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Energy consumption and emissions in the CUIRJG countries and role of PAT in India

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Abstract

Global warming and a rise in carbon dioxide emissions has caused countries to revisit their dependence on fossil fuels. In the last two decades, carbon dioxide emissions have been rising, most of which comes from the consumption of fossil fuels. In order to ensure that countries take steps to reverse the alarming trend, the Paris Agreement came into effect in 2016. Out of all the countries that ratified the Agreement, the share of China, USA, India, Russian Federation, Japan and Germany or the CUIRJG countries has been the highest in total fossil fuel consumption and emissions. The paper evaluates the trends energy consumption, energy intensity, carbon dioxide emissions and rate of growth of carbon dioxide emissions in these six countries. Empirical results show that growth of carbon dioxide emissions has been declining, and a rise in energy intensity has led to a fall in growth of carbon dioxide emissions at an increasing rate. Specifically for the Indian case, the focus is on the Perform-Achieve-Trade policy whose objective is to promote energy efficiency in high energy consuming industries and sectors through market based industries.

1. Introduction

Global warming, exacerbated by carbon dioxide (CO_2) emissions has raised concerns about how countries meet their development goals and how steps need to be taken to move towards a more energy efficient world. It is of utmost importance because the world is still primarily dependent on fossil fuels to meet its energy requirements. Data shows that between the years 2000 to 2015, globally fossil fuel consumption as a percentage of total energy remained more than 80% (World Development Indicators, World Bank), where fossil fuels comprise of coal, oil, petroleum and natural gas products. Carbon dioxide emissions have also registered an increasing trend in this time period, though there are differences depending on the type of fuel considered. Emissions from solid fuel has been the highest, where solid fuel refers to coal as an energy source. This is followed by emissions from liquid fuel, where liquid fuel comprises of petroleum derived fuels. Finally, emissions from gaseous fuels are the lowest and has remained almost constant, where gaseous fuels refer to natural gas as an energy source.

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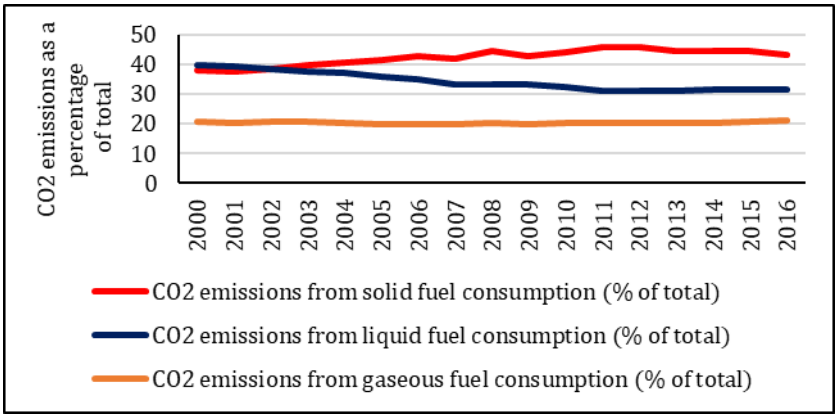


Figure 1. CO_2 emissions from variuos types of fossil fuels (% of total) for 2000-2016

Source: World Development Indicators, World Bank

Therefore, improving efficiency in energy use will help to reduce carbon dioxide emissions overtime, and slow down its rate of growth in the short run.

This is also the basis of the Paris Agreement, that came into effect from November 2016 onwards. The agreement set goals to achieve a reduction in global warming, and requires countries to take steps to reduce their greenhouse gas emission levels through numerous economic and social changes. Out of the 196 parties that have adopted the Paris agreement, China, USA, India, Russian Federation, Japan and Germany or the CUIRJG countries, have had the highest carbon dioxide emissions. One reason is that the overall fossil fuel consumption as a percentage of global consumption of fossil fuels, comprising of the consumption of oil, natural gas and coal, was the highest for CUIRJG countries, as compared to the total for the rest of the world, as shown in Figure 2.

