STATISTICAL METHODS

Statistical Analysis of COVID-19 Impact on India's Trade, Regional Trade Agreements, and Commodity-Wise Trade Dynamics

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Abstract

This study investigates the impact of COVID-19 on India's foreign trade with a focus on overall trade dynamics, the role of Regional Trade Agreements (RTAs), and commodity-specific effects. Using trade data from 2018 to 2023, the analysis evaluates resilience (trade performance during the pandemic) and recovery (post-pandemic trade rebound).

Key findings include a strong negative correlation ($r=-0.86$) between COVID-19 cases and trade volumes, with regression analysis showing a decline of $13,713 million in trade for each additional COVID case. A paired t-test confirms a statistically significant decline in trade during the pandemic ($p < 0.05$). However, comparisons between RTA and non-RTA countries revealed no significant differences in trade resilience or recovery ($p > 0.05$), as indicated by confidence intervals and hypothesis testing. Commodity-level analysis using ANOVA ($F = 22.45$, $p < 0.01$) showed essential commodities like pharmaceuticals and agriculture exhibited higher resilience, while non-essentials experienced sharper declines.

The analysis underscores the uneven effects of the pandemic on India's trade landscape, with sector-specific insights and limited RTA impact during the crisis. This study employs descriptive statistics, hypothesis testing, ANOVA, and regression to provide a comprehensive assessment, offering critical insights for future trade policies and strategies to mitigate global disruptions.

Introduction

The COVID-19 pandemic has profoundly disrupted global commerce, significantly altering trade patterns and impacting economies worldwide. Its effects on foreign trade have been widely studied, with reports like UNCTAD (2021) highlighting the pandemic's far-reaching influence on international trade flows. India, as one of the world's largest economies, provides a compelling case for analysis due to the substantial changes observed in its export and import trends during this period. Understanding these changes is critical to identifying vulnerabilities and formulating strategies to enhance resilience in future crises.

The pandemic caused widespread supply chain disruptions, shifts in demand, and global trade restrictions, leading to significant fluctuations in India's trade performance. Additionally, Regional Trade Agreements (RTAs), which aim to foster trade among member countries, were put to the test during this crisis, raising questions about their effectiveness. The pandemic's impact also varied across commodity categories such as pharmaceuticals, agriculture, and electronics, underscoring the importance of sectoral-level analysis.

This study aims to answer the following key questions:

1. How did India's trade (exports and imports) evolve during pre-COVID, COVID, and post-COVID periods?
2. Did India's trade with RTA partners demonstrate greater resilience compared to non-RTA countries?
3. How were different export commodities affected by the pandemic, and which sectors showed the most resilience?

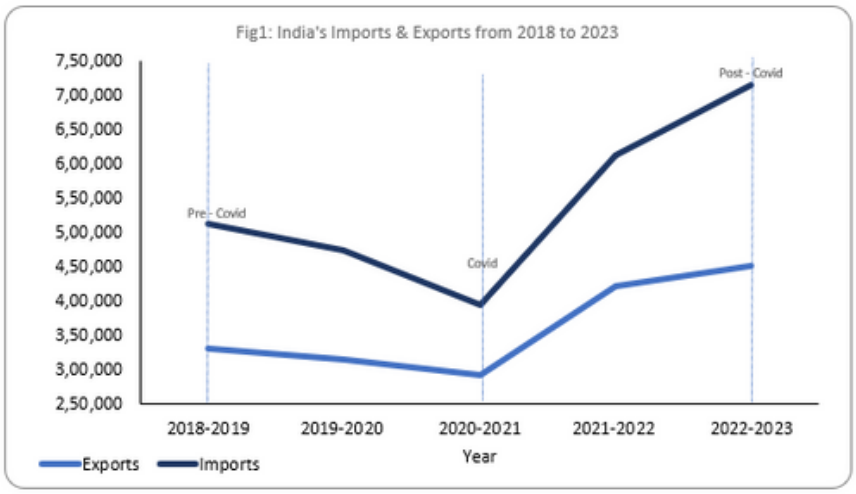
Using trade data from 2018 to 2023, this study employs descriptive and inferential statistical methods to uncover trends and relationships, providing actionable insights for India's trade policy.

