EXPLORING THE LINK BETWEEN TRADE, ECONOMIC GROWTH, TRANSPORT INFRASTRUCTURE AND CO2 EMISSIONS IN INDIA

DISSERTATION

Submitted in partial fulfilment of the requirement of

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by

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APPROVAL SHEET

The dissertation, titled "**Exploring the link between trade, economic growth, transport infrastructure and CO_2 emissions in India**" by Vashishth Doshi is recommended for the degree of Bachelors of Arts (Hons.)

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ABSTRACT

This study explores if there exists a link between trade, economic growth, transport infrastructure and carbon emissions in India. It uses IMF indicator's data of 26 observations spanning three decades to statistically test for cointegration between variables using the Johansen Cointegration test. This study makes use of year over year changes in GDP as a measure of economic growth, year over year changes in import and export volumes as a measure of trade and per capita total inland transport expenditure as an indicator of transportation infrastructure. The results indicate that cointegration might exist, but cannot be confirmed without deeper analyses, and provides strong basis for further exploration in that direction. The policy implications of this study indicate the aligned movement of economic activity like trade, transport and logistics to carbon emissions, and that further research might consolidate the requirement for furthering discussions regarding the sustainability of the dynamic between economy and environment. The introduction to the study and an overview of other literature act as extensive sources for executive reading about these interlinked variables.

Keywords: *Economic growth, Trade, Transport infrastructure, Carbon emissions, India, Johansen Cointegration test, linkages*

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CHAPTER 01

INTRODUCTION

India is the world's fifth largest economy. It is the third largest in terms of purchasing power. Year on year, new trade heights are achieved (*India Exports 1960-2024*, n.d.)and its households have the fifth largest consumption (Households and NPISHs Final Consumption Expenditure (Current US$) (n.d.), which is only poised to grow substantially. This is complemented by unprecedented urbanization (*Number of People Living in Urban and Rural Areas, India*, n.d.) and transportation infrastructure (*Transport Infrastructure*, n.d.). India is also ranked third globally in terms of carbon emissions. In 2021, the country emitted 2.7 billion metric tons of CO_2 or 7 percent of the global total (*CO2 Emissions*, n.d.). India's energy consumption is projected to grow about 1.5 times faster than the global average over the next three decades (*World Energy Outlook 2022*, n.d.). Further, India has become the world's most populous country and is forecast to become the second-largest economy by 2050 (*OECD Economic Outlook, Volume 2022 Issue 1*, 2022). This all, while it has also promised to reduce the total projected carbon emissions by one billion metric tons from now (presumably 2022) through 2030 and achieve the target of net zero by 2070 (Deb & Kohli, 2022).

Considering these intense statistics and their interactions with respect to one another, it is pertinent to explore and understand their dynamic linkage to help gauge trends and effects between them. This will make it easier to see how one variable affects the others and inspire consideration of how to keep each variable functioning at its peak in the context of long-term, sustainable economic growth.

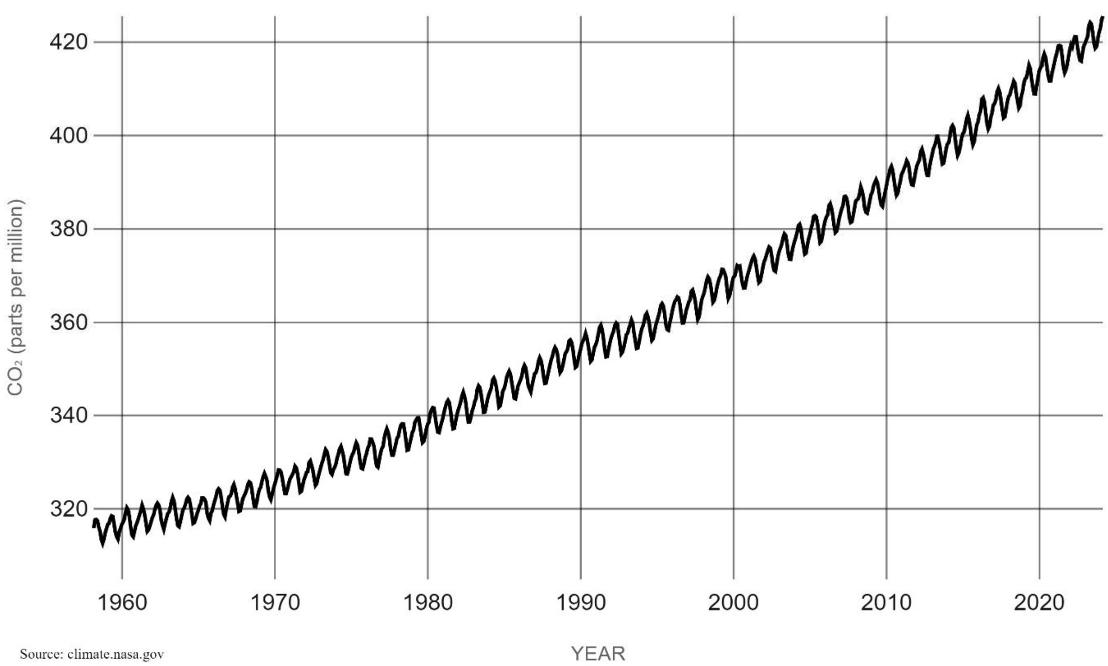
In order to help in the mapping out a future of sustainable growth, this research aims to comprehend and investigate the relationships between trade, economic growth, transport and mobility infrastructure, and CO_2 emissions. We will understand the basic aspects of the research, before connecting them and understanding their interactions in the real world.

1.1 CO2 emissions in India

Burning fossil fuels for transportation, heat, and power is the main human activity-related source of greenhouse gas emissions in the United States. In 2022, CO2 emissions from energy combustion increased by approximately 1.3%, or 423 Mt, according to the International Energy Agency (IEA), whereas CO2 emissions from industrial processes decreased by 102 Mt. The IEA creates projections of energy consumption, energy-related CO2 and other greenhouse gas emissions for 2022 using a wide range of reliable statistical sources. These sources include recent data from the IEA Market Report series, which covers coal, oil, natural gas, renewable energy, electricity, and energy efficiency, as well as real-time data from power system operators worldwide and statistical releases from national administrations. The most recent monthly data submissions to the IEA Energy Data Centre are among these sources. (CO2 Emissions in 2022, 2023).

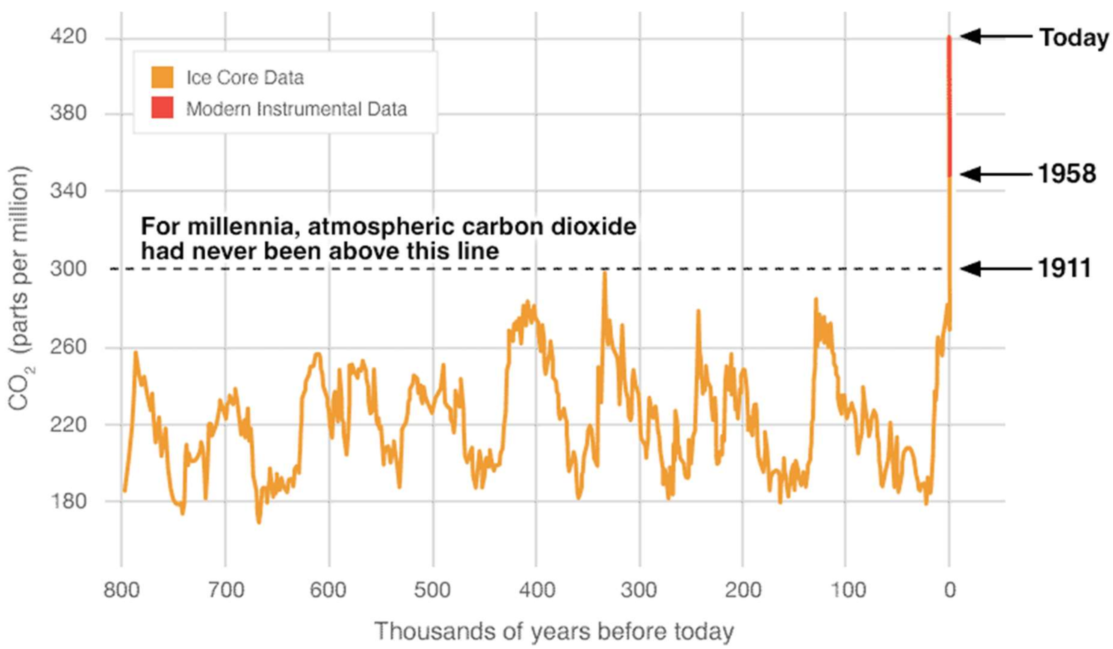
Carbon dioxide (CO2) is the dominant emitted greenhouse gas, while methane (CH4) emissions almost have the same short-term impact. Nitrous oxide (N2O) and fluorinated gases (F-gases) play a lesser role in comparison. Greenhouse gas emissions are measured in CO2 equivalents determined by their global warming potential (GWP), which depends on their lifetime in the atmosphere. Estimations largely depend on the ability of oceans and land sinks to absorb these gases.

The United States has emitted more CO2 than any other country to date: at around 400 billion tonnes since 1751, it is responsible for almost one-quarter of historical emissions. Carbon dioxide emissions are the primary driver of global climate change3. It's widely recognized that to avoid the worst impacts of climate change, the world needs to urgently reduce emissions (Ritchie & Roser, 2020).



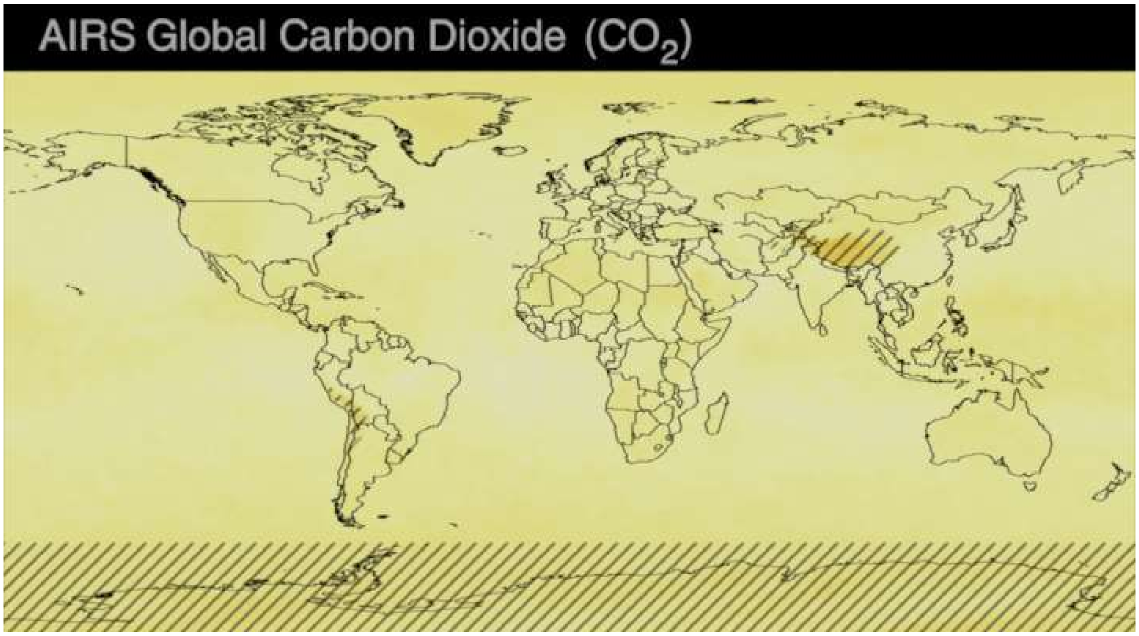
Data source: NOAA, measured at the Mauna Loa Observatory

Carbon dioxide (CO2) is a significant gas that traps heat and is also referred to as a greenhouse gas. It is produced by burning fossil fuels, which include coal, oil, and natural gas, as well as by wildfires and other natural events like volcanic eruptions. The first graph displays atmospheric CO2 concentrations that NOAA has been measuring since 1958 at Hawaii's Mauna Loa Observatory. According to air bubbles trapped in ice sheets and glaciers, the second graph depicts CO2 levels during the course of the planet's last three glacial cycles (Carbon Dioxide, 2024). Human activity has increased atmospheric CO2 by 50% since the 18th century, when industrialization began. CO2 concentrations now are 150% greater than they were in 1750. The spike caused by humans is higher than the one that occurred naturally 20,000 years ago at the conclusion of the last ice age.]

