensus is that the GDP, both global and Indian, is going to be severely hit in the close future due to a standstill of major industries and economies all across the world.

This will also cause an increase in the unemployment rate due to lack of jobs in all sectors. Along with this, a large portion of the working population of India (Ages 31 years – 40 years) has seen adverse effects on health due to the virus, whose spread is further facilitated due to underlying comorbid health conditions. With this as our base, we researched further into the decline of GDP with respect to these factors that have directly been affected by the global pandemic.

III. RESEARCH DESIGN

This research is quantitative in nature. The quantitative method of research design helps researchers to use a wide range of statistical techniques to analyse quantitative data. This type of research is often associated with social sciences and statistics, but researchers in other fields, such as education, use it. The results obtained from this type of research method are often logical, statistical and unbiased. Data is collected in a structured manner. There are two

ways in which the data can be collected: Primary Data Collection and Secondary Data Collection. In this research project, data is collected from a secondary source. Secondary data collection technique includes collecting data from various sources such as books, journals, periodicals, internet websites, etc. Likewise, in this research paper, the data is collected from various websites such as the World Bank, Reserve Bank of India, Statista and Trading Economics.

IV. DATA ANALYSIS

Section 1: Predicting GDP of India based on Factors Affected by COVID-19

The Indian GDP of previous years was collected from the World Bank. Out of all the factors affecting Indian GDP, we decided to consider the top three factors which are majorly affected by the global pandemic. These factors include Unemployment Rate, Population Rate and Labour Force Participation Rate. The data for these three factors for the previous years as well as the predicted data considering COVID 19 impact were taken from various websites. After collecting the data, Multiple Linear Regression was performed in the Excel sheet to determine the dependence of Indian GDP on these three independent factors.

The summary table of the model was as follows:

Table 1 Summary Table of the Regression Model.

REGRESSION 1		
Factors Considered	R-square	p values
Unemployment Rate	0.989481	0.05200305
Population Rate		0.08632370
Labor Force Participation Rate		0.79008280

From the above output, we can see that the p-values of all the three factors are above 0.05. Hence, the factor with the highest p-value was discarded and multiple linear regression was performed again. This process is called feature engineering wherein the unnecessary variable gets discarded.

The hypothesis is as follows:

H0: There is no significant dependence of Indian GDP on Unemployment Rate and Population Rate.

H1: There is a significant dependence of Indian GDP on Unemployment Rate and Population Rate.

The summary table of the model after discarding Labour Force Participation Rate is as follows:

Table .2 Summary Table of the Regression Model after discarding Labour Force Participation Rate.

REGRESSION 2				
Factors Considered	R-square	p values	Coefficient [C]	Slope [M]
Unemployment Rate	0.989382	0.00830409	-213399854.8	-4320044.951
Population Rate		7.92249E-10		3820355.469

From the output of the model above, we can see that the p-values are less than 0.05. Hence, we reject the null hypothesis. Thus, the model states that there is a significant dependence of Indian GDP on Unemployment Rate and Population Rate. The R-square value denotes that the model is able to explain 98% variance which is a very accurate model. The equation of the model is as follows:

$$Y = M1 * X1 + M2 * X2 + C + e$$

$$Y = (-4320044.951) * X1 + (3820355.469) * X2 + (-213399854.8) + e$$

- Where Y – Dependent Variable (Indian GDP)
- X1 – Independent Variable 1 (Unemployment Rate)
- X2 – Independent Variable 2 (Population Rate)
- M1 – Slope or gradient of independent variable 1
- M2 – Slope or gradient of independent variable 2
- C – Intercept
- e – Residual error.

Thus, with the help of the multiple linear regression model we predicted the Indian GDP for the years 2020, 2021, 2022, 2023 and 2024.