Statistical Analysis

1. Did the Covid pandemic have an effect on India's imports and exports?

As per the line chart, it is evident that India's exports and imports saw a decline during Covid period.

Based on cases reported, lockdowns and other restrictions, 2018-2019 is conisdered pre-covid, 2020-2021 is considered covid period, and 2022-2023 is considered post-covid. The periods of 2019-2020 and 2021-2022 are not considered since they were transition periods.



1.1 Descriptive Analysis of the Data

For this analysis, we have used India's country wise export & import data (from the Ministry of Commerce and Industry). The below tables describe the year-wise data in terms of all of it's vital parameters including mean, median, mode, standard deviation etc. It also gives the population mean at 95% confidence interval.

Table 1: Descriptive Analysis of Exports

Pre-Covid	*2018-2019*	*Covid*	*2020-2021*	*Post-Covid*	*2022-2023*
Mean	1,370	Mean	1,211	Mean	1,872
Standard Error	286	Standard Error	262	Standard Error	395
Median	131	Median	114	Median	155
Mode	-	Mode	-	Mode	-
Standard Deviation	4,443	Standard Deviation	4,068	Standard Deviation	6,136
Sample Variance	19,743,781	Sample Variance	16,549,123	Sample Variance	37,647,415
Kurtosis	80	Kurtosis	101	Kurtosis	104
Skewness	8	Skewness	9	Skewness	9
Range	52,406	Range	51,623	Range	78,543
Minimum	-	Minimum	-	Minimum	-
Maximum	52,406	Maximum	51,623	Maximum	78,543
Sum	330,078	Sum	291,809	Sum	451,070
Count	241	Count	241	Count	241
Confidence Level(95.0%)	564	Confidence Level(95.0%)	516	Confidence Level(95.0%)	779

Table 2: Descriptive Analysis of Imports

Pre-Covid	*2018-2019*	*Covid*	*2020-2021*	*Post-Covid*	*2022-2023*
Mean	2,285	Mean	1,715	Mean	3,113
Standard Error	457	Standard Error	380	Standard Error	659
Median	59	Median	39	Median	98
Mode	-	Mode	-	Mode	-
Standard Deviation	6,849	Standard Deviation	5,756	Standard Deviation	10,001
Sample Variance	46,907,981	Sample Variance	33,132,678	Sample Variance	100,025,629
Kurtosis	47	Kurtosis	68	Kurtosis	43
Skewness	6	Skewness	7	Skewness	6
Range	70,320	Range	65,212	Range	98,506
Minimum	-	Minimum	-	Minimum	-
Maximum	70,320	Maximum	65,212	Maximum	98,506
Sum	514,078	Sum	394,436	Sum	715,969
Count	225	Count	230	Count	230
Confidence Level(95.0%)	900	Confidence Level(95.0%)	748	Confidence Level(95.0%)	1,299

1. 2 Correlation of Covid Cases and India's Foreign Trade

To check whether there is any relationship between covid cases and India's foreign trade, we checked the correlation between Total Trade and Covid Cases per million for each country and overall.

Total trade is caluculated as,

Total Trade = Exports + Imports

The correlation is then calculated as,

=CORREL(covid cases per year (2018-2023), totdal trade per year (2018-2023))

