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Short-Run vs Long-Run Impact of COVID-19 on India's GDP

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Abstract: *The COVID-19 pandemic caused a profound disruption to India's economic growth, with sharply contrasting short-run and long-run effects on Gross Domestic Product (GDP). In the short run (2020–2021), stringent lockdowns, supply chain disruptions, and demand contraction led to one of the deepest recessions in India's history. Economic activity declined across major sectors-specially manufacturing, services, and informal enterprises-resulting in a historic GDP contraction and widespread unemployment. Studies indicate that lockdown-induced output losses, halted production, and reduced consumption significantly depressed GDP growth, with forecasts suggesting continued slowdown through 2022.*

In contrast, the long run (post-2021 recovery phase) reflects a gradual but uneven economic rebound. Government fiscal stimulus, monetary easing, and structural reforms supported recovery in investment, exports, and domestic demand. Over time, GDP growth regained momentum, driven by digitalization, resilience in agriculture, and expansion in services and manufacturing. However, the pandemic also exposed structural weaknesses—such as the vulnerability of the informal sector, rising inequality, and labour market scarring—which may constrain long-term growth potential.

Overall, while COVID-19 caused a severe short-term contraction in India's GDP, its long-term impact is mixed, characterized by recovery alongside persistent structural challenges. The pandemic has accelerated economic transformation but also highlighted the need for inclusive and resilient growth strategies..

Keywords: COVID-19, India, GDP, Short-run impact, Long-run impact, Service Sector, Economic growth, Industrial Sector, Economic recovery, Agriculture Sector.

I. INTRODUCTION

The outbreak of the COVID-19 pandemic in early 2020 marked one of the most significant global economic disruptions since the Great Depression. Originating as a public health crisis, the pandemic quickly evolved into an economic shock of unprecedented scale, affecting both developed and developing economies. India, as one of the world's largest and fastest-growing emerging economies, experienced substantial economic turbulence during this period. The spread of the virus and the subsequent containment measures, including nationwide lockdowns, travel restrictions, and social distancing norms, had a profound impact on the country's economic structure and growth trajectory. This paper aims to examine the short-run and long-run impacts of COVID-19 on India's Gross Domestic Product (GDP), highlighting the nature, extent, and implications of the economic disruption and recovery.

In the short run, the Indian economy faced an abrupt halt in economic activity due to the stringent lockdown imposed in March 2020. The lockdown, although necessary to control the spread of the virus, resulted in the suspension of production, disruption of supply chains, and a sharp decline in consumption demand. Industries such as manufacturing, construction, tourism, hospitality, and transportation were among the hardest hit, experiencing significant declines in output and employment. The informal sector, which constitutes a large portion of India's workforce, was particularly vulnerable due to its lack of social security and financial resilience. Millions of migrant workers lost their jobs and livelihoods, leading to reverse migration and further economic distress. As a result, India witnessed a historic contraction in GDP during the financial year 2020–21, reflecting the severity of the economic shock.

The short-run impact of COVID-19 on India's GDP was characterized not only by reduced output but also by heightened uncertainty and financial instability. Investment activity declined sharply as businesses postponed expansion plans and faced liquidity constraints. Consumer confidence weakened due to income losses and job insecurity, leading to reduced spending on non-essential goods and services. Financial markets also experienced volatility, although timely interventions by the Reserve Bank of India (RBI) and the Government of India helped stabilize the situation to some extent. Policy measures such as monetary easing, fiscal stimulus packages, and relief programs were introduced to mitigate the immediate economic impact and support vulnerable sections of society.

While the short-run effects were predominantly negative, the long-run impact of COVID-19 on India's GDP presents a more complex and nuanced picture. As the country gradually eased restrictions and adapted to the "new normal," economic activity began to recover. The resilience of certain sectors, particularly agriculture, played a crucial role in supporting the economy during the recovery phase. Additionally, the pandemic accelerated structural changes in the economy, most notably the rapid adoption of digital technologies. Sectors such as e-commerce, information technology, digital payments, and online education experienced significant growth, contributing to the revival of economic activity and opening new avenues for development.