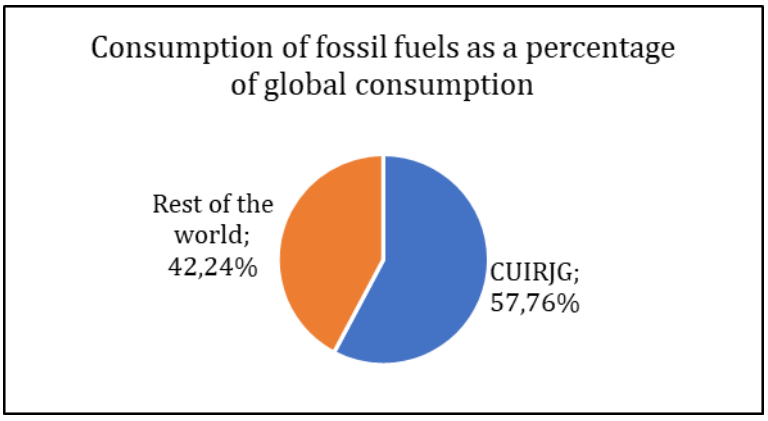


Figure 2. Consumption of fossil fuels by CUIRJG countries and the rest of the world, as a percentage of global consumption of fossil fuels.

Source: BP Statistical Review of World Energy, 2021

The high correlation between fossil fuel consumption and emissions have led to these countries having the highest emission levels as well. Figure 3 shows the carbon dioxide emissions as a percentage of overall global emissions in the year 2019[1] and Figure 4 shows the trends in carbon dioxide emissions as a percentage of world total, for the CUIRJG countries and the rest of the world for the period 2000-2018.

[1] Year 2020 has not been considered as the COVID pandemic lockdowns were in effect in many countries.

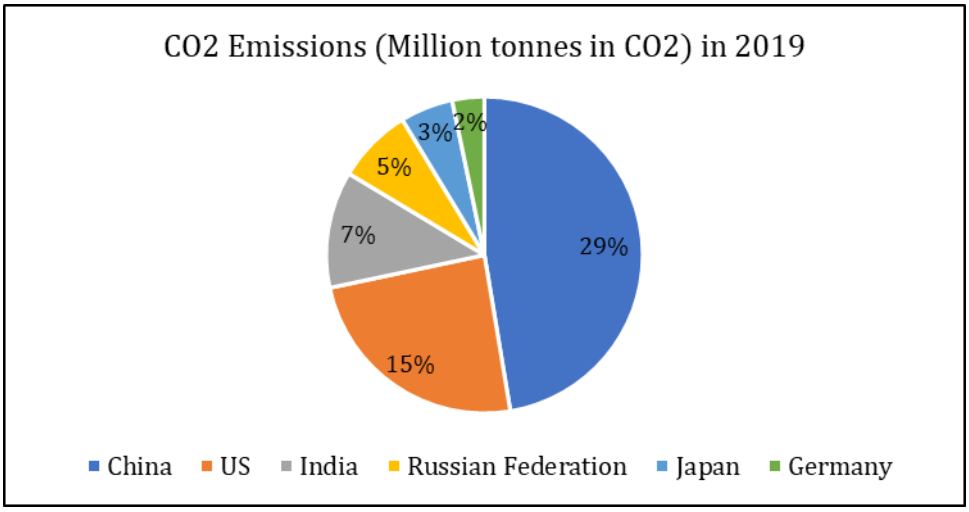


Figure 3. Carbon dioxide emissions as a percentage of overall global emissions in the year 2019