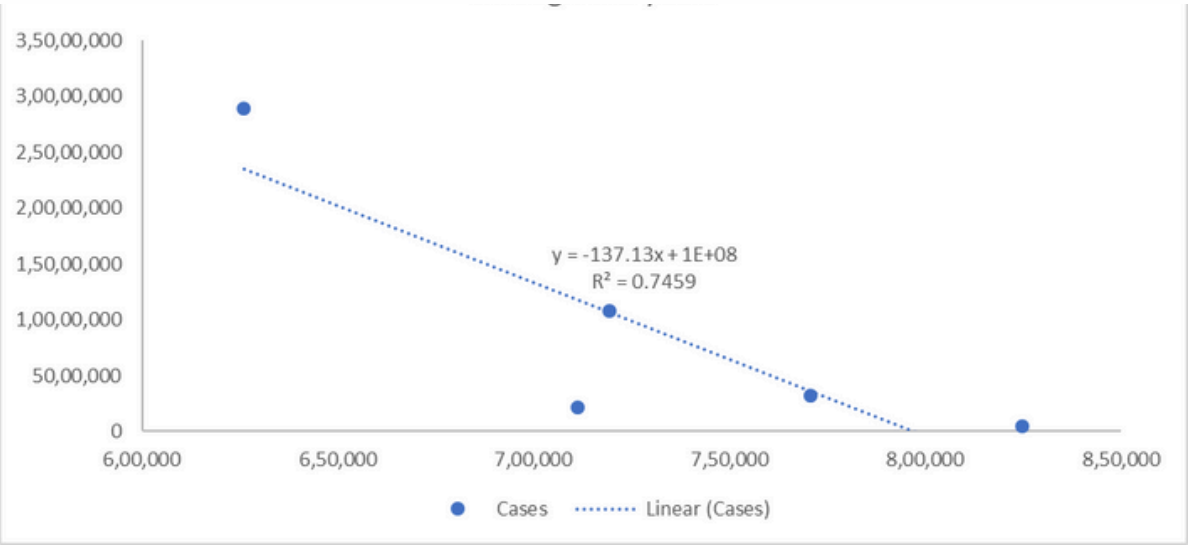
While different countries exhibited different correlation, the overall correlation was **-0.86.**

This implies that there is a significant negative correlation between cases per year and foreign trade. With increase in cases, there is a decrease in total trade.

1.3 Linear Relationship between Covid Cases and Total Trade

We use linear regression to find whether the correlation between covid cases and total trade is linear or not. This is done using a scatter plot that is plotted between total trade (in USD millions) and Covid cases per million.

Fig 2: Covid Cases vs Total Trade



As per the graph, it is clear that the line of best fit is,

$$y = -137.13x + 1E+08$$

- The slope of the line, here -52.838, represents that for every additional COVID-19 case, the total trade is expected to decrease by 13,713 million USD. The negative sign indicates an inverse relationship.
- The intercept value of 50,000,000 indicates the estimated total trade when there are 0 cases.

For our model, the R-squared value is,

$$R^2 = 0.7459$$

- This represents that the model captures a moderate-to-strong relationship between COVID-19 cases and total trade.
- The R-squared value indicates that approximately 74.59% of the variability in total trade can be explained by the number of COVID-19 cases during the analyzed period.

1.4 Hypothesis Testing using Paired t-test

Null Hypothesis (H0): The mean trade during Pre-COVID and COVID periods is the same (**$\mu 1 = \mu 2$**).
Alternative Hypothesis (H1): The mean trade during Pre-COVID and COVID periods is different (**$\mu 1 \neq \mu 2$**).

Our sample data represents the total trade of India with 241 countries.

Since this sample size is significantly large enough, through the **Central Limit Theorem**, we can assume that the data is normally distributed.

As we are comparing the same dataset (trade data) across two related time periods: Covid and Pre-Covid, and we do not have access to the overall population variance, we will be using **paired t-test** for the hypothesis testing.

Using Excel's Data Analysis ToolPak to conduct a "t-Test: Paired Two Sample for Means", we get the below table.