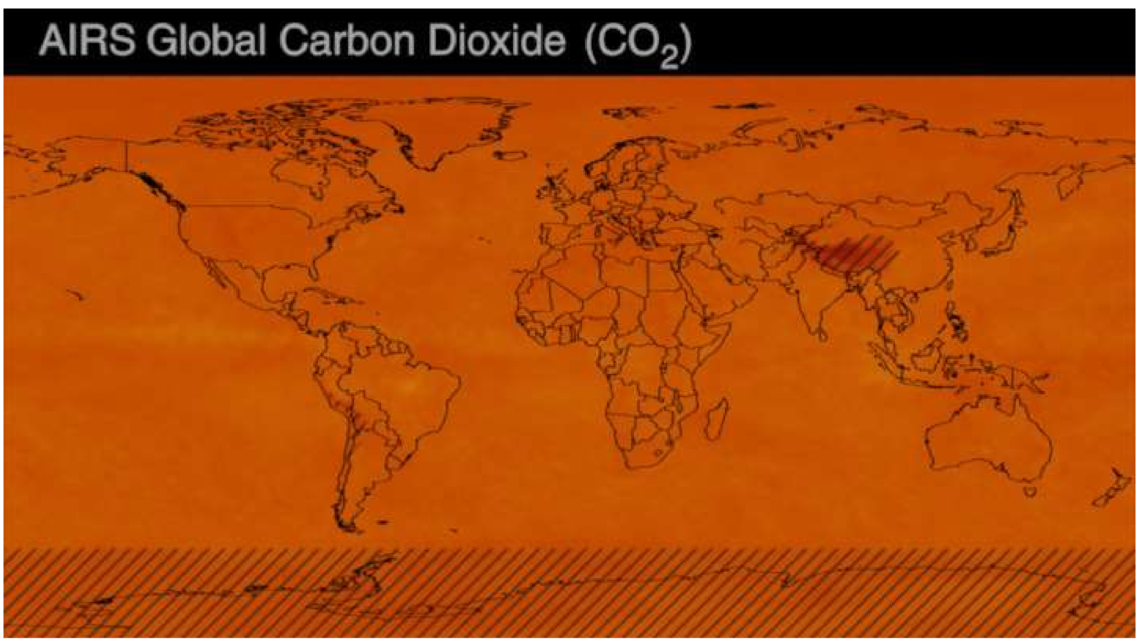


Data Source: Ice Core reconstruction; NOAA

CO2 emissions are primarily driven by the burning of fossil fuels for electricity, heat, and transportation, and are a major contributor to global climate change.



Data Source: NASA, Atmospheric Infrared Sounder (AIRS) – September 2002



Data Source: NASA, Atmospheric Infrared Sounder (AIRS) – November 2022

1.1.1 History of CO2 emission measurement and its significance

The first direct measurements of atmospheric CO2 levels were made by Charles David Keeling at the Mauna Loa Observatory in Hawaii starting in 1958 (*A Brief History of Carbon Dioxide Measurements*, 2008). Prior to this, scientists had believed that the oceans were absorbing most of the CO2 emitted by human activities, so any increase in atmospheric CO2 would be very slow. However, Keeling's measurements showed that only about half of the CO2 emitted was being absorbed, leading to a relatively rapid increase in atmospheric CO2 levels.

Over the next decade, other scientists replicated the Mauna Loa CO2 trend at other locations, and also began measuring increases in other greenhouse gases like methane and chlorofluorocarbons. By the mid-1970s, it was clear that human activities were changing the chemistry of the atmosphere(Friedrich & Damassa, 2021).

In the late 1960s, NASA's Moustafa Chahine developed a method to measure atmospheric temperature profiles from satellite data, which could also be used to measure CO2 levels in the mid-troposphere. This led to the development of the Atmospheric Infrared Sounder (AIRS) instrument, which has been providing global CO2 measurements since 2002 (*Carbon Dioxide*, 2024).

More recently, the Orbiting Carbon Observatory (OCO-2) satellite was launched in 2009 to provide even more detailed measurements of atmospheric CO2 levels. By combining data from AIRS and OCO-2, scientists can now create a more complete picture of global CO2 sources and sinks(*A Brief History of Carbon Dioxide Measurements*, 2008).

Overall, the history of CO2 measurement has evolved from early ground-based observations to increasingly sophisticated satellite-based monitoring, allowing us to better understand the human impact on the global carbon cycle.

1.1.2 Marked increase of CO2 emissions

Global CO2 emissions have grown significantly since the 1950s. In the 1950s, the United States and European Union were the biggest emitters, responsible for over 70% of total annual emissions. However, this trend changed as other nations like China and India experienced rapid economic growth and increases in emissions1. From 1950 to 2000, China's emissions surged over 4,500%, reaching 3.6 billion tonnes by 2000. Overall, global CO2 emissions have grown six-fold since 1950, from around 6 billion tonnes to over 37 billion tonnes in 2022 (Oguz, 2023).

The rate of increase in atmospheric CO_2 levels has also accelerated over time (Lindsey, 2024). In the 1960s, the global growth rate of atmospheric CO_2 was around 0.8 ppm per year. Over the next 50 years, the annual growth rate tripled, reaching 2.4 ppm per year during the 2010s.This is about 100 times faster than the natural increases that occurred at the end of the last ice age 11,000-17,000 years ago (Lindsey, 2024).

However, the growth in global emissions has slowed since 2000 (Hausfather, 2021). Emissions rebounded by 4.9% in 2021 after a pandemic-related dip in 2020. But emissions in 2021 remained slightly below the pre-pandemic peak in 2019. The authors caution that a further rise in emissions in 2022 cannot be ruled out as the transportation sector recovers.

Global CO_2 emissions from fossil fuels and cement production grew by around 1.5% in 2022 compared to 2021, reaching 36.1 $GtCO_2$ (Z. Liu et al., 2023). This represents a recovery from the sharp COVID-19-related decrease in 2020, followed by growth beyond pre-pandemic 2019 levels. However, the rate of emissions increase has slowed in 2022 compared to 2021 across most sectors, including power, industry, and ground transportation (Z. Liu et al., 2023). The exception is international aviation, which saw a 44% rise in emissions in 2022 compared to 2021, though it remains 25% below pre-pandemic 2019 levels. While global emissions have not yet peaked, the continued growth suggests the global peak in emissions has yet to be reached. The Intergovernmental Panel on Climate Change (IPCC) prediction that global emissions won't peak before 2025 remains consistent with the latest data (Z. Liu et al., 2023).

Emissions trends vary by country, with China seeing a 1.5% decline in 2022, the USA and EU increasing by 3.2% and 0.5% respectively, and India continuing rapid growth at 7% in 2022. Russia's emissions fell by 1.8% in 2022 (Z. Liu et al., 2023).

1.1.3 What are the major factors influencing CO_2 emissions?

1. Economic growth and industrialization:

Economic growth and the associated increase in industrial activities are major drivers of rising CO_2 emissions. Industrialization, including the growth of energy-intensive industries, has led to higher energy consumption and CO_2 emissions (S. Li et al., 2021).

2. Urbanization:

The process of urbanization, with more people living in cities, has contributed to increased energy consumption and CO_2 emissions from transportation, buildings, and other urban activities (S. Li et al., 2021).

3. Fossil fuel consumption:

The burning of fossil fuels, such as coal, oil, and natural gas, for electricity generation, transportation, and industrial processes is the largest source of CO_2 emissions globally (Ritchie et al., n.d.).

4. Lack of progress in renewable energy adoption:

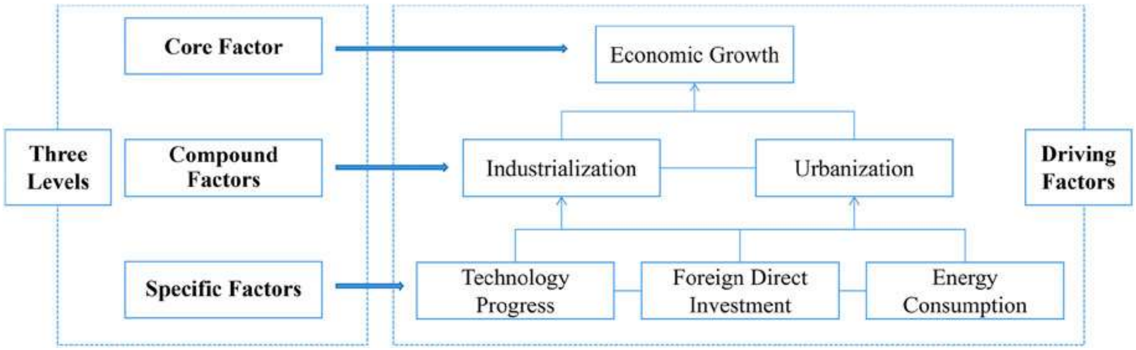
Despite the growth of renewable energy sources, the world still relies heavily on fossil fuels, leading to continued increases in CO_2 emissions (Ritchie et al., n.d.).

5. Rapid growth in developing countries:

Rapid economic and industrial development in countries like China and India has led to a surge in their CO_2 emissions, offsetting reductions in other parts of the world (Ritchie & Roser, 2020).

6. Insufficient policy action:

The lack of strong, coordinated policy measures to drive the transition to a low-carbon economy has hindered the reduction of global CO_2 emissions (Ritchie et al., n.d.).



Source: Shanshan Li, et al.

1.1.4 Policy instruments in place to reduce CO2 emissions

Several policies and initiatives have been implemented to reduce global CO2 emissions. Here are some examples:

1. Carbon Tax

A carbon tax is a policy where a tax is imposed on the carbon content of fossil fuels, providing a financial incentive for companies and individuals to reduce their carbon footprint (Krupnick & Parry, n.d.). This approach is considered effective in reducing emissions as it directly targets the source of the problem and can be designed to be revenue-neutral by using the revenue generated to reduce other taxes or invest in low-carbon technologies.

2. Cap-and-Trade Systems

Cap-and-trade systems set a cap on the total amount of emissions allowed and issue permits to companies to emit a certain amount of CO2. Companies can then trade these permits among themselves, creating a market-based incentive for reducing emissions (Krupnick & Parry, n.d.). This approach has been implemented in various forms around the world, including the European Union's Emissions Trading System.

3. Renewable Energy Targets

Setting renewable energy targets and providing incentives for the development and use of renewable energy sources, such as solar and wind power, can help reduce emissions by decreasing the reliance on fossil fuels (*The Sectoral Solution to Climate Change*, n.d.). Many countries have set ambitious renewable energy targets, and some have implemented policies to support the growth of renewable energy, such as feed-in tariffs and tax credits.