Source: BP Statistical Review of World Energy, 2021

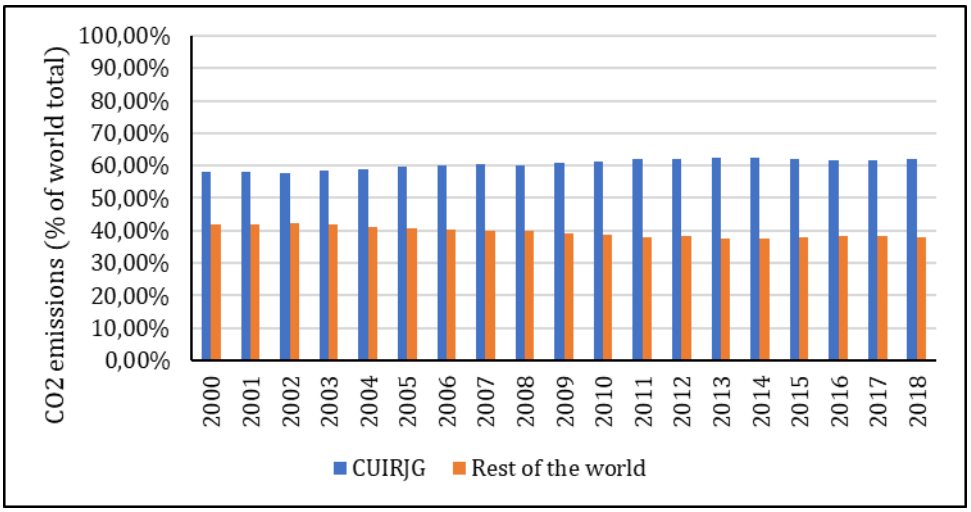


Figure 4. Carbon dioxide emissions as a percentage of world total, 2000-2018

Source: World Development Indicators, World Bank

As Figure 4 clearly indicates, for all the CUIRJG countries taken together, carbon dioxide emissions have been consistently higher than the rest of the world. Therefore, if energy in the form of fossil fuels is used more efficiently in these countries, then a greater decline in emissions can be achieved at the global level. The next section analyses the trends in various types of fossil fuels, carbon dioxide emissions and energy intensity within the CUIRJG countries. The last section elaborates on an energy intensity improvement policy introduced by the Government of India to improve the specific energy consumption of high energy consuming industries in India.

2. CUIRJG countries: Trends in emissions and energy consumption

The CUIRJG countries as a block had the highest fossil fuel consumption and highest emissions in the last decade. Within this block, consumption is not uniform between countries. Consumption of fossil fuels as a percentage of the overall global consumption, is the highest for China, followed by USA, India, Russian Federation, Japan and Germany.

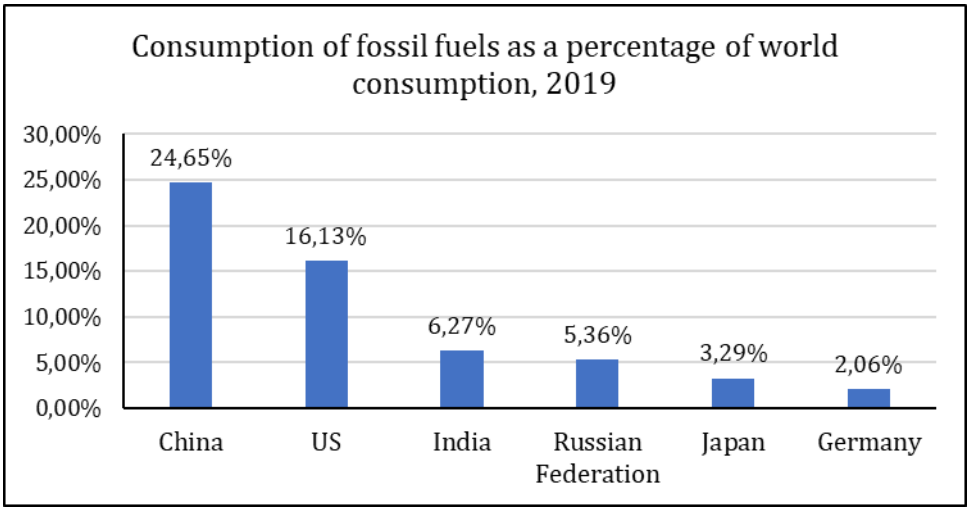
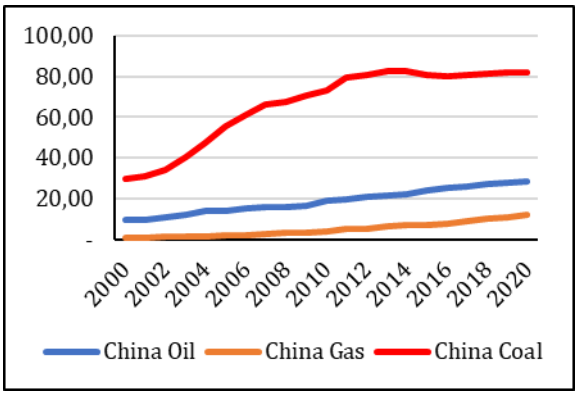