Section 2: Predicting Sector – Wise Contribution to GDP of India

After predicting the Indian GDP of future years, we decided to do a deeper analysis. We determined the sector-wise contribution to Indian GDP. The sector-wise contribution to Indian GDP in the previous years was taken from the world bank. A simple linear regression model was performed in Python to predict the future contribution of three sectors viz. Agriculture, Industry and Services to the Indian GDP. The following is the scatter plot graph of the three sectors with respect to Indian GDP with the best fit regression line:

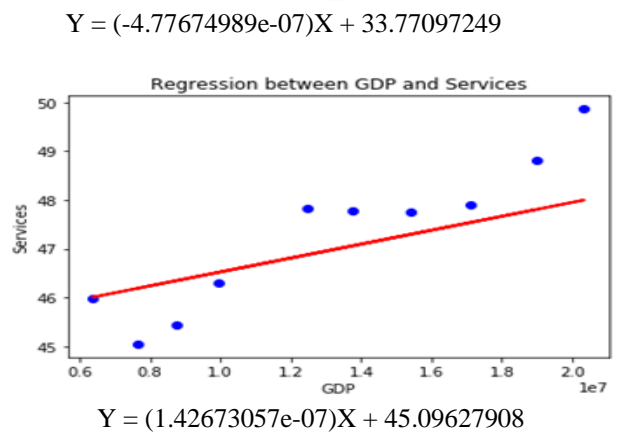
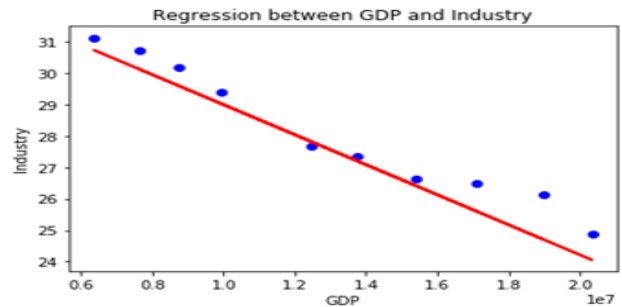
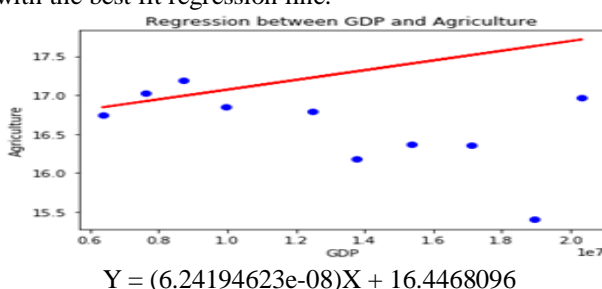


Fig.1 Regression between GDP and Sectors.

Thus, with the help of the best fit line of regression we can determine the predicted values of the sector-wise contribution to the Indian GDP.

The table below shows the actual values and the values predicted by our regression model for the three sectors.

4.2.1 Agriculture

Table .3 Agriculture.

ACTUAL	PREDICTED
16.7920	17.2251
16.9650	17.7164
16.8450	17.0675
15.4070	17.6310
17.0270	16.9233
16.3640	17.4075
16.7440	16.8442
16.1750	17.3064
16.3580	17.5141
17.1920	16.9921

4.2.2 Industry

Table 4 Industry.

ACTUAL	PREDICTED
27.6560	27.8153
24.8810	24.0551
29.3990	29.0210
26.1290	24.7089
30.7250	30.1242
26.6190	26.4188
31.1210	30.7299
27.3470	27.1925
26.4790	25.6035
30.1620	29.5978

4.2.3 Services

Table 5 Services.

ACTUAL	PREDICTED
47.8220	46.8751
49.8770	47.9982
46.3010	46.5150
48.8120	47.8030
45.0340	46.1855
47.7490	47.2923
45.9850	46.0046
47.7840	47.0612
47.8920	47.5357
45.4420	46.3427

We have plotted the following bar graph of the actual and predicted values for all the three sectors.