Government initiatives such as the Atamnirbhar Bharat (self-reliant India) campaign further aimed to strengthen domestic production, reduce dependency on imports, and promote long-term economic sustainability. Reforms in areas such as labour laws, agriculture, and industrial policy were introduced to enhance productivity and attract investment. These measures, combined with global economic recovery and increased vaccination coverage, have contributed to a gradual improvement in GDP growth rates in the post-pandemic period.

However, despite signs of recovery, the long-run impact of COVID-19 also raises concerns about structural challenges that may hinder sustained economic growth. One of the most significant issues is the widening income and wealth inequality, as the pandemic disproportionately affected low-income groups and informal workers. The disruption in education and skill development has also had long-term implications for human capital formation, potentially affecting productivity and future growth prospects. Furthermore, the labour market continues to face challenges, including underemployment and a slow recovery in job creation.

Another important aspect of the long-run impact is the shift in global economic dynamics. The pandemic exposed vulnerabilities in global supply chains, prompting countries, including India, to reconsider their trade and production strategies. While this presents opportunities for India to position itself as a global manufacturing hub, it also requires substantial investment in infrastructure, technology, and human resources.

In conclusion, the COVID-19 pandemic has had a dual impact on India's GDP, with severe short-run contraction followed by a gradual and uneven long-run recovery. The crisis not only disrupted economic activity but also accelerated structural transformations that may shape the future trajectory of the Indian economy. Understanding the differences between short-run and long-run impacts is essential for designing effective policy responses and ensuring sustainable and inclusive economic growth. This study seeks to provide a comprehensive analysis of these dynamics, contributing to a deeper understanding of the economic consequences of the pandemic in the Indian context.

Main objectives of research paper are:

To analyse the short-run impact of COVID-19 on India's GDP

This includes examining the immediate economic effects such as GDP contraction, decline in industrial output, unemployment, and disruption in supply chains during the lockdown period.

To evaluate the long-run impact of COVID-19 on India's GDP

The study aims to assess the recovery trends, structural changes, and long-term growth patterns in the post-pandemic period.

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To examine sector-wise effects on the Indian economy
This involves analysing how key sectors like agriculture, manufacturing, services, and the informal sector were affected in both the short and long run.

To assess the effectiveness of government policy responses
The research evaluates fiscal stimulus measures, monetary policies, and reforms introduced to mitigate the economic impact of the pandemic.

To identify structural challenges and opportunities emerging from the pandemic
This includes studying issues such as inequality, labour market disruptions, digital transformation, and changes in global supply chains.

To compare pre-pandemic and post-pandemic GDP trends
The objective is to understand the extent of economic disruption and the pace of recovery.

To suggest policy recommendations for sustainable economic growth
Based on the findings, the study aims to propose measures to strengthen economic resilience and ensure inclusive development in the long run.

II. RESEARCH METHODOLOGY

This section outlines the methods and procedures used to analyse the short-run and long-run impact of COVID-19 on India's Gross Domestic Product (GDP). The study adopts a systematic and analytical approach based on secondary data.

1. Research Design

The research is **descriptive and analytical in nature**. It focuses on examining economic trends before, during, and after the COVID-19 pandemic to understand both short-term disruptions and long-term recovery patterns in India's GDP.

2. Nature and Sources of Data

The study is based entirely on **secondary data**, collected from reliable and authentic sources, including:

- Government of India publications (Economic Survey, Ministry of Statistics and Programme Implementation)
- Reserve Bank of India (RBI) reports and bulletins
- World Bank and International Monetary Fund (IMF) databases
- Research journals, articles, and working papers
- Reports from NITI Aayog and other policy institutions

The data covers the period from **2018 to 2021**, allowing comparison between pre-pandemic, pandemic, and post-pandemic phases.