Figure 5. Consumption of fossil fuels by CUIRJG countries as a percentage of global consumption of fossil fuels in 2019.

Source: BP Statistical Review of World Energy, 2021

There are also substantial differences between these countries with respect to the share of different types of fossil fuels, mainly due to inter-country differences in the geographical concentration of these non-renewable resources, as shown in Figure 6 below.



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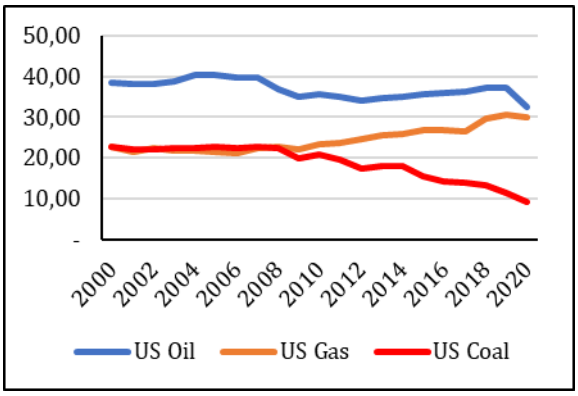

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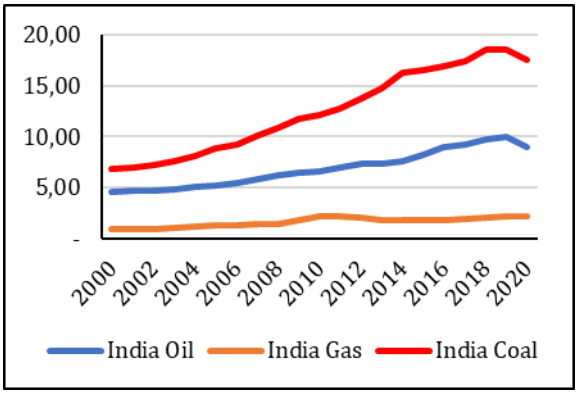

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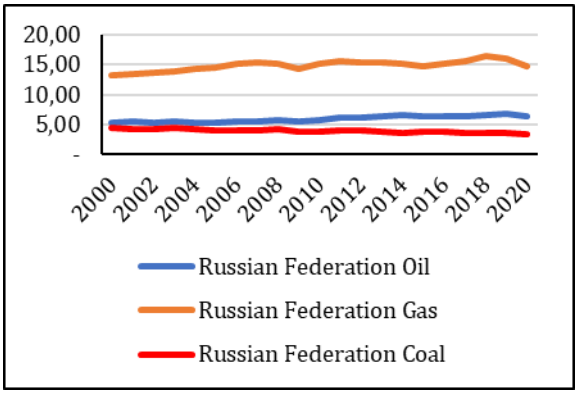