4. Energy Efficiency Standards

Implementing energy efficiency standards for buildings and appliances can help reduce energy consumption and emissions (Policies to Reduce Greenhouse Gas Emissions in Industry - Successful Approaches and Lessons Learned, n.d.). This can be achieved through regulations, labeling schemes, and incentives for energy-efficient technologies.

5. Electric Vehicle Incentives

Offering incentives for the adoption of electric vehicles, such as tax credits, rebates, and exemptions from certain fees, can help reduce emissions from transportation (*Measures to Reduce Greenhouse Gas Emissions*, n.d.). Many countries have implemented policies to encourage the adoption of electric vehicles, and some have set targets for the share of electric vehicles in their fleets.

6. Carbon Capture and Storage (CCS)

CCS technologies capture CO2 emissions from power plants and industrial processes, and store them underground, preventing them from entering the atmosphere (Krupnick & Parry, n.d.). While still in the early stages of development, CCS has the potential to significantly reduce emissions from these sectors.

7. Sustainable Land Use

Promoting sustainable land use practices, such as reforestation and agroforestry, can help sequester carbon dioxide from the atmosphere (*The Sectoral Solution to Climate Change*, n.d.). This can be achieved through policies and incentives that support sustainable agriculture and forestry practices.

8. Climate-Resilient Infrastructure

Investing in climate-resilient infrastructure, such as sea walls and green roofs, can help reduce the impacts of climate change and support adaptation efforts (*Measures to Reduce Greenhouse Gas Emissions*, n.d.). This can be achieved through government investments and regulations that prioritize climate resilience in infrastructure development.

9. Carbon Pricing

Carbon pricing mechanisms, such as carbon taxes or cap-and-trade systems, can provide a financial incentive for companies and individuals to reduce their carbon footprint (Policies to Reduce Greenhouse Gas Emissions in Industry - Successful Approaches and Lessons Learned, n.d.). This approach is considered effective in reducing emissions as it directly targets the source of the problem and can be designed to be revenue-neutral by using the revenue generated to reduce other taxes or invest in low-carbon technologies.

10. International Cooperation

International cooperation and agreements, such as the Paris Agreement, can help coordinate global efforts to reduce emissions and address the global nature of climate change (*Measures to Reduce Greenhouse Gas Emissions*, n.d.). This can be achieved through international agreements, climate diplomacy, and cooperation on climate-related research and development.

These are just a few examples of the many policies and initiatives that have been implemented to reduce global CO2 emissions. The effectiveness of these policies has varied depending on the specific context and the level of commitment to reducing emissions.

Notably, several countries have seen varying degrees of success in reducing carbon emissions while sustaining economic growth since 2000 – as indicated in a World Bank study:

- Ukraine: Reduced CO2 emissions by 77% since 1988 (Lamb et al., 2022).

- Denmark: Reduced CO2 emissions by 56% since 1996 (Lamb et al., 2022).

- United Kingdom: Reduced CO2 emissions by 46% since 1973 (Lamb et al., 2022).

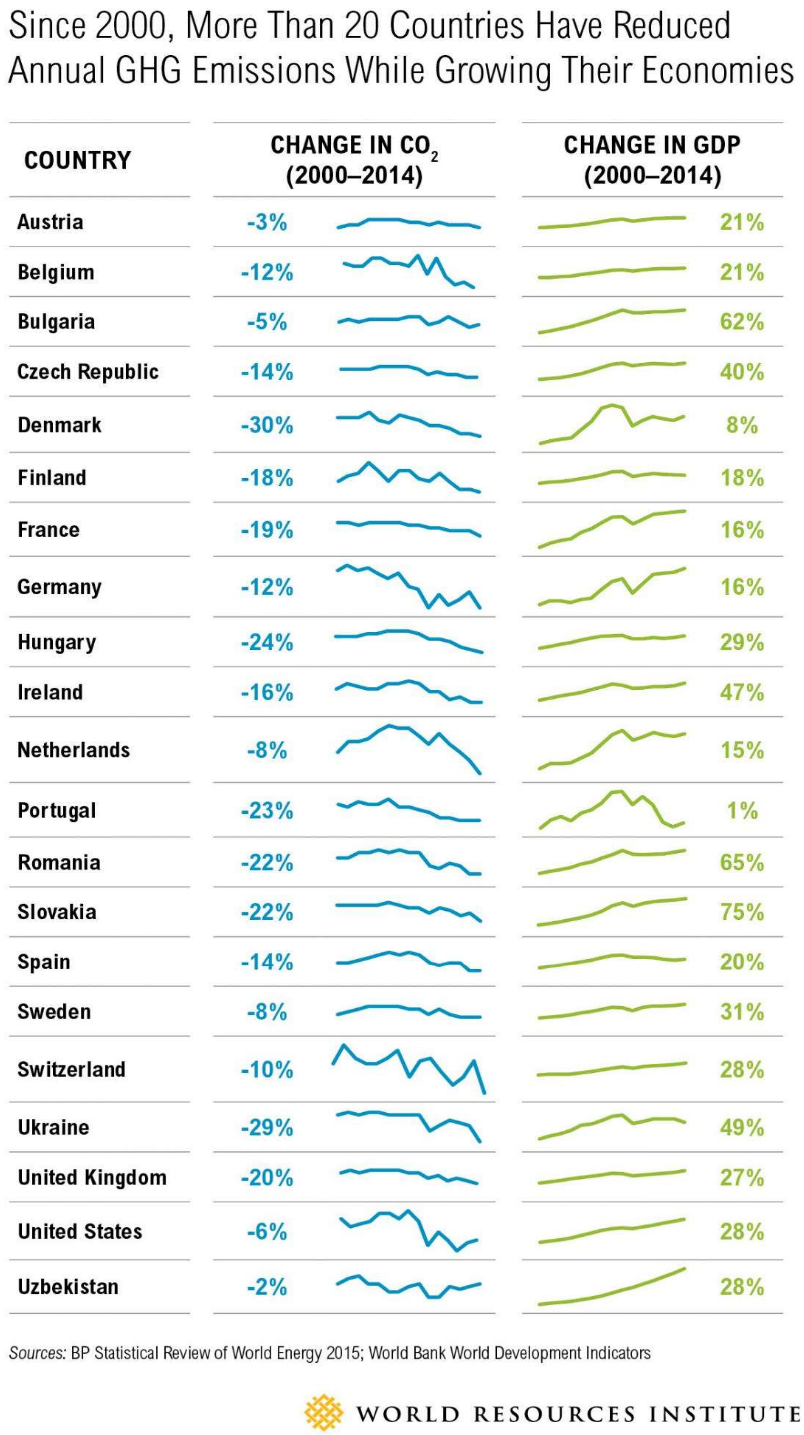
- Sweden: Reduced CO2 emissions by 8% (Aden, n.d.).

- Switzerland: Reduced CO2 emissions by 10% (Aden, n.d.).

- United States: Reduced CO2 emissions by 6% (Aden, n.d.).

- Uzbekistan: Reduced CO2 emissions by 2% (Aden, n.d.).

These countries have demonstrated sustained reductions in their annual CO2 emissions, showcasing the feasibility of achieving significant emission reductions while maintaining economic growth.



1.1.5 The perils of increasing CO_2 emissions in India – recent developments

1. Continued reliance on coal-fired power generation:

India is constructing around 27 GW of new thermal (mostly coal) power plants to meet growing electricity demand. The share of coal-fired generation in India's power mix is expected to rise to 77% by 2025. India's power minister has stated that the country "cannot survive without coal" and has no other viable options for meeting its energy needs (Singh, 2023).

2. Rapid economic and industrial growth:

India's booming economy is driving a 9.6% increase in electricity demand in fiscal year 2023 (Singh, 2023). This economic and industrial expansion is a major contributor to the projected 8.2% increase in India's carbon emissions in 2023 ("Carbon Emissions in India to Increase by 8.2 per Cent in 2023: Study," 2023).

3. Increasing natural gas consumption:

India's natural gas demand across sectors like fertilizers, power, and refining has grown strongly, increasing by 19% year-over-year in Q3 2023 (Singh, 2023).

This growth in gas consumption, while relatively small compared to coal, is also contributing to the rise in India's overall emissions.

4. Insufficient progress in renewable energy adoption:

Despite India's renewable energy targets, the country's reliance on coal-fired power generation remains high and is expected to continue increasing in the near future (Singh, 2023).

The lack of sufficient progress in transitioning to renewable energy sources is hindering India's efforts to curb its rising CO_2 emissions.

<u>The consequences of India's increasing CO_2 emissions include:</u>

1. Climate Change Impact:

Rising CO_2 emissions contribute to global climate change, leading to more frequent and severe weather events like heatwaves, floods, and droughts ("Carbon Emissions in India to Increase by 8.2 per Cent in 2023: Study," 2023). Climate change can disrupt ecosystems, impact agriculture, and threaten food security, affecting the livelihoods of millions of people.

2. Air Pollution:

CO2 emissions are often accompanied by other pollutants like particulate matter and nitrogen oxides, contributing to poor air quality and health issues in urban areas (Singh, 2023). Increased CO2 emissions can worsen respiratory problems and cardiovascular diseases, leading to higher healthcare costs and reduced quality of life.

3. Environmental Degradation:

The release of CO2 into the atmosphere can lead to ocean acidification, affecting marine ecosystems and coral reefs ("Carbon Emissions in India to Increase by 8.2 per Cent in 2023: Study," 2023). Deforestation and habitat destruction driven by economic growth and energy demand can further exacerbate environmental degradation.

4. Resource Depletion:

The reliance on coal and other fossil fuels for energy production can deplete natural resources and contribute to water and soil pollution (Singh, 2023). Increased energy consumption can strain water resources, especially in regions facing water scarcity.

5. Global Impact:

India's growing CO2 emissions contribute to the overall global carbon footprint, impacting international efforts to mitigate climate change ("Carbon Emissions in India to Increase by 8.2 per Cent in 2023: Study," 2023). Failure to curb emissions can lead to missed climate targets, exacerbating the challenges of achieving global climate goals like those set in the Paris Agreement.

The consequences of India's increasing CO2 emissions are far-reaching, affecting not only the country's environment and public health but also contributing to global climate change and its associated impacts on ecosystems and societies worldwide.

<u>More significantly, the key economic consequences of India's increasing CO2 emissions are:</u>

1. Reduced GDP Growth:

Studies indicate that CO_2 emission reduction measures can impose costs in terms of lower Gross Domestic Product (GDP) for India. Constraining carbon emissions without adequate compensation can deny India access to legitimate avenues of economic development (Parikh & Krishnamurthy, n.d.).

2. Increased Poverty:

Reducing CO_2 emissions is found to be associated with higher poverty levels in India. The effects of environmental constraints on the economy are equivalent to a major oil shock, which can have significant adverse impacts on the poor (Parikh & Krishnamurthy, n.d.).

3. Higher Operational Costs for Industries:

Climate-friendly regulations, reduced utilization of old infrastructure, and investment in greener technologies can increase operational costs for industries in India. Relocation of production processes due to climate-related losses can also add to economic losses (Sharma, 2023).

4. Disruption in the Service Sector:

Increased insurance claims, disruptions in travel and hospitality, and pressure on financial services can pose threats to the service sector (Sharma, 2023).

5. Labor Market Impacts:

Health hazards from climate change can lead to a loss in productivity and cause migration from climate-vulnerable areas. It is estimated that India could account for about 3.4 crore of the projected eight crore global job losses from heat stress by 2030 (Sharma, 2023).