3. Data Collection Method

Data has been collected through **document analysis**, which involves reviewing published reports, statistical databases, and academic literature. Relevant GDP data, sectoral outputs, employment trends, and policy measures were extracted and compiled for analysis.

III. LITERATURE REVIEW

The economic research on COVID-19's impact on India's GDP spans a range of studies that analyse both short-run shocks and long-run trends, offering a diverse set of perspectives from different authors and methodologies.

Ramkumar and Kanitkar (2021) examine how India's economic slowdown prior to the pandemic was worsened by COVID-19, emphasizing that GDP contraction was deepened by pre-existing weaknesses such as rising unemployment and stagnant growth. Their work highlights the substantial short-run disruptions across sectors following the lockdown, particularly in agriculture, manufacturing, and services.

Kumra, A. (2020) investigates early pandemic impacts on macroeconomic variables, including GDP, showing that the nationwide lockdown led to significant output losses and higher unemployment. The study also discusses policy responses by the Government of India and the Reserve Bank aimed at mitigating short term economic decline.

Sharada Narayanappa et al. (2022) provide a broader overview of the economic effects of COVID-19 across sectors, underscoring the pandemic's immediate impact on GDP growth, consumption, and investment patterns. Their work stresses the role of containment measures in reducing economic activity.

Chitranjan Kumar Maurya and Pooja Tarun (listed in an analysis of pandemic impacts) examine how macroeconomic variables such as exports, FDI, inflation, and unemployment relate to GDP growth during 2020–2021, suggesting that some long-run adjustments (such as trade performance) can have sustained effects on GDP trajectory.

Kumar Bijoy and Shaurya Shivam (2021) review the monetary policy responses by the Reserve Bank of India, analysing how liquidity measures and regulatory actions were designed to cushion both short-run disruptions and support sustained recovery. Their critique illustrates how policy choices themselves influence longer-run GDP outcomes.

While research on COVID-19's economic impact in India has expanded rapidly, the above gaps reveal important areas where further study is needed. Addressing these gaps would provide more nuanced insights into how short-run shocks evolve into long-term economic trajectories and help policymakers design effective strategies for inclusive and sustainable growth.

Research Gap

The review of existing studies on the impact of the COVID-19 pandemic on India's GDP reveals that, while substantial research has been conducted, several critical gaps remain unaddressed. Most studies have primarily focused on the immediate economic contraction during 2020–2021, often overlooking the pre-pandemic slowdown and the long-term structural effects on the economy beyond 2022.

Furthermore, the heavy reliance on aggregate GDP data has limited a deeper understanding of sectoral differences, particularly the contrasting performance of agriculture, industry, and services. The informal sector, which constitutes a significant portion of India's economy, remains underrepresented in GDP estimations, leading to an incomplete assessment of the actual economic impact.

In addition, regional disparities and variations across states have not been sufficiently explored, and there is a lack of comprehensive evaluation of government policy measures in supporting economic recovery. Many studies also fail to integrate GDP analysis with broader socio-economic indicators such as employment, poverty, and inequality.

Therefore, future research should adopt a more holistic and data-driven approach by incorporating long-term perspectives, sector-wise and region-wise analysis, informal sector dynamics, and policy effectiveness. Addressing these gaps will provide a more accurate and comprehensive understanding of the true impact of COVID-19 on India's GDP.

Impact of COVID-19 on Agriculture Sector in India

The outbreak of the COVID-19 in late 2019 and its rapid spread across the globe created unprecedented challenges for all sectors of the economy. In India, the nationwide lockdown imposed in March 2020 to control the spread of the virus had significant economic consequences. However, the agriculture sector, which plays a crucial role in ensuring food security and providing employment to a large portion of the population, showed remarkable resilience during this period. Between 2018 and 2021, the Indian agriculture sector experienced varying growth trends. While the pre-pandemic years (2018–19 and 2019–20) reflected normal economic fluctuations, the pandemic year (2020–21) brought both challenges and opportunities. Disruptions in supply chains, labour shortages due to migration restrictions, and difficulties in accessing markets affected farmers across the country. At the same time, timely government interventions, favourable monsoon conditions, and the essential nature of agricultural activities helped the sector maintain positive growth when most other sectors of the economy contracted.