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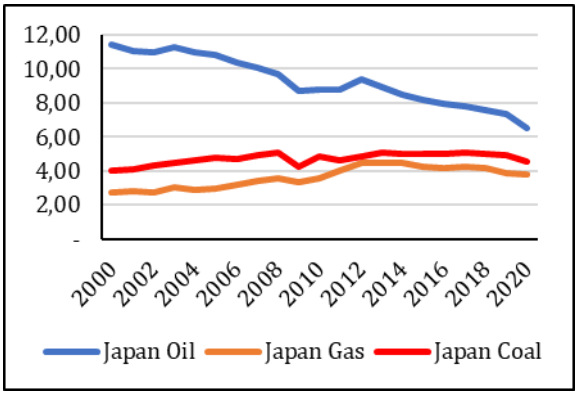

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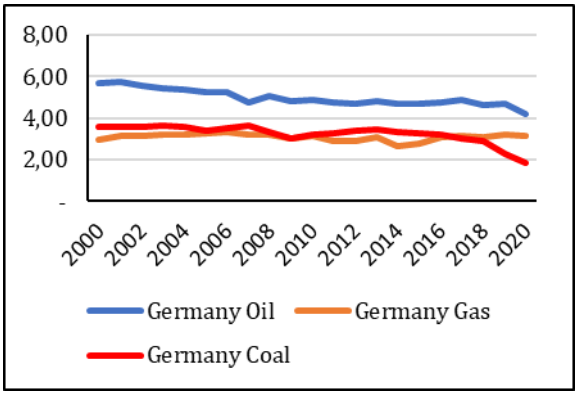

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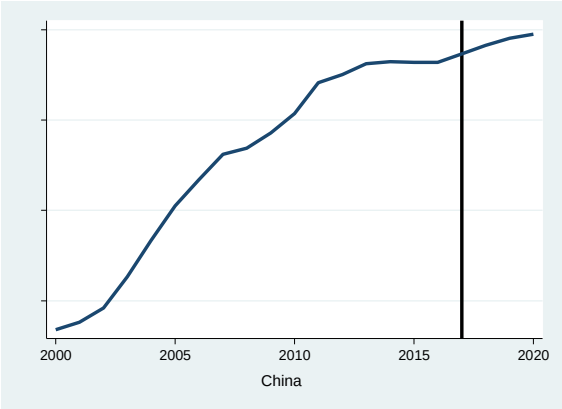
Figure 6. Country-wise dependence on different types of fossil fuels (in Exajoules)

Source: BP Statistical Review of World Energy, 2021

USA, Japan and Germany have been more dependent on oil than coal and natural gas. As per the BP Statistical Review of World Energy, South and Central America, and North America have the second and third highest reserves of oil as of years 2010 and 2020. Japan does not have enough domestic oil, natural gas or coal, and is completely dependent on imports from abroad. Most of the oil is imported from the Middle East. Though oil continues to have a dominant share in total energy, there has been a shift towards coal and natural gas. Germany, which was the largest consumer of energy in Europe in 2019 (BP Statistical Review of World Energy), is also dependent on imports to meet its energy needs, with oil and other petroleum products forming the largest proportion of its total energy consumption.

USA and the Russian Federation have been the two largest producers of natural gas in the last decade (World Energy and Climate Statistics Yearbook 2021). Not surprisingly, the proportion of natural gas in total fossil fuel consumption is the highest in the Russian Federation, followed by USA. Though China is also among the large producers of natural gas, its share is still low as compared to coal. China are India are among the largest producers of coal in the world, with USA, Russian Federation and Germany also being among the large producers (World Energy and Climate Statistics Yearbook 2021). In 2019, consumption of coal was the highest in China, followed by India, USA, Russian Federation and Japan.