6. Overall Economic Risks:

The Reserve Bank of India estimates that up to 4.5% of India's GDP could be at risk by 2030 due to lost labor hours from extreme heat and humidity. Climate change can severely disrupt crop cycles and agricultural yields, impacting the rural economy and causing inflation in urban areas (Sharma, 2023).

In summary, the economic consequences of India's increasing CO_2 emissions include reduced GDP growth, higher poverty, increased operational costs for industries, disruption in the service sector, labor market impacts, and overall economic risks to the country.

<u>Some actionable steps by India in the direction of reducing CO_2 emissions over time have been appreciated for their forwardness and have been backed by policy formulation:.</u>

1. Hydrogen-Based Production:

India is working towards reducing industrial carbon emissions through the use of hydrogen-based production as an environment-friendly alternative. The steel sector, being the biggest emitter of carbon in India, is considering hydrogen-based production as a crucial method to reduce pollution levels (Ministry of External Affairs, 2021).

2. National Hydrogen Energy Mission:

India has announced plans to set up a National Hydrogen Energy Mission to produce some of the world's cheapest hydrogen by 2050 using low-priced renewable power sources. This mission aims to transition to hydrogen-based technology for steelmaking and other industrial processes to reduce greenhouse gas emissions (Ministry of Environment Forest and Climate Change, 2022).

3. National Action Plan on Climate Change (NAPCC):

India has implemented the National Action Plan on Climate Change, which includes missions in specific areas like solar energy, energy efficiency, water, sustainable agriculture, and green initiatives. The NAPCC provides an overarching framework for all climate actions in India, focusing on low-carbon, sustainable development (Ministry of Environment Forest and Climate Change, 2022).

4. State Action Plans on Climate Change (SAPCC):

Thirty-three States/Union Territories in India have prepared their State Action Plans on Climate Change in line with the NAPCC, addressing state-specific issues related to climate change and outlining sector-specific priority actions, including adaptation (Ministry of Environment Forest and Climate Change, 2022).

5. International Coalitions:

India has launched international coalitions like the International Solar Alliance (ISA) and the Coalition for Disaster Resilient Infrastructure (CDRI) to address climate change at a global level. New initiatives under CDRI and ISA, such as Infrastructure for Resilient Island States (IRIS) and Green Grids Initiative—One Sun One World One Grid (GGI-OSOWOG), were launched at COP26 in Glasgow (Ministry of Environment Forest and Climate Change, 2022).

6. Renewable Energy Targets:

India has set ambitious renewable energy targets, aiming to reach 450 GW by 2030 and 500 GW by 2030, as declared at COP26. The country is working towards installing 50% of non-fossil sources to generate power by 2030, emphasizing the transition to cleaner energy sources (Rao, 2022).

These steps reflect India's commitment to reducing CO_2 emissions and transitioning towards a more sustainable and environmentally friendly development path.

1.2 Trade, Economic Growth and India

The relationship between trade, economic growth, and India is a complex and evolving one, as highlighted in several research papers. Analyzing this relationship reveals key insights into India's economic dynamics:

Trade Openness and Economic Growth: A comparative study between China and India shows that both countries have experienced growth through trade, with China being more integrated into global trade than India. While both nations have seen an increase in export-GDP ratios since 1991, the global recession in 2008 impacted these figures. China has emerged as India's largest trading partner, but India faces challenges due to a growing bilateral trade gap, which can be addressed by focusing on technology-intensive exports to China (Falendra Kumar Sudan, 2022), (Orhan et al., 2021).

Environmental Sustainability and Economic Growth: Research in India has explored the linkage between economic growth, CO_2 emissions, and environmental sustainability. Studies have shown that agriculture and energy consumption play crucial roles in determining CO_2

emissions, with trade openness not significantly affecting environmental degradation. Policy measures are recommended based on these findings to ensure sustainable economic growth while mitigating environmental impact (Khan & Gupta, 2020).

FDI and Trade Openness: The role of Foreign Direct Investment (FDI) and trade openness in India's energy security, economic growth, and environmental sustainability has been investigated. These studies emphasize the importance of FDI and trade openness in shaping environmental outcomes and economic development in the country (Nepal et al., 2021), (Zameer et al., 2020).

The interplay between trade, economic growth, and environmental sustainability in India underscores the need for strategic policies that balance economic expansion with environmental preservation, leveraging trade relationships and foreign investments to foster sustainable development.

1.2.1 The widely marked impact of trade on economic growth

The key findings regarding the impact of trade on economic growth are:

1. Positive Impact of Trade Openness:

Studies on Ghana, Nigeria, and Côte d'Ivoire have found that trade openness has a positive and significant impact on economic growth, both in the short and long run (Oppong-Baah et al., 2022). The results suggest that increased trade openness and integration into the global economy can promote economic growth in developing countries (Keho, 2017).

2. Role of Complementary Factors:

The impact of trade on growth is influenced by other complementary factors, such as capital formation and human capital. Research on Asian countries indicates that trade openness and human capital have a significant positive relationship with economic growth, while labor force participation can have a negative effect (Amna Intisar et al., 2020). In Côte d'Ivoire, the study found a positive and strong complementary relationship between trade openness and capital formation in driving economic growth (Keho, 2017).

3. Intra-Industry Trade and Growth:

A study on the impact of marginal intra-industry trade (a proxy for trade openness) found that it has a positive impact on economic growth, suggesting that the dynamics of trade patterns matter for growth (Leitao, 2012).

4. Heterogeneity across Regions:

The impact of trade openness, FDI, and other factors on growth can vary across different regions or country groups, as seen in the contrasting results for Western and Southern Asia (Amna Intisar et al., 2020). The research evidence indicates that trade openness and integration into the global economy can have a positive impact on economic growth, but the magnitude and nature of this impact are influenced by complementary factors such as capital formation, human capital, and the specific trade patterns of a country or region.

In particular for India, trade has affected economic growth in various ways, which have been researched:

1. Positive Impact of Trade Openness:

Studies have found that trade openness has a positive and significant impact on economic growth in India, both in the short and long run (Karimzadeh & Karimzadeh, 2013). The research suggests that increased trade openness and integration into the global economy can promote economic growth in India (Manocha, 2023).

2. Role of Complementary Factors:

The impact of trade on growth in India is influenced by other complementary factors, such as human capital and capital formation(Leitao, 2012). Research indicates that trade openness and human capital have a significant positive relationship with economic growth in India, while labor force participation can have a negative effect (Karimzadeh & Karimzadeh, 2013). In the case of India, the complementary relationship between trade openness and capital formation is found to be positive and strong in driving economic growth (Oppong-Baah et al., 2022).

3. Intra-Industry Trade and Growth:

A study on the impact of marginal intra-industry trade (a proxy for trade openness) found that it has a positive impact on economic growth in India, suggesting that the dynamics of trade patterns matter for growth (Manocha, 2023).

4. Bidirectional Causality:

The research also points to a bidirectional causality between merchandise trade, services trade, and economic growth in India, suggesting a mutually reinforcing relationship (Bhattacharyya & Bhattacharya, 2023). Research evidence suggests that trade openness and integration into the global economy have had a positive impact on economic growth in India. However, the magnitude and nature of this impact are influenced by complementary factors such as human capital and capital formation, as well as the specific trade patterns of the country.

1.2.2 What are the environmental impacts of India's trade?

Trade openness and foreign direct investment (FDI) in India have been found to contribute to increased carbon emissions and environmental degradation. The "pollution haven hypothesis" suggests that India's trade and investment policies have led to a shift towards more polluting industries. Studies using the STIRPAT (Stochastic Impacts by Regression on Population, Affluence and Technology) framework have empirically validated the Environmental Kuznets Curve (EKC) for India, showing that economic growth and population growth initially lead to higher carbon emissions, but at higher levels of development, emissions start to decline (Manocha, 2023). However, trade openness and FDI inflows in India have been found to contradict the EKC, suggesting that they contribute to environmental degradation rather than mitigation (Khan & Gupta, 2020).

The agriculture and energy consumption sectors in India have been identified as crucial determinants of carbon emissions, with trade openness not having a significant direct impact on environmental quality (Orhan et al., 2021).

Fixed Capital Formation and Carbon Emissions: The liberalization of India's economy through trade reforms has influenced carbon emissions. Post-liberalization, there is a significant positive impact of fixed capital formation on carbon emissions, highlighting the role of trade liberalization in shaping environmental outcomes in the country (Prakash & Sethi, 2023).

To address these environmental challenges, the studies recommend policy initiatives towards green and sustainable production processes, as well as leveraging trade in climate-friendly goods and technologies to support India's climate change mitigation efforts (Manocha, 2023), (Dinda, 2018).

In summary, the research indicates that India's trade policies, particularly increased trade openness and FDI, have had adverse environmental impacts, contributing to higher carbon emissions and environmental degradation. Balancing economic growth with environmental sustainability remains a key policy challenge for India.

1.2.3 The dynamic between international trade and CO2 emissions

The relationship between international trade and carbon emissions is multifaceted, as highlighted in these points:

1. Trade Rule Uncertainty and Carbon Emissions:

One study emphasizes that increasing trade volume in developing countries can lead to trade rule uncertainty, triggering conflicts and potentially impacting carbon emissions. This uncertainty plays a mediating role in the relationship between international trade and carbon emissions (Zhao et al., 2023).

2. Dual-Edged Impact of Foreign Trade:

Another source discusses how foreign trade can have a dual impact on carbon emissions. While it promotes emissions in local and similar economic areas, it also exhibits a dual-threshold effect on economic development. This suggests that foreign trade can both contribute to and potentially mitigate carbon emissions, depending on the context and economic conditions (Gao et al., 2021).

3. Import-Export Dynamics in China:

Research focusing on China reveals that there is a positive correlation between imports and carbon emissions, while exports have a contrary relationship. The study suggests that China should import more high-tech products to upgrade high-emission industries and reduce the proportion of labor-intensive products exported to control carbon emissions effectively (J. Wang & Li, 2021).

4. Threshold Impact of Foreign Trade Openness and FDI:

A study on the relationship between foreign trade openness, foreign direct investment (FDI), and carbon emissions highlights a threefold threshold impact on industrial carbon emissions. FDI initially lowers and then increases emissions, while foreign trade openness has both positive and negative effects, exacerbating emissions in some sectors and mitigating them in others. This underscores the complex interplay between trade, investment, and carbon emissions in industrial sectors (Salman et al., 2023).

5. Net Impacts of International Trade on CO2 Emissions in Africa:

The study on African countries suggests that there is a significant impact of net trade on CO2 emissions, along with other factors like population size and the manufacturing sector. The findings indicate that changes in net trade can lead to corresponding changes in CO2 emissions, with different effects observed across income levels in African countries (Abdulrasaki, 2021).

The relationship between international trade and carbon emissions is influenced by various factors such as trade rule uncertainty, the nature of trade activities (imports vs. exports), the impact of foreign trade openness and FDI, and the specific context of different regions and income levels. These studies highlight the complexity of how international trade can both contribute to and potentially mitigate carbon emissions, emphasizing the need for strategic policies to address environmental concerns while fostering economic growth through trade.

1.2.4 The dynamic between economic growth and CO2 emissions

The relationship between economic growth and carbon emissions is complex and influenced by various factors. Research has explored the connections between economic growth, carbon emissions, and renewable and non-renewable energy in China, highlighting the need for a nuanced understanding of this relationship (Zhang & Zhang, 2021). The nexus among economic growth, carbon emissions, and renewable and non-renewable energy in China is a critical area of study, as it can inform policy decisions aimed at reducing carbon emissions while promoting economic growth.