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Thus, the period from 2018 to 2021 provides an important case study to understand the impact of COVID-19 on India's agriculture sector, highlighting both its vulnerabilities and its strength as a backbone of the Indian economy.

Table-1, Growth Rate of Agriculture & Allied Sectors (GVA)

Year	Growth Rate (%)	Situation / Impact
2018–19	2.6%	Pre-COVID slowdown; low rural demand
2019–20	4.3%	Slight recovery before pandemic
2020–21	3.4%	COVID year – sector remained resilient despite lockdown
2021–22*	3.6% – 3.9%	Post-COVID recovery supported by policies & good monsoon

**2021–22 included for continuity (post-pandemic effect)*

Source: Ministry of Statistics and Programme Implementation (MOSPI), Economic Survey of India 2021–22

1. Percentage Change Calculation

Formula:

$$\text{Percentage Change} = \frac{\text{New Value - Old Value}}{\text{Old Value}} \times 100$$

Change from 2018–19 to 2019–20

$$= \frac{4.3 - 2.6}{2.6} \times 100 = \frac{1.7}{2.6} \times 100 = 65.38\%$$

Interpretation: Strong growth before COVID

(b) Change from 2019–20 to 2020–21 (COVID Impact)

$$= \frac{3.4 - 4.3}{4.3} \times 100 = \frac{-0.9}{4.3} \times 100 = -20.93\%$$

Interpretation: Growth declined due to COVID

2. Average Growth Rate (2018–2021)

Formula:

$$\text{Average} = \frac{\text{Sum of all values}}{\text{Number of years}}$$

$$= \frac{2.6 + 4.3 + 3.4}{3} = \frac{10.3}{3} = 3.43\%$$

Interpretation: Moderate overall growth

3. Standard Deviation (Variation)

Formula:

$$\sigma = \sqrt{\frac{\sum(x - \bar{x})^2}{n}}$$

Mean = 3.43

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Year	Value (x)	(x − Mean)	(x − Mean)²
2018–19	2.6	–0.83	0.69
2019–20	4.3	0.87	0.76
2020–21	3.4	–0.03	0.001

$$\sigma = \sqrt{\frac{0.69 + 0.76 + 0.001}{3}} = \sqrt{0.483} = 0.69$$

Interpretation: Low fluctuation → agriculture is stable even during COVID

Table-2, Additional COVID-Specific Impacts (2020–21)

Indicator	Data / Observation
Agricultural GDP growth	Increased from 2.4% (2019) to 4% (2020)
Farmers unable to harvest	37% farmers affected
Farmers forced to sell at low prices	37%
Unable to sell produce	15%
Overall economy growth	–7.2%, but agriculture stayed positive

Source: Research studies & surveys

The mathematical analysis of the agriculture sector during the COVID-19 period (2018–2021) shows that the sector remained relatively stable despite the economic disruptions caused by the pandemic. The growth rate increased significantly by **65.38%** from 2018–19 to 2019–20, indicating a strong pre-pandemic performance. However, during the COVID-19 year (2020–21), the growth rate declined by **20.93%**, reflecting the negative impact of lockdowns, supply chain disruptions, and labour shortages.

Despite this decline, the sector maintained a **positive growth rate of 3.4%**, unlike many other sectors that experienced negative growth. The **average growth rate of 3.43%** over the three years indicates moderate and consistent performance. Furthermore, the **low standard deviation of 0.69** highlights minimal fluctuation, proving that agriculture was one of the most stable sectors during the pandemic.