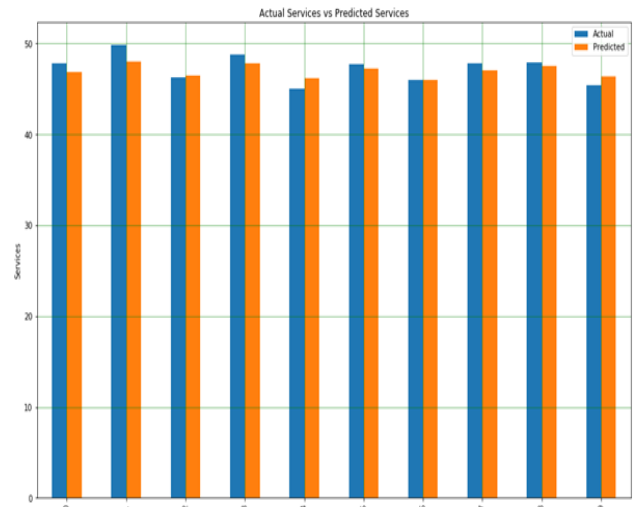


Fig. 4 Services - Actual vs Predicted Values.

We can see that there is a little difference between the actual and predicted values of sector-wise contribution to the Indian GDP. By using the Indian GDP of the years 2020, 2021, 2022, 2023 and 2024, we can predict the sector-wise contribution of those years respectively.

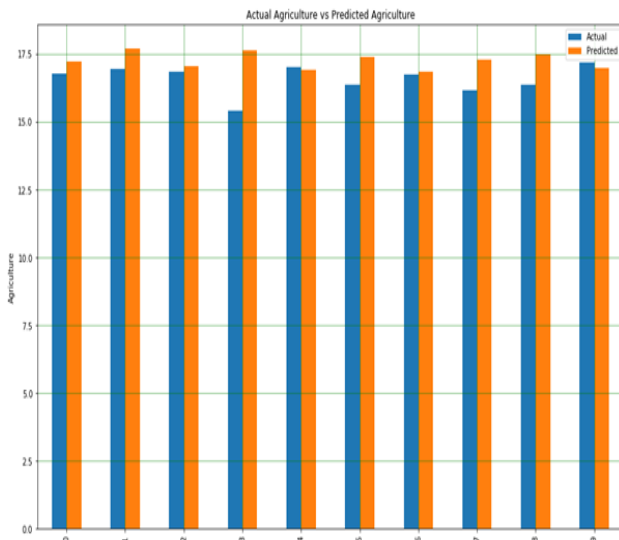


Fig. 2 Agriculture - Actual vs Predicted Values.

Section 3: Predicting Gross State Domestic Product based (GSDP) on GDP of India Further, we decided to do a detailed state-wise analysis of the GDP. The top nine states with the highest GDP of the previous years were downloaded from the reserve bank of India. A simple linear regression model was applied by considering each of these states as the dependent variable and Indian GDP as the independent variable. The summary table of regression for the nine states is as follows: Since the p-value of each of these states are less than 0.05 and the R-square value is above 85% which means our model is sufficiently accurate.

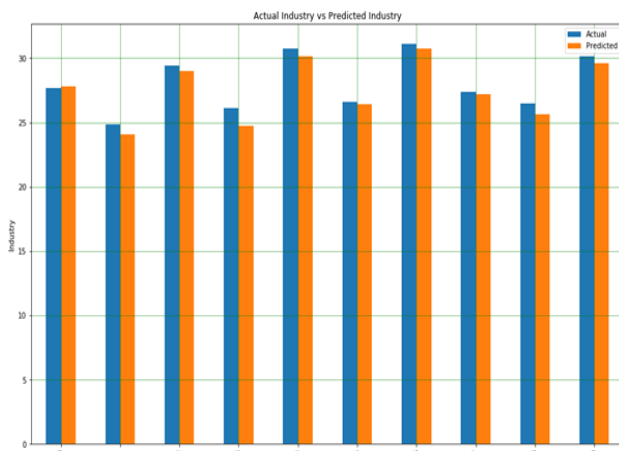


Fig. 3 Industry - Actual vs Predicted Values.

Table 6 Summary Table of the Nine States.