Threshold Impact of Foreign Trade Openness and FDI

Research has examined the relationships among carbon emissions (CO_2), foreign trade openness, and foreign direct investment (FDI). The influence of the industrial sector on carbon emissions was evaluated using a threshold regression model, which showed a threefold threshold impact on industrial carbon emissions (Salman et al., 2023). The industrial sector's carbon emissions and foreign direct investment (FDI) exhibit a trend of first decreasing and then increasing emissions, suggesting possible harm. On the other hand, unrestricted commerce with other countries has an impact on carbon emissions that is both beneficial and harmful. Openness to international commerce reduces emissions in industries with high carbon emission levels but increases emissions in industries with lower carbon intensity.

Cointegration and Multivariate Causality

Cointegration and linear and nonlinear Granger causality have also been used in multivariate settings to study the connections between China's economic growth, CO_2 emissions, and use of fossil fuels (Lv et al., 2019). According to the research, rising CO_2 emissions boost economic growth both now and in the future, both linearly and nonlinearly. This suggests that China's economic growth is not always going to slow down when CO_2 emissions and/or the use of fossil fuels are reduced.

Population Aging and the Economic Growth-Carbon Emissions Nexus

A population aging threshold effect between per capita GDP and per capita carbon emissions has been found by analyzing the influence of aging populations on the link between economic growth and carbon emissions (Q. Wang et al., 2023). This suggests that the age of the population has a significant impact on how economic growth and carbon emissions are related. Despite the fact that economic growth and carbon emissions are correlated, the correlation weakens as population aging exceeds a certain threshold. This implies that the decoupling of economic growth and carbon emissions is facilitated by the aging of the population.

International Trade and Carbon Emissions

The relationship between international trade and carbon emissions has been explored, highlighting the dual-edged nature of foreign trade (Gao et al., 2021). While foreign trade promotes carbon emissions in local and similar economic areas, it has an apparent dual-threshold effect on economic development. This suggests that countries can focus on overall planning and coordination to promote the optimal allocation of resources and reduce carbon emissions based on their development stages and comparative advantages.

In summary, the relationship between economic growth and carbon emissions is influenced by various factors, including the threshold impact of foreign trade openness and FDI, cointegration and multivariate causality, population aging, and international trade. These findings can inform policy decisions aimed at reducing carbon emissions while promoting economic growth.

1.3 Transportation infrastructure in India

Transportation infrastructure in India encompasses a variety of elements crucial for the movement of goods and people within the country. This infrastructure includes roads, railways, ports, inland waterways, airports, and urban transport systems. The development of transportation infrastructure in India is vital for economic growth, connectivity, and overall development. Key components of transportation infrastructure in India are:

Roads: India's road network plays a significant role in transporting both passengers and goods. Despite challenges like low road quality and poor access to rural areas, the country has been expanding its highway network rapidly to improve connectivity.

Railways: Indian Railways is a major mode of transportation, with a vast network connecting various parts of the country. The railways have been crucial in facilitating the movement of people and goods, contributing to economic development.

Ports and Shipping: India's ports are essential for international trade, facilitating the import and export of goods. The development of ports is crucial for enhancing trade and economic growth.

Inland Waterways: Inland waterways provide an alternative mode of transportation, particularly for bulk goods. Developing this infrastructure can reduce transportation costs and ease congestion on roads and railways.

Airports: India's aviation sector has been growing rapidly, with increasing air travel demand. The expansion and modernization of airports are essential for accommodating this growth and improving connectivity.

Urban Transport: Urban transport systems, including metros, buses, and other modes of public transportation, are vital for ensuring efficient movement within cities. Improving urban transport infrastructure is crucial for enhancing livability and productivity in urban areas.

Overall, transportation infrastructure in India is undergoing significant development to meet the growing demands of a rapidly expanding economy and population. The government's focus on infrastructure development, including transportation, is aimed at boosting economic growth, connectivity, and overall development across the country.

1.3.1 Infrastructure as a logistic aid for economic movement in a country

Infrastructure plays a crucial role as a logistic aid for economic movement in a country, facilitating the smooth flow of goods and services. In India, the development of logistics infrastructure, including roads, railways, waterways, and air networks, is essential for economic growth and connectivity. The logistics sector enables businesses to access domestic markets and ensures consumers have a wide array of products, sustaining domestic consumption and fueling economic growth. McKinsey & Company's research highlights the significance of logistics infrastructure in India's economic development, emphasizing the need for increased investment to meet the growing demand for freight movement in the coming years (Building India: Transforming The Logistics Sector In India, n.d.). The Government of India has been focusing on enhancing road infrastructure, with significant budget allocations for roadways and rural development projects to improve urban-rural connectivity (NITI Aayog and Rocky Mountain Institute, 2018). Additionally, regulatory reforms are being prioritized to attract more foreign investment into India's transport sector, with a projected need for substantial investments to advance the country's transport infrastructure by 2035 (Varghese, 2018). Granting infrastructure status to the logistics sector is a significant step taken by the government to boost the sector and promote integrated development at the state level, emphasizing the importance of logistics and supply chain management in addressing industry challenges comprehensively (Department of Commerce, 2021). Overall, robust logistics infrastructure is vital for efficient economic movement, trade facilitation, and overall economic development in India.

Infrastructure plays a crucial role in facilitating economic movement within a country by providing the necessary physical framework for transportation, communication, and energy distribution. Here are some key points highlighting the significance of infrastructure in supporting economic activities:

1. Transportation Networks: Well-developed transportation infrastructure, including roads, railways, ports, and airports, enables the efficient movement of goods and people. This connectivity reduces transportation costs, enhances trade, and boosts economic growth.

2. Communication Infrastructure: Robust communication networks, such as internet connectivity and telecommunications systems, are essential for businesses to operate efficiently, access markets, and engage in global trade. Reliable communication infrastructure fosters innovation and competitiveness.

3. Energy Infrastructure: Adequate energy infrastructure, including power generation and distribution systems, is vital for industrial production, commercial activities, and overall economic development. Reliable energy supply is a cornerstone for economic growth.

4. Water and Sanitation Infrastructure: Access to clean water and proper sanitation facilities is fundamental for public health, productivity, and economic progress. Developing water and sanitation infrastructure contributes to a healthier workforce and improved living standards.

5. Investment Magnet: Countries with well-developed infrastructure often attract more investments due to the ease of doing business, reduced operational costs, and increased market accessibility. Infrastructure acts as a magnet for both domestic and foreign investments, driving economic expansion.

In conclusion, infrastructure serves as a vital logistic aid for economic movement in a country by creating an enabling environment for businesses to thrive, facilitating trade, reducing costs, and attracting investments. A well-planned and maintained infrastructure network is essential for sustainable economic development and prosperity.

1.3.2 Transportation infrastructure, economic agglomeration and urbanization

Transportation infrastructure, economic agglomeration, and urbanization are interconnected factors that significantly influence each other in the context of economic development.

1. Transportation Infrastructure:

Transportation infrastructure plays a crucial role in shaping economic agglomeration and urbanization patterns by affecting the efficiency of production factors, spatial distances, and transportation costs between regions (Wu, 2020).

The development of road infrastructure has historically impacted land use changes in cities, accelerating urbanization and city agglomeration while also posing challenges such as rapid urbanization and environmental issues (Hartatik et al., 2022).

Proxies for transportation infrastructure positively influence the location of new foreign-owned manufacturing plants, highlighting its importance in attracting foreign direct investment (Coughlin & Segev, 2000).

2. Economic Agglomeration:

Economic agglomeration, driven by factors like transportation infrastructure, urbanization, and industrial concentration, is a key aspect of regional economic development. The spatial effect of urbanization and transportation infrastructure significantly impacts manufacturing industry agglomeration, with nonlinear relationships observed between these factors (Xi-gu, 2014).

Factors like banking concentration, foreign openness, and information, along with transportation infrastructure, play significant roles in manufacturing agglomeration (Wu, 2020).

3. Urbanization:

Urbanization provides resource elements for industrial agglomeration and accelerates urban population agglomeration, influencing the spatial dynamics of economic activities. Urban population growth generates a high demand for urban transportation, with provincial and economic center cities serving as key agglomeration centers for population and industries (Wu, 2020).

Urban areas tend to have more favorable conditions for foreign direct investment, with factors like labor force quality, agglomeration economies, and transportation infrastructure playing key roles in location decisions (Coughlin & Segev, 2000).

Transportation infrastructure, economic agglomeration, and urbanization are intertwined elements that shape the economic landscape of regions, influencing industrial concentration, population dynamics, and investment patterns. The interaction between these factors underscores the importance of well-planned infrastructure development in fostering economic growth and regional competitiveness.

1.3.3 The dynamic between transportation infrastructure and CO2 emissions

The relationship between transportation infrastructure and CO2 emissions can be summarized as follows:

1. Positive Relationship: Transportation infrastructure development generally has a positive and statistically significant relationship with CO2 emissions. Investments in transportation infrastructure, such as roads, railways, and other modes of transport, tend to increase CO2 emissions in the long run.

2. Nonlinear Relationship: Some studies suggest a nonlinear, or "Transportation Kuznets Curve" relationship between transportation infrastructure investment and CO2 emissions (Beysatlar & Berk. I., 2019). This implies that at lower levels of infrastructure development, emissions may increase, but at higher levels, emissions may start to decline.

3. Sectoral Differences: The impact of transportation infrastructure on CO2 emissions may vary across different sectors. For example, research and development (R&D) spending in China was found to be significant in the lower quantiles, suggesting that R&D is mainly allocated to sectors with higher emissions (Han et al., 2023).

4. Policy Implications: The evidence highlights the need for policymakers to consider sustainable transportation infrastructure development, such as investments in low-carbon transportation options (e.g., railways, urban metros, light rail) to mitigate the environmental impact of transportation (Y. Liu et al., 2023), (Han et al., 2023).

In summary, transportation infrastructure development generally has a positive relationship with CO2 emissions, though the nature of this relationship may be nonlinear and vary across different sectors. Policymakers should focus on promoting sustainable transportation infrastructure to balance economic development and environmental protection.