Overall, the mathematical calculations demonstrate that while COVID-19 had a negative impact on agriculture, the sector showed strong resilience and played a crucial role in supporting the Indian economy during a period of crisis.

Impact of COVID-19 on Industrial Sector in India

The outbreak of the COVID-19 pandemic had a severe impact on the industrial sector in India, which is a major contributor to the country's GDP and employment. The nationwide lockdown imposed in March 2020 led to the closure of factories, disruption of supply chains, shortage of labour, and a sharp decline in production and demand.

During the period 2018–2021, the industrial sector already showed signs of slowdown before the pandemic, but COVID-19 significantly worsened the situation. Unlike agriculture, the industrial sector experienced a steep contraction during 2020–21 due to halted economic activities. However, with the gradual reopening of the economy and government stimulus measures, the sector began recovering in 2021.

Thus, analysing the industrial sector through mathematical calculations helps in understanding the extent of decline and recovery during the COVID-19 period.

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Table-3, Growth Rate of Industry (GVA – %)

Year	Year	Situation
2018–19	5.5%	Stable industrial growth
2019–20	0.8%	Pre-COVID slowdown
2020–21	–7.0%	Severe contraction due to COVID lockdown
2021–22*	11.8%	Strong recovery (base effect)

**2021–22 included for continuity (post-pandemic effect)*

Source: Ministry of Statistics and Programme Implementation (MOSPI), Economic Survey of India 2021–22

1. Percentage Change Formula

$$\text{Percentage Change} = \frac{\text{New Value - Old Value}}{\text{Old Value}} \times 100$$

(a) Change from 2018–19 to 2019–20

$$= \frac{0.8 - 5.5}{5.5} \times 100 = \frac{-4.7}{5.5} \times 100 = -85.45\%$$

Interpretation: Sharp slowdown before COVID

(b) Change from 2019–20 to 2020–21 (COVID Impact)

$$= \frac{-7.0 - 0.8}{0.8} \times 100 = \frac{-7.8}{0.8} \times 100 = -975\%$$

Interpretation: Extreme contraction due to COVID

2. Average Growth Rate

$$= \frac{5.5 + 0.8 + (-7.0)}{3} = \frac{-0.7}{3} = -0.23\%$$

Interpretation: Overall negative growth during the period

3. Standard Deviation (Volatility)

Mean = –0.23

Year	Value (x)	(x − Mean)	(x − Mean)²
2018–19	5.5	5.73	32.83
2019–20	0.8	1.03	1.06
2020–21	–7.0	–6.77	45.83

$$\sigma = \sqrt{\frac{32.83 + 1.06 + 45.83}{3}} = \sqrt{26.57} = 5.15$$

Interpretation: High fluctuation → industrial sector is highly unstable

The mathematical analysis of the industrial sector in India during 2018–2021 highlights the severe impact of COVID-19 on industrial growth and stability. The sector's growth rate declined sharply from **5.5% in 2018–19 to 0.8% in 2019–20**, a **decrease of 85.45%**, indicating a slowdown even before the pandemic. During the COVID-19 year, 2020–21, the growth rate fell further to **–7.0%**, representing a **–975% change** compared to the previous year. This extreme

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contraction reflects the effects of nationwide lockdowns, supply chain disruptions, labour shortages, and reduced industrial production.

The **average growth rate over the three-year period was –0.23%**, showing that the sector's overall performance was slightly negative. The **standard deviation of 5.15** indicates high volatility, confirming that the industrial sector was highly unstable and vulnerable to external shocks like the pandemic. Compared to agriculture, which maintained moderate positive growth, industry was more sensitive to disruptions.

In conclusion, mathematical calculations demonstrate that COVID-19 caused **massive contraction and high fluctuations** in the industrial sector. The data highlights the sector's **fragility** during crises and underscores the importance of government support, stimulus measures, and supply chain stabilization to restore industrial growth and ensure economic resilience.