The high fossil fuel consumption has led to carbon dioxide emissions to rise for most of the CUIRJG countries. However, the Paris agreement, which is a binding agreement, has caused countries to take measures to limit their emissions. Figure 7 shows trends in carbon dioxide emissions for the period 2000-2020. A vertical black line has been drawn for the year 2017. The Paris Agreement came into force from November 2016 onwards, so by 2017 countries would have started taking steps to reduce their emissions. The graph also reflects the pre and post agreement trends.



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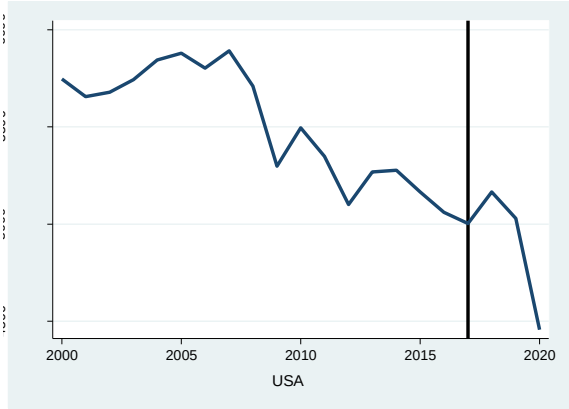

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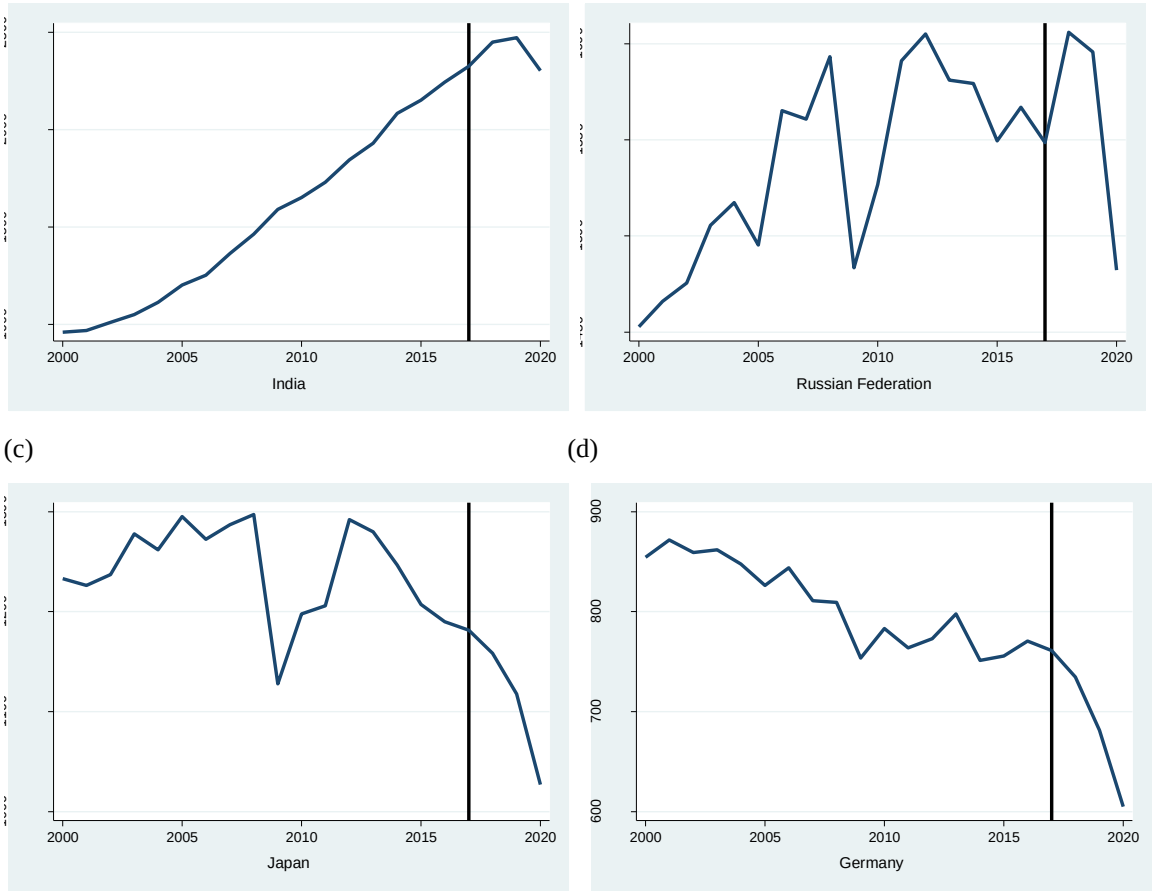