STATE	R-square	p value
Maharashtra	0.8638	1.22604E-05
Tamil Nadu	0.9927	5.15430E-12
Uttar Pradesh	0.9905	1.87534E-11
Gujarat	0.9916	1.03897E-11
West Bengal	0.9852	1.75085E-10
Rajasthan	0.9978	1.28782E-14
Andhra Pradesh	0.9780	1.28365E-09
Telangana	0.9812	5.80977E-10
Madhya Pradesh	0.9947	1.01381E-12

The equation of regression is as follows:

$$Y = M * X + C$$

Where Y - Dependent Variable (state GDP)
X - Independent Variable (Indian GDP)
C - Intercept
M - Slope or gradient of independent Variable

The slope and intercept of all the nine states is as follows:

Table 7 Slope and Intercept of the Nine States.

STATE	Coefficient [C]	Slope [M]
Maharashtra	254202.3413	0.110065869
Tamil Nadu	-171816.6456	0.096282159
Uttar Pradesh	-64788.4508	0.086468224
Gujarat	-165123.3420	0.087857488
West Bengal	-8263.2598	0.061762909
Rajasthan	-63181.8526	0.052881943
Andhra Pradesh	-110956.1204	0.054505871
Telangana	-157086.8025	0.053183526
Madhya Pradesh	-96907.1996	0.048108661

Thus, with the help of the above regression equation, the GDP of the above nine states were predicted.

V. RESULTS

Section 1: Predicting GDP of India based on Factors Affected by COVID-19

The GDP of India for the years 2020, 2021, 2022, 2023 and 2024 was predicted by the multiple regression model. They are as shown in the table below:

Table 8 Prediction Table of Indian GDP.

YEAR	GDP
2020	\$ 6,875,075.51
2021	\$ 3,068,452.92
2022	\$ 9,947,580.99
2023	\$ 12,161,060.51
2024	\$ 12,473,720.26

The graph of Indian GDP versus year was constructed with the help of statistical tools in the Excel sheet. It is as shown below:

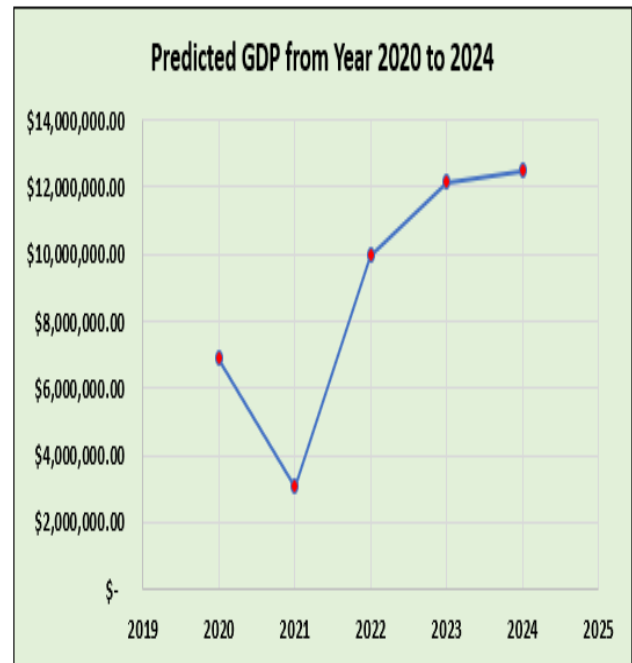


Fig. 5 Predicted Indian GDP from 2020 to 2024.

From the above graph, it can be seen that the GDP of India will reach its lowest point in the year 2021. The main reason for the decline in GDP is due to the global pandemic. However, it will start rising after year 2021 till year 2024. The curve will be an upward curve after the year 2021.

Section 2: Predicting Sector - Wise Contribution to GDP of India

The table below shows the individual contribution of the three sectors - Agriculture, Industry and Services to the Indian GDP for the years 2020, 2021, 2022, 2023 and 2024.

Table 9 Prediction Tables of Agriculture, Industry and Services Sector.