Impact of COVID-19 on Service Sector in India

The services sector is a key driver of India's economy, contributing nearly 55–60% of the country's GDP and providing employment to millions of people. It encompasses diverse industries such as trade, transport, communication, finance, real estate, tourism, education, healthcare, and information technology.

The outbreak of the COVID-19 in early 2020, followed by nationwide lockdowns and social distancing measures, created unprecedented disruptions in the services sector. Activities such as tourism, hospitality, retail, and transport were directly affected, while financial services, education, and IT faced indirect challenges due to remote work and reduced economic activity.

During the period 2018–2021, the services sector witnessed fluctuations in growth. Pre-pandemic years (2018–19 and 2019–20) showed steady growth, while 2020–21 saw a sharp contraction due to restrictions, labour shortages, and disrupted supply chains. The pandemic highlighted the vulnerability of service-oriented industries that rely heavily on human interaction and mobility.

Studying the sector through data analysis and mathematical calculations helps quantify the extent of decline, recovery patterns, and resilience, providing insights into policy measures needed to support this critical sector during crises.

Table-4, Growth Rate of Services (GVA %)

Year	Growth Rate (%)	Situation
2018–19	7.6	Stable growth pre-pandemic
2019–20	6.1	Slight slowdown before COVID
2020–21	–8.0	Severe contraction due to COVID-19 lockdown
2021–22*	9.1	Recovery due to reopening and digital adaptation

2021–22 included to show recovery trend

Source: Ministry of Statistics and Programme Implementation (MOSPI), Economic Survey of India 2021–22

1. Percentage Change Calculations

Formula:

$$\text{Percentage Change} = \frac{\text{New Value - Old Value}}{\text{Old Value}} \times 100$$

(a) Change from 2018–19 to 2019–20

$$= \frac{6.1 - 7.6}{7.6} \times 100 = \frac{-1.5}{7.6} \times 100 = -19.74\%$$

Interpretation: Slight slowdown before COVID-19.

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(b) Change from 2019–20 to 2020–21 (COVID Impact)

$$= \frac{-8.0 - 6.1}{6.1} \times 100 = \frac{-14.1}{6.1} \times 100 = -231.15\%$$

Interpretation: Severe contraction due to COVID-19 lockdowns, reduced mobility, and disruptions in services like tourism, hospitality, and transport.

2. Average Growth Rate (2018–2021)

$$\text{Average} = \frac{7.6 + 6.1 + (-8.0)}{3} = \frac{5.7}{3} = 1.90\%$$

Interpretation: Despite a sharp drop in 2020–21, the average growth remained positive due to strong pre-pandemic performance.

3. Standard Deviation (Volatility)

Mean = 1.90

Year	Value (x)	(x − Mean)	(x − Mean)²
2018–19	7.6	5.7	32.49
2019–20	6.1	4.2	17.64
2020–21	–8.0	–9.9	98.01

$$\sigma = \sqrt{\frac{32.49 + 17.64 + 98.01}{3}} = \sqrt{49.38} = 7.03$$

Interpretation: High standard deviation indicates **significant volatility** in the services sector during COVID-19.

The mathematical analysis of India's services sector during 2018–2021 clearly shows the severe impact of COVID-19. The sector grew steadily before the pandemic, with growth of **7.6% in 2018–19** and **6.1% in 2019–20**, although this represented a **19.74% slowdown** before COVID-19. During the pandemic year 2020–21, the growth rate plunged to **–8.0%**, indicating a **231.15% decline** compared to the previous year. This reflects the effects of nationwide lockdowns, restrictions on mobility, closure of hotels, transport, tourism, and reduced business activity in financial and professional services.

The **average growth rate over the three years was 1.90%**, showing that pre-pandemic growth partially offset the pandemic-induced contraction. However, the **high standard deviation of 7.03** highlights extreme volatility, confirming that the services sector was highly vulnerable to external shocks like COVID-19.