(c) (d)

(e) (f)

Figure 7. Carbon dioxide emissions overtime 2000-2020

Note: The vertical black line indicates the year 2017 immediately after the Paris agreement came into effect

The above graphs show a clear increasing trend for China and India, and a decline for USA and Germany, with intermittent periods of increase in emissions during the sample period of 2000-2020. In Japan emissions have been declining steadily since 2012. For the Russian Federation, carbon dioxide emissions mostly increased till 2008, after which there was a sharp fall in emissions. This could be due to the global financial crisis in 2008 and temporary plunging of the oil prices. Post 2009, emissions continued a fluctuating trend and declined after 2018. Therefore countries that experienced a clear downtrend in emissions, did so even before the Paris Agreement came into being. For all the countries the decline in emissions in the period 2019-2020 can be attributed to various forms of lockdowns and corrective measures taken due to the COVID pandemic.

But along with the actual trends in emissions, the rate of growth of emissions is also important. Countries are not expected to record an abrupt fall in emissions after the implementation of an agreement, but the rate at which emissions increase is likely to go down. This will ensure a gradual fall in actual emissions over time. Results from the exponential model or semi-log model shows that the rate of growth of carbon dioxide emissions has been declining overtime.

Table 1. Rate of growth of carbon dioxide emissions overtime using a semi-log model

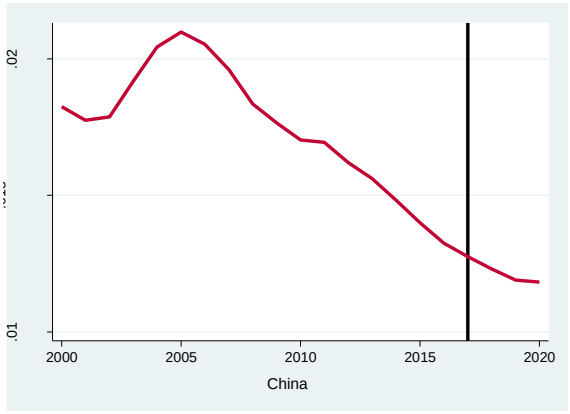
Variables	Model 1
time	-0.0628**
	(0.0268)
Constant	-3.965***
	(0.533)
Observations	73
R-squared	0.553
Year fixed effects	Yes
Country fixed effects	Yes

, and ***: Null hypothesis rejected at 10%, 5% & 1%; levels of significance respectively.*

Robust Standard Errors in parenthesis.

ln(Growth of carbon dioxide emissions) is the dependent variable

Results from the semi-log model shows that the instantaneous rate of growth is -6.28% and the compound rate of growth for the sample period is -6.09%. This implies that though the carbon dioxide emissions are rising, there is a decline in the rate of growth of emissions. In fact, energy intensity, defined as fossil fuel consumption per unit of gross domestic product, shows a decline overtime (Figure 8 below).