Agriculture

YEAR	PERCENTAGE
2020	16.9540
2021	17.1670
2022	16.7820
2023	16.6580
2024	16.6400

Industry

YEAR	PERCENTAGE
2020	30.6570
2021	32.2870
2022	29.3410
2023	28.3930
2024	28.2590

Services

YEAR	PERCENTAGE
2020	45.6140
2021	44.5650
2022	46.4610
2023	47.0710
2024	47.1580

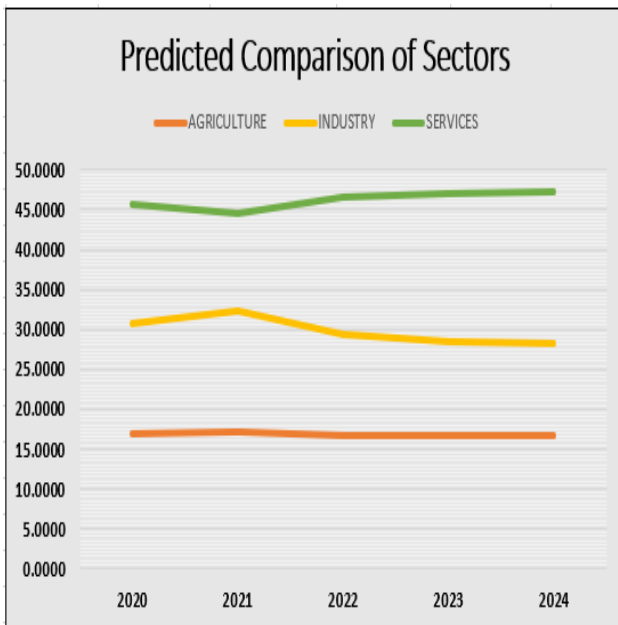


Fig. 6 Predicted Comparison of Sectors.

The graph shown above is a comparison between the three sectors - agriculture, industry and services for the coming years. We can see that the agriculture sector will contribute lowest to the GDP of India. It is going to follow a downward trend over the coming years. The services sector will contribute highest to the Indian GDP. After year 2020, it is slightly going to decline till year 2021. Post year 2021, there is going to be an increase in the contribution of the service sector to Indian GDP. As opposed to the service sector, the contribution of the industry sector to Indian GDP will first rise till the year 2021 and after year 2021 there is going to be a decline in its contribution.

Section 3: Predicting Gross State Domestic Product (GSDP) based on GDP of India

This section shows the predicted GDP of the nine states - Maharashtra, Tamil Nadu, Uttar Pradesh, Gujarat, West Bengal, Rajasthan, Andhra Pradesh, Telangana and Madhya Pradesh. These nine states were particularly chosen because their GDP has highly contributed to the GDP of India. The table below represents the State GDP of these nine states from year 2020 to year 2024:

Table 10 Prediction Table of GDP of Nine States.

STATE	2020	2021	2022	2023	2024
Maharashtra	\$ 1,010,913.50	\$591,934.28	\$ 1,349,091.49	\$ 1,592,720.03	\$ 1,627,133.20
Tamil Nadu	\$ 490,130.47	\$123,620.63	\$ 785,957.93	\$ 999,076.52	\$ 1,029,180.07
Uttar Pradesh	\$ 529,687.12	\$200,535.22	\$ 795,361.21	\$ 986,756.85	\$ 1,013,791.99
Gujarat	\$ 438,903.52	\$104,463.22	\$ 708,846.14	\$ 903,316.89	\$ 930,786.39
West Bengal	\$ 416,361.40	\$181,253.32	\$ 606,128.28	\$ 742,839.22	\$ 762,149.99
Rajasthan	\$ 300,385.50	\$ 99,083.90	\$ 462,865.55	\$ 579,918.65	\$ 596,452.71
Andhra Pradesh	\$ 263,775.86	\$ 56,292.58	\$ 431,245.45	\$ 551,893.07	\$ 568,934.87
Telangana	\$ 208,553.95	\$ 6,104.34	\$ 371,960.63	\$ 489,681.27	\$ 506,309.62
Madhya Pradesh	\$ 233,843.48	\$ 50,711.96	\$ 381,657.61	\$ 488,145.14	\$ 503,186.78

The maps shown below will give a clear idea about the state GDP contributing to the Indian GDP from year 2020 to year 2024.