In conclusion, mathematical calculations show that the services sector experienced **one of the sharpest contractions among all sectors**, with significant fluctuations. While some sub-sectors like education and IT were relatively resilient, the overall sector's instability underscores the need for targeted policy support, digital adoption, and recovery strategies to enhance resilience against future crises.

Impact of COVID-19 on India's GDP

Gross Domestic Product (GDP) is the **most important indicator of a country's economic performance**, representing the total value of goods and services produced within a country. India, as one of the fastest-growing major economies, experienced steady GDP growth during 2018–19 and 2019–20. However, the outbreak of the COVID-19 in early 2020 severely disrupted economic activity across all sectors.

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The nationwide lockdowns, travel restrictions, and social distancing measures led to a sudden **halt in industrial production, trade, transport, and services**, causing demand and supply shocks. Agriculture showed relative resilience, but other sectors like industry and services faced steep contractions. As a result, India experienced its first **negative GDP growth in decades** in 2020–21.

Analysing GDP trends during 2018–2022 provides insights into the magnitude of the pandemic's economic impact, sectoral disparities, and the pace of recovery. Mathematical calculations of percentage change, average growth, and volatility help quantify the severity of the decline and subsequent rebound. Understanding these patterns is critical for policymakers to design effective stimulus measures, ensure economic stability, and strengthen resilience against future crises.

Table-5 India's GDP Growth Rate (%)

Year	GDP Growth Rate (%)	Situation
2018–19	6.4	Stable growth pre-COVID
2019–20	3.9	Pre-COVID slowdown
2020–21	–7.3	Severe contraction due to COVID
2021–22*	9.0	Recovery post-lockdown

*2021–22 and 2022–23 included to show recovery trend

Source: Ministry of Statistics and Programme Implementation (MOSPI), RBI Annual Reports, Economic Survey 2021–22

1. Percentage Change Calculations

Formula:

$$\text{Percentage Change} = \frac{\text{New Value - Old Value}}{\text{Old Value}} \times 100$$

(a) Change from 2018–19 → 2019–20

$$= \frac{3.9 - 6.4}{6.4} \times 100 = \frac{-2.5}{6.4} \times 100 = -39.06\%$$

Interpretation: GDP growth slowed before COVID.

(b) Change from 2019–20 → 2020–21 (COVID Impact)

$$= \frac{-7.3 - 3.9}{3.9} \times 100 = \frac{-11.2}{3.9} \times 100 = -287.18\%$$

Interpretation: Extreme contraction due to nationwide lockdown, demand shock, and industrial/service disruption.

(c) Change from 2020–21 → 2021–22 (Recovery)

$$= \frac{9.0 - (-7.3)}{-7.3} \times 100 = \frac{16.3}{-7.3} \times 100 = -223.29\%$$

Interpretation: Strong recovery (base effect), but still reflecting volatility.

2. Average GDP Growth Rate (2018–2021)

$$\text{Average} = \frac{6.4 + 3.9 + (-7.3)}{3} = \frac{3.0}{3} = 1.0\%$$

Interpretation: Overall, India's GDP grew very slowly over this period due to COVID-19.

3. Standard Deviation (Volatility Indicator)

Mean = 1.0

Year	Value (x)	(x − Mean)	(x − Mean)²
2018–19	6.4	5.4	29.16
2019–20	3.9	2.9	8.41
2020–21	–7.3	–8.3	68.89

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$$\sigma = \sqrt{\frac{29.16 + 8.41 + 68.89}{3}} = \sqrt{35.49} = 5.96$$

Interpretation: High standard deviation indicates that India's GDP was highly volatile during the COVID period.

The mathematical analysis of India's GDP during the COVID-19 period (2018–2022) clearly highlights the severe economic impact of the pandemic. GDP growth declined from **6.4% in 2018–19 to 3.9% in 2019–20**, showing a **39.06% decrease**, which indicates that the economy was already slowing before the pandemic. During 2020–21, GDP growth fell sharply to **–7.3%**, representing a **287.18% decline** compared to the previous year. This drastic contraction reflects the effects of nationwide lockdowns, disruption of economic activities, reduced consumption, and halted production across major sectors.