CHAPTER 02

LITERATURE REVIEW

2.1 Review of Literature

Dai, J., Alvarado, R., Ali, S. et al. analyze the transport infrastructure, economic growth, and transport CO_2 emissions nexus and question if green energy consumption in the transport sector matters? This paper finds that the transport EKC is invalid in the case of the US, and increased growth levels are harmful to the environment. The association between TCO_2 and economic growth is similar to a U-shaped curve. This study assesses the role of transport renewable energy consumption (TRN) in TCO_2 by taking into consideration transport fossil fuel consumption (TTF) and road infrastructure (RF) from 1970 to 2019 for the United States (US). This study assessed the presence of transport environmental Kuznets curve (EKC) to assess the direction of transport-induced growth. (Dai et al., 2023)

Patel, N and my esteemed advisor Mehta, D (2023) reported on the asymmetry effect of industrialization, financial development and globalization on CO_2 emissions in India. This study explores the impact of India's economic growth, industrial development, fossil fuel energy output, financial development, and globalization on CO_2 emissions. The findings suggest a long-term association between CO_2 emissions and these factors. Industrialization and economic expansion have a positive impact on CO_2 emissions, while globalization reduces them. The study emphasizes the importance of policymakers focusing on economic development while also addressing environmental concerns. India should enact laws supporting cleaner production practices and non-polluting sectors to uphold sustainability commitments and discourage CO_2 emitting industries. The study used Non-Linear autoregressive distributive lag (NARDL) to analyze the relationship using data from 1971 to 2019. (Patel & Mehta, 2023)

In 'Can nuclear energy fuel an environmentally sustainable economic growth?', Bandyopadhyay and Rej (2021) noted that this study explores the relationship between GDP, FDI, nuclear energy consumption, trade openness, and CO_2 emissions in India from 1978-2019. It confirms an inverted N-shaped environmental Kuznets curve and a J-shaped relationship between FDI and CO_2 emissions. Trade openness benefits environmental quality, while nuclear energy consumption improves air quality. The study suggests policy recommendations for sustainable economic growth and highlights the importance of nuclear energy in transitioning to a cleaner energy pathway. (Bandyopadhyay & Rej, 2021)

Sanjeev, A. and Kaur, S. (2020) described environmental sustainability, trade and economic growth in India. The text discusses the relationship between economic growth, trade openness, and environmental degradation in India from 1980 to 2012. It explores the impact of factors such as FDI, energy consumption, and oil prices on carbon emissions. The study validates the existence of an inverted U-shaped Environmental Kuznets Curve (EKC) in the short run, indicating that carbon emissions decrease after a certain GDP per capita threshold is reached. The findings suggest that trade openness and economic freedom play a role in reducing carbon emissions. The study also forecasts a continued growth in global CO2 emissions. (Sajeev & Kaur, 2020)

Rana and Sharma (2018) reported on dynamic causality testing for EKC hypothesis, pollution haven hypothesis and international trade in India. This study explores the relationships between foreign direct investment, economic growth, and CO2 emissions in India using data from 1982-2013. The study finds evidence of the Pollution Haven Hypothesis and Environmental Kuznets Curve in India. It also shows that FDI influences exports, which in turn affect imports and CO2 emissions. Additionally, CO2 emissions and GDP have a mutual relationship in India. (Rana & Sharma, 2019)

Solarin, S. A., Al-Mulali, U., Ozturk, I. (2017) reported that the research examines the relationship between CO2 emissions, hydroelectricity consumption, urbanization, and real GDP in China and India from 1965-2013. The study finds that real GDP and urbanization have a positive long-term impact on emissions, while hydroelectricity consumption has a negative long-term impact. The results support the environmental Kuznets curve hypothesis in both countries, showing a bidirectional relationship between the variables. (Adebola Solarin et al., 2017)

A research team led by Franco, S. from the National Remote Sensing Centre (2017) studied urbanization, energy consumption and emissions in the Indian context A review. India, a rapidly urbanizing country with a growing economy and large population, is facing challenges related to energy consumption and emissions. A study explores the relationship between urbanization, energy use, and emissions, recommending measures such as energy efficiency incentives and smart grid investments to address these issues. Urbanization has a significant impact on carbon dioxide emissions, and understanding the urbanization process in India is crucial for sustainable development. (Franco et al., 2017)

In 'CO2 emissions structure of Indian economy', a research group led by Jyoti Parikh at the Indira Gandhi Institute of Development Research (2009) reported that the analysis of carbon dioxide emissions in the Indian economy for the year 2003-04 shows that total emissions were 1217 million tons, with 57% coming from coal and lignite use. The highest direct emissions were from the electricity sector, followed by manufacturing, steel, and road transportation. The top 10% of the urban population in India had emissions one-sixth of those in the US. Construction and manufacturing sectors had the highest emissions due to both direct and indirect factors. The per capita emissions were about 1.14 tons, with significant lifestyle differences in emissions across income classes. (Parikh et al., 2009)

The impact of economic growth, trade openness and manufacturing on CO2 emissions in India was analyzed using the autoregressive distributive lag (ARDL) bounds test approach by Karedla Yaswanth et. al. The study finds that there exists a long-run relationship between CO2 emissions and economic growth, trade openness, and manufacturing in India. Trade openness has a significant negative association with CO2 emissions in the long run. As trade opens up, it facilitates the spillover of cleaner and more efficient technologies, which helps reduce environmental degradation. Manufacturing and GDP per capita have a significant and positive relationship with CO2 emissions in the long run. As India is a developing country, its increasing economic activity requires higher energy demand, which is more reliant on fossil fuels, increasing CO2 emissions. Every 1% increase in GDP leads to a 2.56% increase in CO2 emissions in India. To keep its commitment to sustainability, India needs to implement regulations that encourage cleaner manufacturing methods, establish non-polluting industries, and disincentivize CO2-emitting industries through policy frameworks such as carbon taxes, pollution taxes or green taxes. Simultaneously, India should encourage preferential trade policies with a particular emphasis on technological value addition through reciprocal trade liberalization and removal of trade barriers (Karedla et al., 2021)

In ‘Dynamic linkages among transport energy consumption, income and CO2 emission in Malaysia’, a research team led by Aziz Azlina from the Universiti Malaysia Terengganu (2014) noted that this paper analyzes the relationship between income, energy use, and carbon dioxide emissions in Malaysia from 1975 to 2011. The study finds a long-run relationship between these variables but does not fully support the environmental Kuznet curve hypothesis. Income is found to Granger-cause energy consumption and renewable energy use, while structural change and renewable energy use Granger-cause energy consumption in road transportation. The study also shows that the relationship between GDP and CO2 emissions is unidirectional. (Azlina et al., 2014)

In ‘Transport CO2 emissions, drivers, and mitigation’, Zahoor Ahmed and colleagues (2020) noted that India's transport sector heavily relies on oil products for over 95% of its energy needs, leading to significant environmental degradation in urban areas. Economic growth and road sector energy use contribute to increased transport emissions, while urbanization helps mitigate them. Industrialization and road infrastructure also play a role in stimulating transport emissions. Oil prices do not influence transport emissions. Policy ramifications are suggested to reduce CO2 emissions for a sustainable environment in India, which has one of the world's largest road transportation networks. (Ahmed et al., 2020)

A team led by Tomiwa Adebayo from the Instituto Superior de Gestão (2021) reported on modeling the Dynamic Linkage between Renewable Energy Consumption, Globalization, and Environmental Degradation in South Korea. The research in South Korea examines the impact of energy use, renewable energy, globalization, and technological innovation on CO2 emissions. Technological innovation and globalization are found to predict CO2 emissions, with technological innovation having a negative impact on CO2 emissions. The study incorporates yearly data from 1980 to 2018 and uses econometric techniques to analyze the relationship. The ARDL bounds test reveals a long-term association between CO2 emissions and the variables. Extreme weather events in 2018 led to a significant increase in CO2 emissions, highlighting the urgent need to address climate change for human health and safety. (Adebayo et al., 2021)

Artur Tamazian and colleagues (2009) studied how does higher economic and financial development lead to environmental degradation. The study investigates the relationship between economic and financial development and environmental quality in BRIC economies. It finds that higher levels of economic and financial development lead to decreased environmental degradation. Financial liberalization and openness are important for reducing CO2 emissions. The inclusion of US and Japan in the analysis does not change the main findings. Previous studies have focused on the relationship between economic development and environmental degradation, but not financial development. (Tamazian et al., 2009)

A research group at the University of International Business and Economics led by Mahmood Ahmad (2021) report that this study examines the effects of financial globalization, urbanization, eco-innovation, and economic growth on the ecological footprints of the G7 countries. Financial globalization and eco-innovation reduce ecological footprints, while urbanization increases them. Eco-innovation can support sustainable urbanization. The study suggests that G7 countries should prioritize financial integration, eco-innovation projects, sustainable urbanization, and sustainable production and consumption to balance economic growth with environmental protection. The Environment Kuznets Curve hypothesis holds for the G7 countries. (Ahmad et al., 2021)

Debashis Mukherjee (2013) asks how do trade and investment flows affect environmental sustainability? FDI is increasingly directed towards LDCs and developing countries with a focus on primary and manufacturing products. A study analyzed data from 114 countries from 2000-2010, finding a negative relationship between environmental sustainability and merchandise export orientation and FDI inward movements, but a positive one with service exports and FDI outward movements. Higher income countries showed a positive relationship with environmental performance, while lower income countries displayed a negative coefficient. The study confirms the impact of trade and investment flows on environmental sustainability. (Chakraborty & Mukherjee, 2013)

In 'Dynamic modeling of causal relationship between energy consumption, CO_2 emissions and economic growth in India', a research group at the University of Plymouth led by Mohammad Alam (2011) reported that the study found bi-directional Granger causality between energy consumption and CO_2 emissions in the long-run, but no causal relationship between energy consumption and income. This suggests India can implement energy conservation policies without hindering economic growth and reduce CO_2 emissions to combat global warming. (Alam et al., 2011)

A research team led by Qiang Wang from the Fujian Normal University (2016) report that this paper examines the impact of urbanization on energy consumption and CO_2 emissions in China, taking into account provincial differences. Urbanization increases energy consumption and CO_2 emissions, with significant variations between provinces. In northern China, urbanization has a strong impact on CO_2 emissions due to heavy industry, while in post-industrial cities, it affects energy consumption in residential and service sectors. Western and central China see high energy consumption and emissions from industrial development. Eastern China has a smaller impact from urbanization due to a mix of light industry and rapid urbanization. The study provides evidence supporting urban environmental transition theory and highlights the importance of considering provincial differences in analyzing urbanization effects on energy consumption and CO_2 emissions. (Q. Wang et al., 2016)

Ke Lin (2015) described impacts of urbanization and industrialization on energy consumption/CO_2 emissions. Urbanization and industrialization impact energy consumption and CO_2 emissions differently based on income levels. In middle-/low-income and high-income countries, industrialization decreases energy consumption but increases CO_2 emissions. Urbanization increases both energy consumption and CO_2 emissions in these groups. For middle-/high-income countries, urbanization does not affect energy consumption but hinders emission growth, while industrialization has an insignificant impact. Different development strategies are needed based on income levels to conserve energy and reduce emissions. (K. Li & Lin, 2015)

2.2 Research Gap

India seems to be on autopilot in its growth possibilities. Its population is not only booming but is also increasingly enabled in its private spending capacities and demands of energy, transportation and goods. Its policies have positioned it to be a destination of investment and manufacturing and it is charted for a transition in its energy mix. By such nature, it is going to be associated with environmental emissions. The policy choices India makes and the targets it sets to reduce greenhouse gas (GHG) emissions are crucial to the world achieving the goal of 1.5°C pathway and not exceeding its carbon budget.

To fully comprehend their interacting capacity, all of these factors and their interactions must be investigated. This will make it easier to see how one variable affects the others and inspire consideration of how to keep each variable functioning at its peak in the context of long-term, sustainable economic growth.

The study that is done will also be empirical in character, which hasn't happened much in the Indian setting. Further, factors like the mobility and transportation infrastructure and economic development in terms of private consumption have never been studied for India in the same context previously. Additionally, the study will make use of the most recent data available, taking into account the structural disruption to the economy that the pandemic brought about.

2.3 Research Specifics

2.3.1 Research Objectives

The objectives of the study are:

- To measure the impact of economic growth on CO_2 emissions.
- To measure the impact of trade on CO_2 emissions.

To measure the impact of mobility and transport infrastructure on CO_2 emissions.

2.3.2 Research Questions

The questions this study aims to solve:

Does economic growth have an impact on CO_2 emissions of India?

Does trade an impact on CO_2 emissions of India?

Does mobility and transport infrastructure have an impact on CO_2 emissions of India?

CHAPTER 03

RESEARCH DESIGN

3.1 Johansen Co-integration Test:

The Johansen cointegration test is a statistical technique used to assess if two or more nonstationary time-series variables have a long-term, stable relationship. In the late 1980s, Danish econometrician Søren Johansen created it. In econometrics, this test is frequently employed, especially when analyzing financial and economic data, where variables may exhibit long-term relationships.