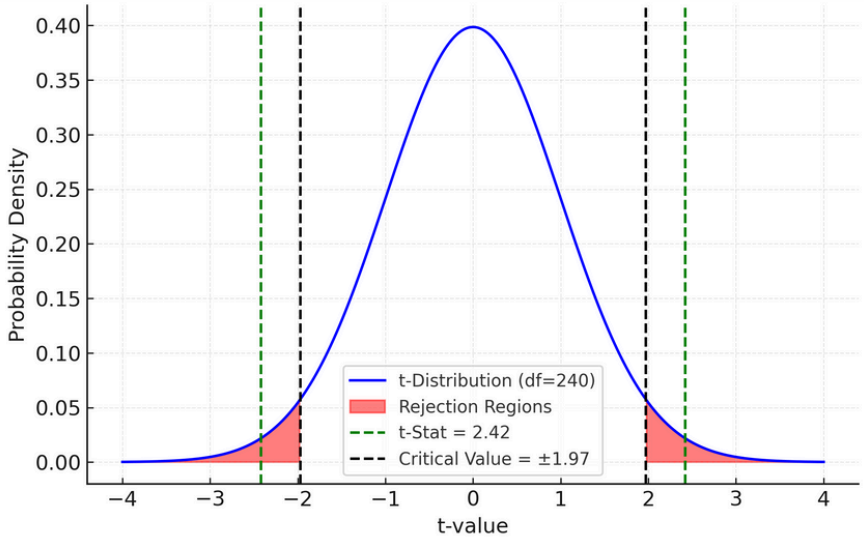
Table 3: Paired t-test on Pre-Covid and Covid Total Trade

	Pre-Covid	*Covid*
Mean	3496.522822	2844.817427
Variance	105233068.7	81514252.95
Observations	241	241
Pearson Correlation	#N/A	
Hypothesized Mean Difference	0	
df	240	
t Stat	**4.933349975**	
P(T<=t) one-tail	7.56E-07	
t Critical one-tail	1.651227393	
P(T<=t) two-tail	**1.51E-06**	
t Critical two-tail	**1.969897635**	

- Critical Value Test: Since t stat is greater than the t critical value (two-tail), we **reject the null hypothesis**.
- p-value Test: Since p-value is less than alpha (0.05), null hypothesis is rejected.

This can also be visualised as,

Fig 3: Paired t-test: Bell Curve Representation*



**Generated using generative AI model (ChatGPT)*

Thus, we can say with 95% certainity that the null hypothesis is unlikely to be true.

Here, we can say with 95% certainity that the means of total trade Pre-Covid and during Covid were not equal.

We can conclude that India's total foreign trade was significantly impacted by the Covid pandemic.

2. How Effective Were RTAs in Mitigating Trade Disruptions in India During the Pandemic?

Regional Trade Agreements (RTAs) are agreements between countries within a region aimed at reducing trade barriers and enhancing economic cooperation. They facilitate smoother trade by lowering tariffs and easing regulations.

According to UNCTAD (2021), RTAs played a significant role in reducing the decline in trade during the pandemic. The study found that trade within RTAs declined significantly less than trade under no-agreement, with a difference of about 5.6 percentage points.

While the study focuses on trade on a global level, this part of the project examines the relevance of RTAs for India during the COVID-19 pandemic, focusing on their potential impact on mitigating trade disruptions and supporting trade recovery.

Table 4: India's Active Regional Trade Agreements (RTAs)

RTA Name	Date of entry into force	Signatories
India - Australia	29-Dec-22	Australia; India
India - United Arab Emirates	1-May-22	India; United Arab Emirates
India - Mauritius	1-Apr-21	India; Mauritius
India - Thailand	1-Sep-04	India; Thailand
ASEAN - India	01-Jan-2010(G) / 01-Jul-2015(S)	India; Brunei Darussalam;Myanmar;Cambodia;Indonesia;Lao People's Democratic Republic;Malaysia;Philippines;Singapore;Viet Nam;Thailand
India - Japan	1-Aug-11	India; Japan
India - Malaysia	1-Jul-11	India; Malaysia
India - Nepal	27-Oct-09	India; Nepal
Korea, Republic of - India	1-Jan-10	India; Korea, Republic of
India - Afghanistan	13-May-03	Afghanistan; India
Southern Common Market (MERCOSUR) - India	1-Jun-09	India; Argentina;Brazil;Paraguay;Uruguay
Chile - India	17-Aug-07	Chile; India
India - Bhutan	29-Jul-06	Bhutan; India
India - Singapore	1-Aug-05	India; Singapore
India - Sri Lanka	1-Mar-00	Sri Lanka; India

Excluding RTAs that came into effect after 2020, India has trade agreements with 21 unique countries. This analysis will assess the role of these 21 RTA partners in supporting India's foreign trade resilience and recovery during the COVID-19 pandemic.