However, in 2021–22, the economy showed strong recovery with a growth rate of around **9.0%**, mainly due to the base effect and reopening of economic activities. The **average GDP growth rate for 2018–2021 was approximately 1.0%**, indicating overall weak performance during the period. Additionally, the **high standard deviation of about 5.96** highlights significant volatility in GDP growth, showing that the economy was highly unstable during the pandemic.

In conclusion, mathematical calculations demonstrate that COVID-19 caused a **sharp contraction followed by an uneven recovery** in India's GDP, emphasizing the need for strong economic policies to ensure long-term stability and resilience.

IV. CONCLUSION

The analysis of the impact of the COVID-19 pandemic on India's GDP reveals a sharp contrast between short-run disruptions and long-run economic adjustments. In the short run, the Indian economy experienced an unprecedented contraction, with GDP declining significantly during 2020–21 due to strict lockdowns, supply chain disruptions, reduced consumption, and widespread job losses. Key sectors such as industry and services were severely affected, leading to a steep fall in overall economic output and increased uncertainty.

In contrast, the long-run impact presents a more complex and evolving picture. The economy demonstrated resilience through a gradual recovery supported by government stimulus measures, digital transformation, and structural reforms. Sectors such as agriculture and information technology played a stabilizing role, while increased digitization, remote working, and policy interventions contributed to rebuilding economic momentum.

The short-run impact of the COVID-19 pandemic on India's GDP was severe and unprecedented. The nationwide lockdown imposed in 2020 led to a sharp contraction in economic activity, resulting in a significant decline in GDP growth. With industries shut down, services disrupted, and demand collapsing, the economy experienced one of its worst downturns in decades.

The immediate effects included reduced production, declining consumption, rising unemployment, and disruptions in both domestic and global supply chains. Sectors such as manufacturing, construction, trade, transport, and tourism were particularly affected, contributing heavily to the overall GDP contraction. Although agriculture showed some resilience, it was not sufficient to offset the losses in other sectors.

Overall, the short-run period was characterized by economic instability, uncertainty, and a sharp fall in output. The pandemic exposed structural weaknesses in the economy, especially the vulnerability of the informal sector. Thus, the short-run impact of COVID-19 on India's GDP highlights the extent of economic disruption caused by sudden external shocks and the need for effective policy measures to stabilize the economy during crises.

The long-run impact of the COVID-19 pandemic on India's GDP reflects both recovery and structural transformation. Following the severe short-term contraction in 2020–21, the economy gradually rebounded due to the easing of lockdowns, government stimulus measures, and revival of domestic and international demand. GDP growth recovered in 2021–22 and stabilized in subsequent periods, demonstrating the resilience of the Indian economy.

In the long run, COVID-19 accelerated key structural changes, including increased digitalization, adoption of remote work, growth in e-commerce, and reforms aimed at economic self-reliance. Sectors such as information technology and digital services showed strong recovery, while traditional industries and informal sectors continued to face challenges. The pandemic also exposed persistent vulnerabilities, such as income inequality, regional disparities, and the need for stronger social safety nets.

Overall, while the long-run impact of COVID-19 involved a partial recovery of GDP, it also prompted structural adjustments that are likely to shape India's economic trajectory in the coming years. The experience highlights the importance of resilient policies, investment in technology and infrastructure, and targeted support for vulnerable sectors to ensure sustainable and inclusive growth.

However, the long-term effects also include challenges such as rising inequality, informal sector distress, and shifts in employment patterns. The recovery has been uneven across sectors and regions, indicating that the pandemic has led to both structural changes and persistent vulnerabilities.

In conclusion, while COVID-19 caused severe short-term economic damage, it also accelerated long-term transformations in India's economy, highlighting the need for sustainable growth strategies and stronger economic resilience in the future.

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