We must first comprehend the idea of stationarity in order to comprehend cointegration. A time series that exhibits stable statistical attributes over a given period of time is said to as steady. Conversely, non-stationary time series exhibit time-varying statistical characteristics. Non-stationary variables are frequently encountered while analyzing financial or economic data, and they can provide erroneous correlations and untrustworthy findings.

In order to investigate if a linear combination of nonstationary variables is stationary, cointegration is used to handle this problem. Put more simply, it looks into whether these factors have a lasting link, even if they each show trends or swings over time. The concept of cointegration is expanded to several variables using the Johansen cointegration test. This makes it possible for researchers to look for cointegrating correlations between many non-stationary time series at the same time. This is especially helpful when there could be more than two variables at play because it offers a thorough examination of the connections between them.

Johanson (1988) and Juselius (1990) Johansen's methodology takes its starting point in the vector auto-regression (VAR) of order (p) given by

$$\boldsymbol{Y_t} = \boldsymbol{\mu} + \boldsymbol{A_1 Y_{t-1}} + \ldots\ldots\ldots\ldots\ldots \boldsymbol{A_p Y_{t-p}} + \boldsymbol{\varepsilon_t}$$

Where $\boldsymbol{Y_t}$ is an **nx1** vector of variables that are integrated of order one commonly denoted I(1) and is an **nx1** vector of innovations. Johansen proposes two different likelihood ratio tests of the significance of canonical correlations: the trace test and maximum Eigen value test.

$$\boldsymbol{J_{trace}} = -\boldsymbol{T}\sum_{i=r+1}^{n} \boldsymbol{ln}\,(\boldsymbol{1} - \boldsymbol{\hat{\lambda}_i})$$

$$\boldsymbol{J_{max}} = -\boldsymbol{T}\,\boldsymbol{ln}(\boldsymbol{1} - \boldsymbol{\hat{\lambda}_{r+1}})$$

Where **T** = the number of observations and $\boldsymbol{\lambda\hat{i}}$ = the maximum eigen value. The null hypothesis that there is **r** of co-integrating vectors is tested against the alternative that there is **r + 1** co-integrating vectors.

Trace Statistic: The trace statistic is performed to test the null hypothesis that the number of cointegrating vectors is less than or equal to a specified value. It measures the overall significance of cointegration in the system. The trace statistic was determined by summing the eigenvalues associated with the estimated cointegrating vectors. These eigenvalues show the strength of cointegrating correlations.

If the estimated trace statistic exceeds the critical value from the appropriate statistical distribution (e.g., chi-squared distribution), the null hypothesis of at least the specified number of cointegrating vectors is rejected. This implies that major cointegrating linkages exist in the system.

Conversely, if the estimated trace statistic falls below the crucial value, then the null hypothesis cannot be rejected. This shows that there are fewer cointegrating relationships than the given number, or that there may be no cointegration at all.

Maximum Eigenvalue Statistic: Maximum eigenvalue statistic is employed to examine the null hypothesis, which states that the number of cointegrating vectors is precisely equal to the given value. This aids in determining the cointegrating matrix's rank, which expresses the quantity of cointegrating vectors that are linearly independent.

In order to determine the critical value from the relevant statistical distribution, the maximum eigenvalue statistic compares the largest eigenvalue of the estimated cointegrating matrix to it. The provided number of cointegrating vectors is the null hypothesis, and it is rejected if the calculated maximum eigenvalue is greater than the critical value. This suggests that the number of cointegrating vectors is more than predicted. On the other hand, the null hypothesis can't be discounted out if the computed highest eigenvalue is less than the critical value, indicating that there may be fewer cointegrating vectors than previously thought.

Through a combined analysis of the maximum eigenvalue statistic and the trace statistic, researchers can ascertain the proper quantity of cointegrating vectors within the system. In particular, cointegration between the variables is present if both statistics point to the need to reject the null hypothesis; the number of cointegrating vectors can then be calculated from the data. It might be necessary to do additional research to ascertain the actual nature of the cointegrating linkages in the system if only one statistic rejects the null hypothesis. In general, the trace statistic and the maximum eigenvalue statistic are important components of the Johansen cointegration test because they shed light on the number and significance of cointegrating vectors, which aids in the comprehension of the long-term equilibrium relationships between various time-series variables by researchers.

3.2 Research Hypothesis

For a Johansen cointegration test, which assesses whether there exists a long-term relationship among multiple time series variables, the hypotheses would typically be formulated as follows:

Null Hypothesis (H_0): There is no cointegration among the variables.
Alternative Hypothesis (H_1): There is cointegration among the variables.

Null Hypothesis (H_0):

The null hypothesis (H_0) for the Johansen cointegration test states that there is no cointegration among the variables. In other words, it assumes that the variables are not linearly related in the long run, and any observed correlations between them are merely coincidental or due to short-term fluctuations. Formally, the null hypothesis implies that the rank of the cointegration matrix is equal to zero.

When testing the null hypothesis using the Johansen cointegration test, researchers examine the trace statistic and the maximum eigenvalue statistic. These statistics are derived from the eigenvalues of the estimated cointegration matrix and provide insights into the number of cointegrating relationships present in the data.

Alternative Hypothesis (H_1):

The alternative hypothesis (H_1) for the Johansen cointegration test asserts that there is cointegration among the variables. This hypothesis suggests that the variables exhibit stable long-term relationships that cannot be explained by random fluctuations alone. In terms of the test statistics, the alternative hypothesis implies that the rank of the cointegration matrix is greater than zero.

When testing the alternative hypothesis using the Johansen cointegration test, researchers again focus on the trace statistic and the maximum eigenvalue statistic. These statistics help determine the number of cointegrating relationships present in the data and provide evidence in support of the existence of cointegration among the variables.

3.3 Data

3.3.1 Exploratory Research

Exploratory research is a type of research conducted to gain a better understanding of a topic or issue, especially when little is known about it. The main purposes are to:

1. Gain insight into a problem that is not clearly defined

2. Identify issues that could be the focus of future research

3. Test the feasibility of conducting further research

It is often used in the early stages of a research project, before more formal or conclusive research is conducted. Exploratory research is flexible and can address research questions of all types (what, why, how).

Common exploratory research methods include secondary research, informal and formal qualitative studies and pilot studies.

While exploratory research does not aim to provide conclusive evidence or test hypotheses, it can help researchers gain a better understanding of a problem, generate new ideas, and develop hypotheses to be tested in future research.

3.3.2 Quantitative research approach

In quantitative research, correlations between variables are investigated through the use of numerical data and statistical analysis. Structured data is collected from databases and subjected to rigorous statistical analysis utilizing techniques such as factor analysis, regression analysis, and correlation analysis. Finding patterns, relationships, or trends in the data as well as quantifying the strength and direction of correlations between variables are the goals. Due to the objective and quantitative results that this method produces, researchers are able to base their projections and conclusions on solid factual evidence.

3.4 Variable Description

3.4.1 Independent Variables

I. GDP (% change y-o-y)

The change in GDP is a good indicator of economic growth because GDP, or Gross Domestic Product, measures the total market value of all final goods and services produced within a country in a given period. This measurement is crucial as it reflects the economic activity and performance of a country. When there is an increase in GDP, it signifies growth in the economy, indicating higher production levels and increased economic activity. As GDP accounts for private and public consumption, investment, and net exports, a rise in GDP often correlates with improved living standards, higher incomes, and increased consumer spending, which are positive signs for the economy. GDP growth is used to assess the overall health of an economy, making it a key metric for economists and investors to gauge economic performance and make informed decisions. Considering its widespread use, it makes sense to use it to formulate this effort as part of a contiguous approach to understand the dynamic between economic growth and carbon emissions. In the context of this study, it helps reflect the substantial reasons that could lead production and consumption to be linked to carbon emissions.

Data Source: IMF’s World Economic Outlook Database

II. Import Volume (% change y-o-y)

The change in import trade volume is a good indicator of trade for several reasons:

1. Imports reflect domestic demand: An increase in import volume suggests higher domestic demand for foreign goods, which is a sign of economic growth and consumer confidence.
2. Imports drive export growth: As imports rise, domestic producers may need to increase exports to pay for the increased imports, driving overall trade growth.
3. Import volume tracks economic cycles: Imports tend to rise during economic expansions and fall during recessions, making import volume a useful indicator of the business cycle.
4. Imports influence exchange rates: Changes in import volume can affect exchange rates, as increased demand for foreign currency to pay for imports can lead to currency appreciation or depreciation.

5. Imports reflect trade policy changes: Shifts in import volume can signal changes in trade policies, such as tariffs or trade agreements, that impact trade flows.
Import volume is a valuable indicator because it reflects domestic demand, drives exports, tracks economic cycles, influences exchange rates, and responds to trade policy changes, providing insights into the overall health and direction of an economy's trade. In the context of this study, it helps reflect the substantial reasons that could lead trade volumes to be linked to carbon emissions.
Data Source: IMF’s World Economic Outlook Database

III. Export Volume (% change y-o-y)

The change in export trade volumes is a significant indicator of the international trade levels of a country due to several reasons outlined in the provided sources:
1. Export Growth Reflects Economic Performance: An increase in export volumes indicates a country's ability to produce goods and services competitively, showcasing economic strength and competitiveness.
2. Trade Balance and Foreign Exchange: Higher export volumes contribute to a positive trade balance, which is crucial for a country's economic stability and foreign exchange reserves.
3. Market Diversification and Growth Potential: Monitoring changes in export volumes helps countries identify market trends, diversify their export destinations, and tap into new growth opportunities.

4. Dependency on Regional Trade: The export intensity index measures a country's dependency on regional trade, highlighting the importance of exports in regional economic integration and cooperation.

5. Global Trade Dynamics: Changes in export volumes are closely linked to global trade dynamics, reflecting shifts in demand, supply chains, and economic relationships between countries.

Tracking changes in export trade volumes provides valuable insights into a country's economic performance, trade balance, market diversification, regional trade dependencies, and its position in the global trade landscape. In the context of this study, it helps reflect the substantial reasons that could lead trade volumes to be linked to carbon emissions.

Data Source: IMF’s World Economic Outlook Database

IV. Total Inland Transportation Infrastructure (constant USD per capita)

Transportation expenditure is a good representation of transportation infrastructure for several reasons:

1. Transportation expenditure reflects investment in new infrastructure and maintenance of existing networks. Higher spending signals a commitment to improving and expanding transportation systems.

2. Efficient transportation infrastructure provides economic and social benefits by improving market accessibility, productivity, regional development, employment, and connectivity. Tracking expenditure helps assess the level of these benefits.

3. In many developed economies, transportation accounts for 6-12% of GDP, with logistics costs ranging from 6-25% of GDP. Expenditure as a share of GDP indicates the priority placed on transportation infrastructure.

4. Transportation expenditure has both direct and indirect economic impacts, generating value and employment beyond the transportation sector itself. Monitoring expenditure provides insights into these broader economic effects.

5. Infrastructure investment, including transportation, can generate annual returns of 5-20% on capital invested. Expenditure levels signal the expected economic returns from infrastructure projects.

Transportation expenditure is a valuable indicator because it reflects infrastructure investment, economic and social benefits, macroeconomic significance, and direct and indirect economic impacts, providing a comprehensive assessment of the importance

of transportation infrastructure to a country's development. In the context of this study, total inland transportation expenditure is a fair representation of underlying infrastructure requirements including that of maintenance of old infrastructure as well as building of new infrastructure in order to aid the economy. It thus represents the probably causes that may be linking transportation infrastructure to carbon emissions.
Data Source: OECD.*Stat*

3.4.2 Dependent Variable

I. Carbon Emissions (% change y-o-y)

Carbon emissions refer to the release of carbon compounds, primarily carbon dioxide (CO_2), into the atmosphere. The main human-caused sources of carbon emissions are the burning of fossil fuels for energy and transportation, as well as industrial processes like cement manufacturing.