Year 2020

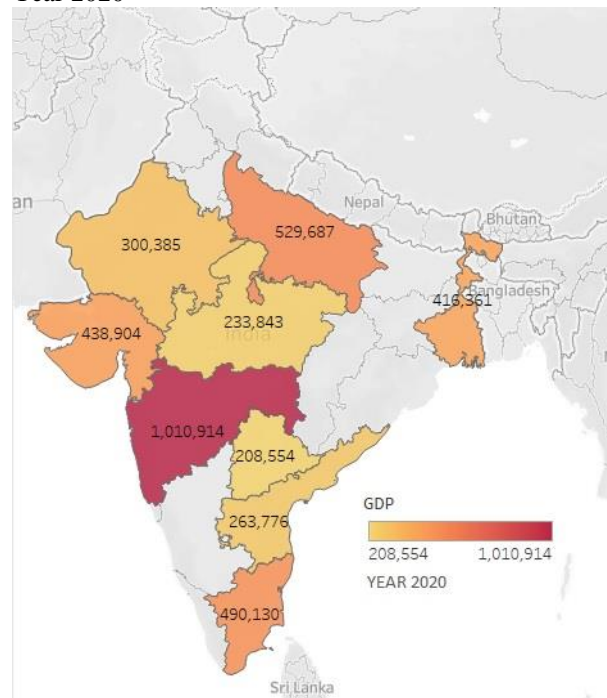


Fig. 7 Predicted State-Wise GDP in 2020.

Year 2021

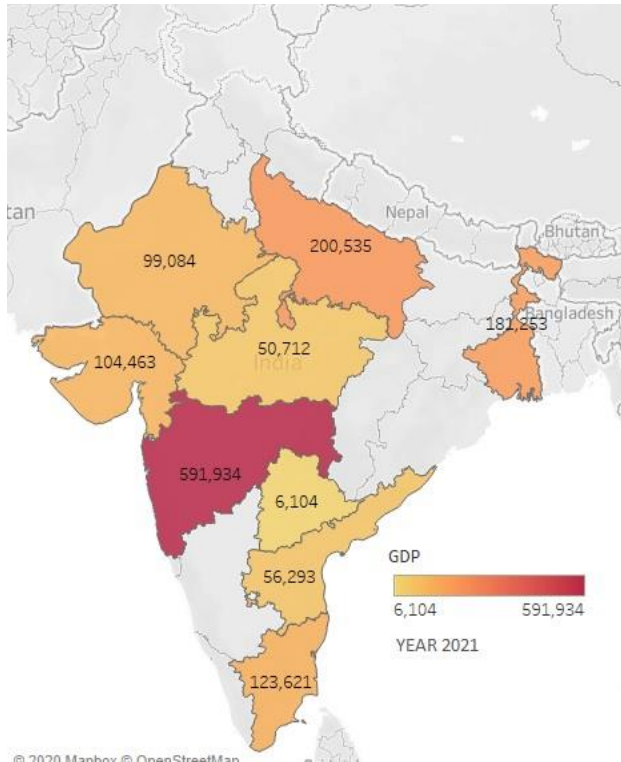


Fig. 8 Predicted State-Wise GDP in 2021.

Year 2022

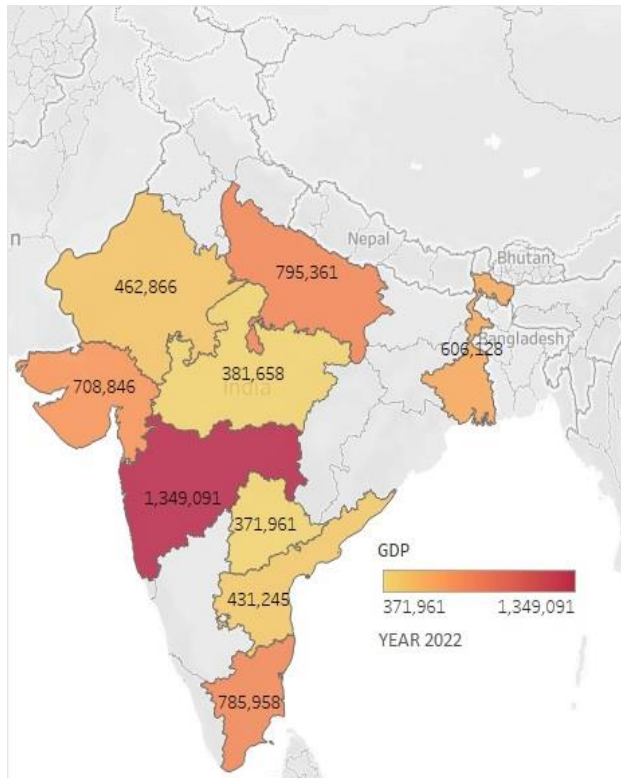


Fig. 9 Predicted State-Wise GDP in 2022.