2.1 Trade Change Metrics

For this analysis, we calculated the trade resilence and recovery of each country.

- **Resilience** measures the percentage change in trade during the COVID period compared to the pre-COVID period, showing how well trade held up during the pandemic.

$$\text{Resilience (COVID)} = \frac{\text{Trade in 2020-2021} - \text{Trade in 2018-2019}}{\text{Trade in 2018-2019}} \times 100$$

- **Recovery** measures the percentage change in trade after the COVID period compared to the pandemic period, indicating how much trade has returned to pre-COVID levels.

$$\text{Recovery} = \frac{\text{Trade in 2022-2023} - \text{Trade in 2020-2021}}{\text{Trade in 2020-2021}} \times 100$$

Table 5: Trade Change Metrics for RTA countries

Export Resilence	Import Resilence	Export Recovery	Import Recovery	Trade Resilence	Trade Recovery
-9.49%	9.39%	31.35%	245.16%	-11.61%	55.01%

Table 6: Trade Change Metrics for non-RTA countries

Export Resilence	Import Resilence	Export Recovery	Import Recovery	Trade Resilence	Trade Recovery
8.81%	52.02%	53.82%	187.13%	16.24%	71.37%

As per the metrics, it can be seen that RTA countries experienced a more significant recovery in imports as compared to non-RTA countries. While the other metrics do not show better results for RTA countries.

However, to better compare, we will use confidence interval to understand the mean resilence and recovery for RTA and non-RTA countries.

2.3 Confidence Intervals for Resilence and Recovery

We calculated the confidence intervals for the two groups (RTA and non-RTA countries) at a confidence level of 95%.

Table 7: Calculation of Confidence Intervals

	RTA countries		Non-RTA countries	
	Resilence	Recovery	Resilence	Recovery
Count (n)	21	21	188	192
Average	-11.61%	55.01%	16.24%	71.37%
Standard Deviation	18%	52%	193%	102%
Standard Error	3.89%	11.37%	14.07%	7.39%
t-value	2.09	2.09	1.97	1.97
Upper Bound	**-3.48%**	**78.73%**	**44.00%**	**85.95%**
Lower Bound	**-19.73%**	**31.30%**	**-11.53%**	**56.78%**

Overall, the data indicates that non-RTA countries have experienced a higher level of resilience and stronger recovery in trade compared to RTA countries, but with a much higher degree of variability within the non-RTA group. The reasons behind these differences would require further investigation and analysis.

2.4 Hypothesis Testing using t-test

Null Hypothesis (H_0): There is no significant difference in trade resilience (or recovery) between RTA and non-RTA countries during the COVID period.

Alternative Hypothesis (H_1): RTA countries experienced smaller trade declines or faster recovery than non-RTA countries during the COVID period.

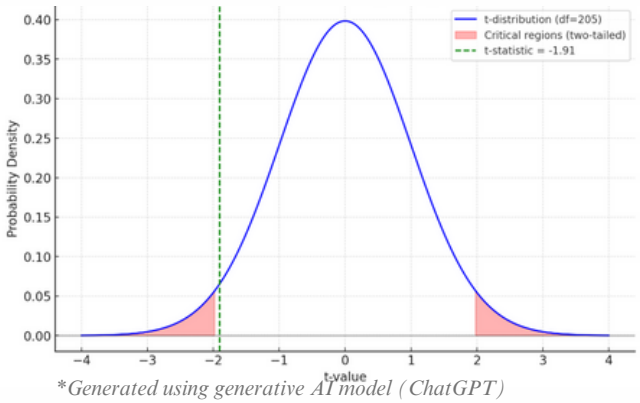
Since the population variance is unkown and the two groups (RTA and non-RTA countries) are independent, we will use "t-Test: Two-Sample Assuming Unequal Variances".