Carbon emissions are considered a major contributor to global warming and climate change because CO_2 is a greenhouse gas that absorbs infrared radiation, trapping heat in the atmosphere. Before the industrial revolution, CO_2 levels in the atmosphere were around 280 parts per million (ppm), but as of May 2022, they have risen to 421 ppm due to human activities.

Data Source: IMF’s Climate Change Indicators Dashboard

CHAPTER 04

DATA ANALYSIS AND INTERPRETATION

To determine if there are long-term correlations between several time series variables, the Johansen cointegration test is a commonly used technique. In the context of economic growth, trade, infrastructural development and carbon emissions in particular, this test offers insightful information on the dynamics between the economy and environment. The trace statistic and the maximum eigenvalue test will be used in this analysis to evaluate the Johansen cointegration test results.

4.1 Data Analysis

Three dependent variables indicating economic growth, trade and transportation infrastructure and dependent variable indicating carbon emissions are grouped under a single Johansen co-integration test on E-Views. This analysis is carried out with 26 observations under a linear deterministic trend under a 1st difference lag interval.

4.2 Data Interpretation

The alternative hypothesis, that there are cointegrating links between the variables, is tested against the null hypothesis, which states that there are at no cointegrating relationships, using the trace statistic.

In the trace statistics, since p-value <0.05, we reject the null hypothesis that there is no cointegration in favour of the alternative hypothesis that there are cointegrating relationships among the variables because the trace statistic is significant at the 5% level. This implies that the variables under investigation have 4 long-term links. As a result, we may draw the conclusion that there is cointegration among the variables, suggesting a long-term stable equilibrium relationship.

For the max-eigenvalue tests, since p-value>0.05, we reject the alternate hypothesis and can interpret that there may not be any cointegrating relationships between the variables.

The significant trace statistic but insignificant maximum eigenvalue test suggest that while there is evidence of cointegration among the variables at the first instance, a deeper involvement between variables must be found before it can be confirmed with the max-eigen value test. The implication here is that there may or may not be a stable long-run relationships among the variables, which persists over time. This indicates the requirement of more extensive data, wider coverage of variables and further testing, before any confirmation regarding the presence of cointegration between variable can be made.

E-Views Output for Johansen Cointegration:

Date: 05/14/24 Time: 14:15
Sample (adjusted): 1997 2022
Included observations: 26 after adjustments
Trend assumption: Linear deterministic trend
Series: IMPORT_VOLUME_CHANGE____CHANGE_Y_O_Y_ GDP_CHANGE...
Lags interval (in first differences): 1 to 1

Unrestricted Cointegration Rank Test (Trace)

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.543904	53.71107	47.85613	0.0128
At most 1 *	0.432748	33.29973	29.79707	0.0190
At most 2 *	0.348191	18.55899	15.49471	0.0167
At most 3 *	0.248590	7.430889	3.841465	0.0064

Trace test indicates 4 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None	0.543904	20.41134	27.58434	0.3134
At most 1	0.432748	14.74074	21.13162	0.3075
At most 2	0.348191	11.12810	14.26460	0.1479
At most 3 *	0.248590	7.430889	3.841465	0.0064

Max-eigenvalue test indicates no cointegration at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

CHAPTER 05

CONCLUSION

The findings of further study will help ascertain the interactions between the research variables. The degrees and directions of causality found will be helpful for policymakers to better ascertain the country's positional advantage in the context of the chosen variable.

An indirect goal of the research is also to further discussions about the importance of conversation about economic development in the context of reversing environmental degradation and sustainable growth.

While there cannot be conclusions of a certain nature considering the unconfirmed long-term cointegration between chosen variables, it is important to record what can be interpreted if further research allows both tests to confirm that all the variables display long term linkages.

Here are some conclusions that can be drawn if economic growth, trade, and transportation infrastructure are linked with carbon emissions in the long term:

<u>Economic activity and emissions are interconnected</u>: There's a complex relationship between economic growth and carbon emissions. While economic growth may initially lead to a decrease in emissions intensity (emissions per unit of GDP) as countries transition from heavy industry, overall emissions can still rise due to increased production and consumption.

<u>Trade can have a significant impact:</u> Increased trade can lead to higher emissions due to the transportation of goods over long distances. This can be mitigated by promoting sustainable shipping practices and developing more efficient trade routes.

<u>Infrastructure plays a dual role:</u> Transportation infrastructure can encourage emissions-intensive travel by car, but it can also facilitate the use of cleaner options like public transportation or electric vehicles. The design and use of infrastructure is crucial.

Overall, this link between economic activity and emissions necessitates a shift towards a "green economy" that prioritizes sustainability alongside economic growth.

5.1 Policy Implications:

Policy and innovation are key: Findings of this and further research will highlight the need for policies that promote sustainable economic growth, trade, and transportation infrastructure. This could involve investing in renewable energy sources, developing cleaner technologies, and encouraging energy efficiency.

Any further research in this direction, particularly with variables having wider ambit and more observation points, will help identify particularities better. The outcomes, in the form of identified causal relationships between chosen relationships, will help bring to the fore the importance of including conscious restrictions in the environmental context while super charging for economic and developmental growth. The weightage each variable is found to have on another across their relationship will help place India's future prospects and particularly bring forward the possibility of channelling India's strengths to bring to fruition India's economic capacity, and also, the realization of its environmental goals via pointed policy development.

Given the reality that increased trade, economic growth, and transportation infrastructure can lead to higher carbon emissions, several policy implications are confirmed and many others emerge in the context of decoupling emissions and economic growth, greening transportation infrastructure, technological innovation and international cooperation.

Energy Efficiency: Policies promoting energy-efficient technologies and practices across industries and buildings can significantly reduce emissions without hindering economic activity. This could involve tax breaks for energy-efficient equipment, stricter building codes, and investment in research and development (R&D) for clean technologies.

Carbon Pricing: Implementing a carbon tax or cap-and-trade system can incentivize businesses and consumers to reduce their carbon footprint. The revenue generated from a carbon tax could be used to invest in clean energy infrastructure and support affected industries in transitioning to lower-carbon operations.

Sustainable Trade Agreements: Trade agreements can be designed to promote environmentally friendly practices. This could involve incorporating environmental standards, encouraging the use of clean shipping technologies, and eliminating tariffs on green technologies.

Sustainable Infrastructure Development: Investing in infrastructure that supports low-carbon transportation options like electric vehicle charging stations, public transportation networks, and dedicated cycling lanes is crucial. Regulations can also encourage cleaner fuels and stricter emission standards for vehicles.

Clean Technology Investment: Government funding and incentives for research and development of clean energy technologies such as renewable energy sources, energy storage solutions, and carbon capture technologies are essential for long-term emissions reduction.

Innovation Partnerships: Collaboration between governments, businesses, and research institutions can accelerate the development and deployment of these clean technologies.

Global Climate Agreements: Strong international agreements with clear emissions reduction targets and mechanisms for enforcement are necessary to ensure all countries contribute to tackling climate change effectively.

Technology Transfer: Developed countries can assist developing nations in adopting clean technologies and infrastructure by providing financial aid, technical expertise, and knowledge transfer.

By implementing these policies, countries can strive for a more sustainable future where economic growth, trade, and infrastructure development are achieved alongside reductions in carbon emissions. The key lies in fostering innovation, collaboration, and a shared commitment to addressing climate change.

5.2 Limitations:

While this study is extensive with regards to a compilation of several academic sources and literature on the comparative and naturally dynamic interlinkages of the economy and environment, the results of the data analysed cannot confirm if the chosen variables are interlinked in the long term. The first two chapters are an good source for a largely complete reading about particulars regarding the chosen variables. The main limitations that emerge with the completion of this study are that it doesn't confirm cointegration and the inability to include all chosen variables in the equations to identify their grouped linkage. The fact that the max-eigenvalue test could not confirm cointegration explains the need for extensive data and larger observations. This may be arranged by using different variables that can represent the same factor with equal measure. It is thus important that a wider scope of variables is included, which have a large number of observation covering the decided factor and/or region extensively.

The Johansen cointegration test, while a valuable tool, has some limitations to consider. The test relies on asymptotic properties, meaning it performs best with large datasets. With a small number of observations, the results can be unreliable and misleading. For this reason, the variable of total inland transportation infrastructure could not be included due to unavailability of a longer time series. The test assumes the time series are integrated with order one, also known as I(1). If the data is instead near-integrated (meaning close to, but not perfectly, I(1)), the test statistics can become biased. The Johansen test requires choosing the appropriate lag length for the Vector Error Correction Model (VECM) used in the analysis. Selecting an incorrect lag can lead to inaccurate results. The test assumes the error terms in the model are normally distributed. Deviations from normality can affect the validity of the test. If the variables are endogenous (meaning their relationship is two-way), the test results may not accurately reflect the cointegration properties.

Quantitative analysis, while powerful for drawing certain conclusions, has some inherent limitations. It focuses on what can be measured and statistically analyzed. This can miss out on crucial qualitative factors like social changes, or unexpected events that can significantly impact outcomes - numbers don't tell the whole story. Quantitative analysis often struggles to capture the context behind the data. External factors or specific situations influencing the data points may not be reflected in the numbers themselves. Complex relationships between variables can be difficult to represent accurately in a quantitative model. The analysis might rely on assumptions that may not perfectly reflect reality. The entire analysis hinges on the quality of the data used. Inaccurate or incomplete data can lead to misleading results and faulty conclusions. Quantitative analysis excels at answering "what" happened questions by identifying trends and correlations. However, it often struggles to explain "why" these patterns occur, limiting deeper understanding.

CHAPTER 06

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CHAPTER 07

APPENDIX

Table 1: Data used in Study

Year	GDP Change (% change y-o-y)	Import volume change (% change y-o-y)	Export volume change (% change y-o-y)	Total inland transport infrastructure investment (constant USD per capita)	Carbon Emissions (% change y-o-y)
1995	7.575	14.162	13.133		7.209
1996	7.550	11.217	6.359		4.737
1997	4.050	13.024	11.495		5.394
1998	6.184	0.296	3.889		2.654
1999	8.463	6.739	4.870		6.882
2000	3.975	-2.196	16.038		3.591
2001	4.944	1.528	2.280		1.646
2002	3.907	9.916	17.205		3.817
2003	7.944	10.953	12.382		3.081
2004	7.849	28.658	15.147	6.762	7.965
2005	9.285	13.655	11.520	8.858	4.314
2006	9.264	6.211	10.262	9.987	6.808
2007	9.801	25.413	17.872	10.488	8.992
2008	3.891	18.061	1.770	12.016	6.412
2009	8.480	3.986	-2.387	11.886	9.396
2010	10.260	10.698	26.181	11.535	6.178
2011	6.638	16.707	13.742	10.290	6.188
2012	5.456	1.530	-0.132	11.581	9.380
2013	6.386	-3.251	6.702	14.297	3.015
2014	7.410	7.223	5.499	17.286	7.696
2015	7.996	0.208	-6.405	19.567	0.764
2016	8.256	2.111	7.826	18.735	1.926
2017	6.795	11.304	5.512		5.695
2018	6.454	3.757	5.413		5.764
2019	3.871	-5.464	-4.727		-1.260
2020	-5.831	-15.276	-7.610		-8.733
2021	9.050	20.863	22.214		8.994
2022	7.240	7.381	0.669		6.559

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