Year 2023

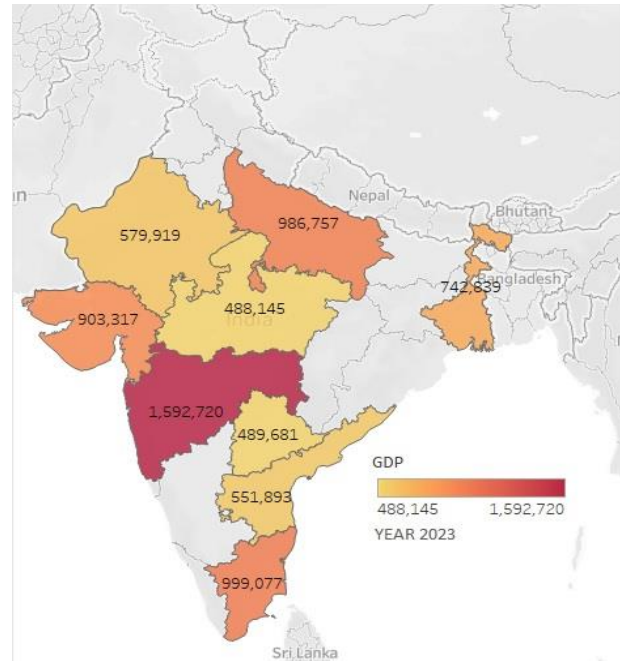


Fig. 10 Predicted State-Wise GDP in 2023.

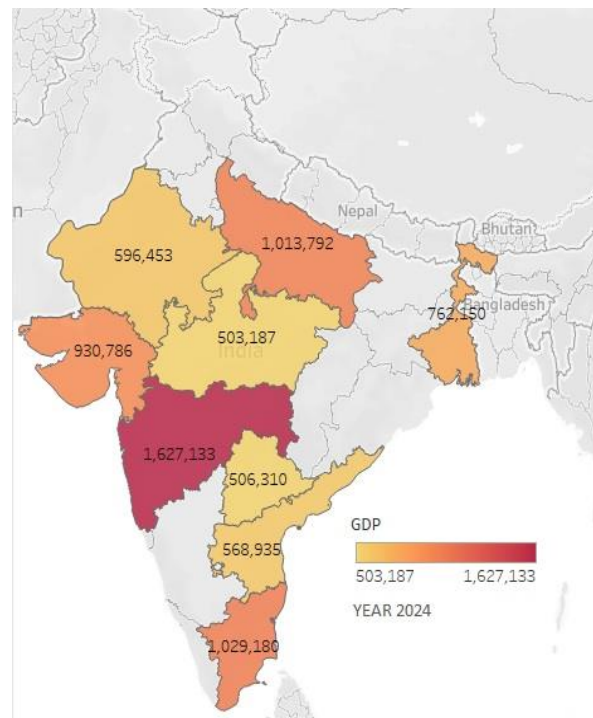


Fig. 11 Predicted State-Wise GDP in 2024.

All the nine states in the 5 maps shown above have been shaded with different colour schemes. The darker the shade, the higher the GDP of that state. In all the 5 maps, it can be seen that Maharashtra has the darkest shade. Hence, it will have the highest state GSDP in the coming years. Similarly, the state with the lightest shading will

have the lowest GSDP for that year. The graph below shows a comparison of all the predicted values of state-wise GDPs over the years 2020 to 2024.