2.4.2 t-test for Trade Resilence

Table 8: t-test for Resilence

	RTA Countries	*Non-RTA countries*
Mean	-0.116	0.162351064
Variance	0.0318817	3.723319684
Observations	21	188
Hypothesized Mean Difference	0	
df	205	
t Stat	-1.906198126	
P(T<=t) one-tail	0.029011647	
t Critical one-tail	1.652320556	
P(T<=t) two-tail	0.058023295	
t Critical two-tail	1.971603499	

Fig 4: Bell-curve for Resilence*



*Generated using generative AI model (ChatGPT)

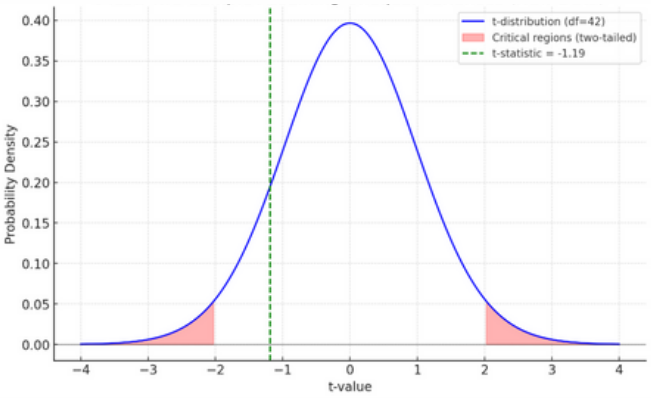
As per the t-test, at 0.05 significance, we cannot reject the null hypothesis.

2.4.2 t-test for Trade Recovery

Table 9: t-test for Recovery

	RTA Countries	*Non-RTA countries*
Mean	0.550095238	0.713666667
Variance	0.27144669	1.163592558
Observations	21	192
Hypothesized Mean Difference	0	
df	42	
t Stat	-1.187096461	
P(T<=t) one-tail	0.120930275	
t Critical one-tail	1.681952357	
P(T<=t) two-tail	0.241860551	
t Critical two-tail	2.018081703	

Fig 4: Bell-curve for Recovery*



*Generated using generative AI model (ChatGPT)

As per the t-test, at 0.05 significance, we cannot reject the null hypothesis.

2.4.3 Inference

Given the above tests, at 0.05 significance level, we cannot reject the null hypothesis.

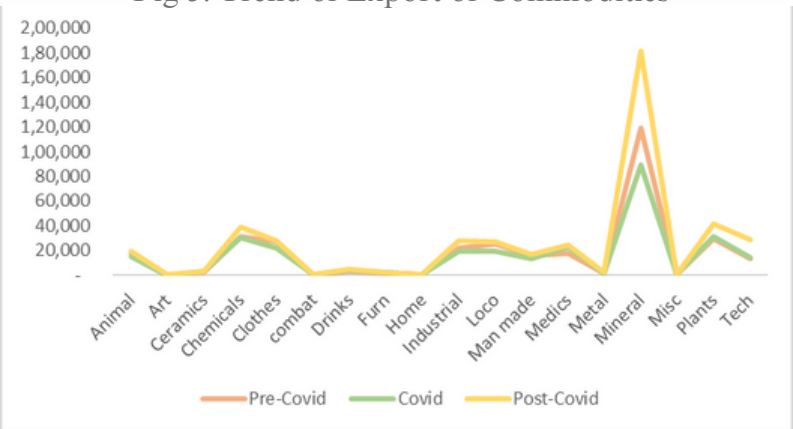
Thus, there is no significant difference in India's foreign trade resilience (or recovery) between RTA and non-RTA countries during the COVID period.

3. Analysis of the effect of covid and commodities on trade

India exports a variety of commodities all over the world, and it is very evident from the below analysis that covid affected foreign trade through the years. We are trying to see if any particular sector recovered faster than the other or how much impact the type of sector could have.

It is clearly visible in the line graph that the type of commodity had no effect on the trend of the commodity for the majority of the sectors.