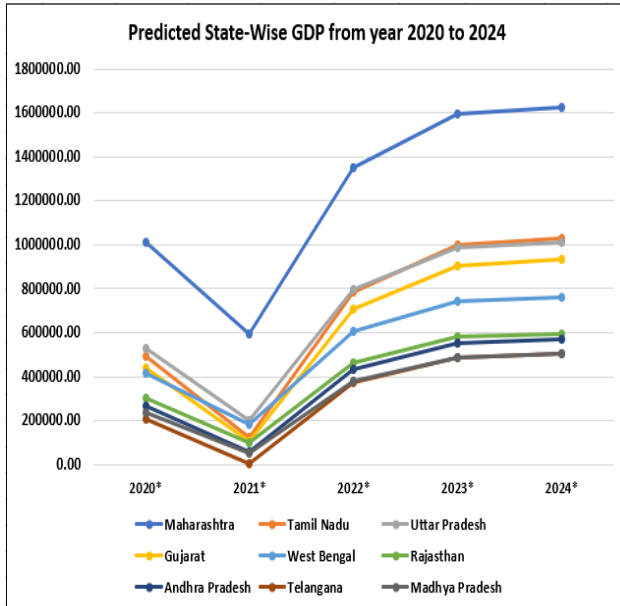


Fig. 12 Comparison of Predicted State-Wise GDP from Year 2020 to 2024.

It can be observed that the state of Maharashtra will show a consistently higher GSDP value than the other eight states. Likewise, the state of Andhra Pradesh will have the lowest GSDP value among all states.

VI. CONCLUSION

The worldwide pandemic of COVID-19 has caused massive disruptions in all processes all over the world. In times of such a crisis, it is the developing countries that suffer the most. India being one of the leading developing countries with the second highest population in the world is enduring losses not only economically, but also in terms of human health. Controlling the spread of coronavirus has been extremely difficult in India due to the large population.

In such difficult times, the undesirable impacts of nationwide lockdowns on the economy are inevitable. Unemployment Rate in the country is steadily increasing, with a decline in Gross Domestic Product (GDP). Subsequent decline in the GDP of various states in India is also inevitable. Maharashtra, the state with the highest Gross State Domestic Product (GSDP), has reported the highest number of COVID-19 cases. Agriculture sector is single handedly responsible for the largest contribution to India's GDP. With a large portion of Indian population engaged in farming, WHO has predicted this sector to be hit with the effects of the virus in the near future.

Based on the analysis using a multiple regression model, a general downward trend was observed up to 2021, after which there would be slight improvement each year. The year with the lowest GDP was 2020. This result was as expected, since the pandemic itself has started in 2020. From our analysis, we concluded that the GDP shows a decline in value with an increase in Unemployment Rate and decrease in Population Rate (Ages 15 to 64).

Further, after using a linear regression model to predict the trend of each of the three sectors of Indian GDP – Agriculture, Industry and Services, it was observed that the Agriculture sector is expected to follow a declining trend after the year 2021, with a decline from 2019 to 2020 and an increase in 2021. These results concur with the statement from WHO regarding the trend of Agriculture in developing countries. The Industry sector follows the same trend as Agriculture. As opposed to the other two, the Services sector shows an upward (increasing) trend from 2021, after a drop in 2020.

After analyzing the GDP and its sectors in detail, we used a linear regression model to predict the trend of Gross State Domestic Product (GSDP) of the nine states. Based on the analysis it was observed that, parallel to India's GDP, the GSDP showed an upward (increasing) trend after 2021. From 2020 to 2021, a decreasing trend was observed. Thus, we were able to conclude that the trend of GSDP would be analogous to that of India's GDP.

Considering the current state of affairs, this data will give the readers and decision makers a comprehensive idea about the trend that the GDP will follow based on the ups and downs in these factors of Unemployment and Working Population. Along with the complete GDP, observing the trend of the three sectors of GDP is also equally important as it will help policy makers and investors decide which sectors require immediate aid so as to attempt to maintain some stability among them. Based on the trend observed in the national GDP, it is also advisable to observe the trends of GSDP of the nine states which have massive contributions to Indian GDP, as any improvement in them is sure to consequently boost India's GDP as well.

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