Fig 5: Trend of Export of Commodities



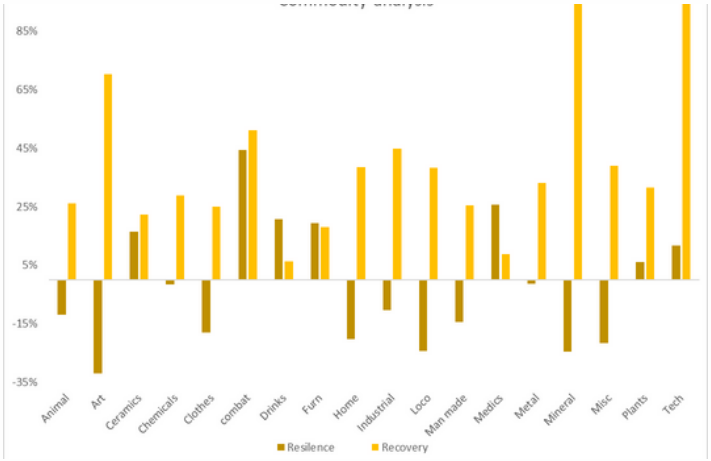
3.1 Descriptive Analysis

We calculated the resilience and recovery rate of the commodities individually and note that the commodities have a variety of change. Some of the commodities have a positive resilience, meaning they were positively impacted by covid, and it is also notable that they have a higher recovery with constant increase in export of those sectors.

Table 10: Commodity-wise exports

Row Labels	For use	Pre-Covid 2018-2019	Covid 2020-2021	Post-Covid 2022-2023	Resilence	Recovery
Animal Based Commodities	Animal	17,717	15,598	19,683	-12%	26%
Works of Art	Art	224	152	259	-32%	70%
Ceramics and Glassware	Ceramics	2,540	2,958	3,619	16%	22%
Chemical Commodities	Chemicals	31,017	30,520	39,320	-2%	29%
Clothing	Clothes	26,952	22,121	27,673	-18%	25%
Explosive or Combat Equipment	combat	232	335	506	44%	51%
Beverages	Drinks	3,525	4,256	4,524	21%	6%
Furniture	Furn	1,710	2,040	2,409	19%	18%
Home Accessories	Home	821	655	907	-20%	39%
Industrial Commodities	Industrial	21,727	19,491	28,238	-10%	45%
Locomotives	Loco	25,512	19,294	26,686	-24%	38%
Artificial or Man Made Commodities	Man made	15,892	13,596	17,055	-14%	25%
Medical Commodities	Medics	18,010	22,657	24,654	26%	9%
Processed Metal	Metal	1,588	1,566	2,083	-1%	33%
Mineral Commodities	Mineral	1,18,841	89,593	1,81,818	-25%	103%
Misc	Misc	811	635	883	-22%	39%
Plant Based Commodities	Plants	29,794	31,621	41,615	6%	32%
Technological Commodities	Tech	13,167	14,719	29,137	12%	98%
TOTAL		3.30.077.58	2.91.807.96	4.51.069.47		

Fig 6: Trend of commodity-wise exports



3.2 Inferential Analysis

We performed Anova two factor analysis and noted that certain commodities (e.g., Minerals, Plants, Chemicals) experienced high trade values and variability (trade value 130,083.69 and variance 2,22,11,59,223.06), possibly reflecting their essential nature and fluctuating demand during the pandemic. Whereas non-essential categories (e.g., Art, Miscellaneous) show lower trade activity (trade value 211.66 and variance 2,971.19), likely reflecting reduced demand during economic downturns.

Commodities:

- F = 22.45, P-value = 0.00: Indicates a statistically significant effect of commodity type on trade. The variation in trade across different commodities is not random and reflects underlying factors that had affected the export.

Time Periods:

- F = 3.19, P-value = 0.05: Indicates a statistically significant effect of time (COVID-19 impact). The trade values changed notably across the three periods, reflecting disruptions caused by the pandemic and subsequent recovery trends.

Summary

The COVID-19 epidemic has disrupted global economies and transformed international trade. India's export and import patterns shifted significantly and this study examines the pandemic's impact on India's exports and imports, focussing on overall trends, Regional Trade Agreements (RTAs), and commodity-specific changes.

1. **Overall Trade Impact**

- **Decline in Trade Volume**: Exports and imports fell dramatically during the pandemic, with year-on-year trade data indicating a large drop in trade volume compared to pre-COVID levels.
- **Correlation with COVID-19 Cases**: A correlation analysis found a strong negative association (correlation: -0.86) between trade and COVID-19 instances, with each new case lowering India's overall commerce by $13,713 million. The R-squared score of 74.59% indicated a strong relationship between the variables.
- **T Test**: A paired t-test revealed a p-value less than 0.05, indicating a significant difference in trade volumes between the pre-COVID and post-COVID periods, leading to the rejection of the null hypothesis. T**his confirmed that the decline in trade during the COVID period was statistically significant, with a 95% confidence level.**

2. **Role of Regional Trade Agreements (RTAs)**

RTAs facilitate commerce by lowering tariffs and regulatory barriers. This section investigates whether India's commerce with RTA partners demonstrated higher resilience during the epidemic than non-RTA countries. Key findings include:

- **Trade Resilience and Recovery Metrics**: Resilience examines trade movements during COVID, whereas recovery assesses post-COVID alterations. RTA countries demonstrated stronger import resilience but no substantial advantage in export resilience or recovery.
- **Confidence Intervals**: At the 95% confidence level, non-RTA nations had more variability in resilience and recovery, but the mean values did not differ significantly from RTA countries.
- **Hypothesis Testing**: A two-sample t-test with unequal variances yielded a p-value of greater than 0.05, showing no statistically significant differences in resilience and recovery between RTA and non-RTA countries. This shows that RTAs did not successfully protect against trade interruptions during the pandemic.

3. **Commodity-Wise Impact**

India's exports span a diverse range of commodities, including pharmaceuticals, textiles, electronics, and agricultural products. This section analyzed the differential impact of COVID-19 on various commodity categories, revealing:

- **Essential vs. Non-Essential Commodities:** Essential goods, such as pharmaceuticals and agricultural products, demonstrated great resilience and faster recovery due to sustained demand, whereas non-essential items, such as art, experienced harsher falls and a slower recovery.
- **Descriptive Analysis:** Pharmaceuticals and chemicals remained stable due to their crucial nature, whereas textiles and electronics saw higher disturbances.
- **ANOVA:** An ANOVA test was conducted to assess the statistical significance of trade variability across commodity categories and time periods. Results showed:

Commodity Effect: F-value = 22.45 and p-value < 0.01 indicate a significant impact of commodity type on trade, with essential goods performing better during the pandemic.
Time Period Effect: F-value = 3.19 and p-value = 0.05 indicate a significant effect of time periods on trade, reflecting COVID disruptions and post-COVID recovery trends.

Appendix

Data source

- Regional Trade agreements - https://rtais.wto.org/UI/PublicAllRTAList.aspx
- Export and Import databases at country and commodity level - https://tradestat.commerce.gov.in/eidb/default.asp

References

- Alessandro N., Mesut S,. (2021) “Trade Agreements and Trade Resilience During COVID-19 Pandemic”,UNCTAD(70). Available at: https://unctad.org/system/files/official-document/ser-rp-2021d13_en.pdf
- Pathania, K. and Datta, H.D. (2022) The Post-COVID Analysis of Indian Foreign Trade. Journal of Emerging Technologies and Innovative Research, 9(12). Available at: https://www.jetir.org/papers/JETIR2212564.pdf
- ChatGPT was minimally used in this project to enhance final output.

Contribution Summary

Name	Contribution	Percentage
Aashna Midha	• Prepared master database • Performed and documented test for RTA vs non-RTA countries • Performed and document Trade analysis	34%
Priya S. Murali	• Obtained and prepared master database • Performed and documented analysis by Commodity • Documented summary of the report	33%
Seema T. Syed	• Obtaining commodity database • Performed Trade analysis • Worked on the report: Introduction, Summary, etc.	33%