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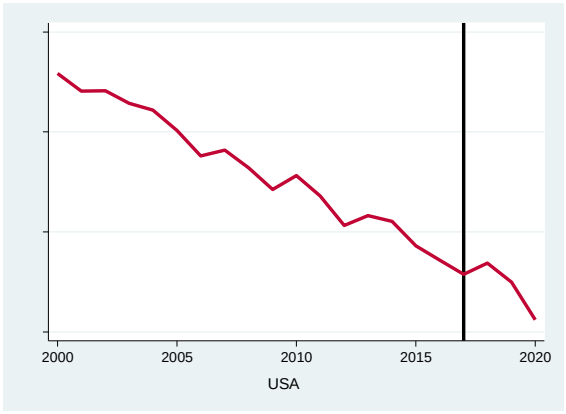

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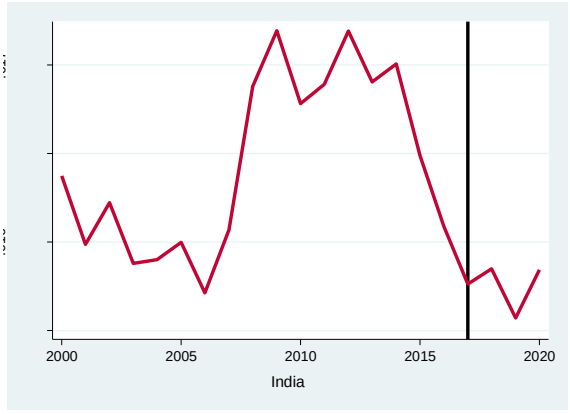

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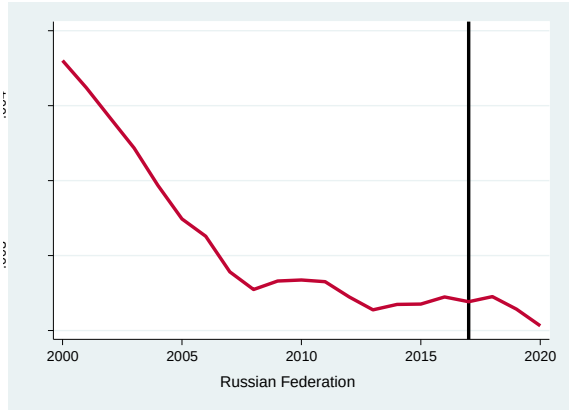

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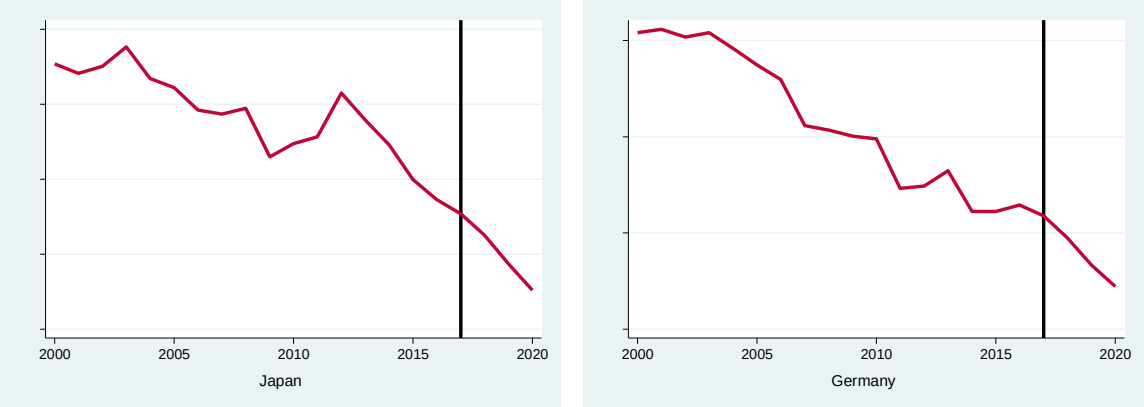

(e) (f)

Figure 8. Energy Intensity overtime 2000-2020

Note: The vertical black line indicates the year 2017 immediately after the Paris agreement came into effect

The graphs in panel (a) to (f) shows that for all the CUIRJG countries, there has been a decline in energy intensity. For India, energy intensity showed an increasing trend till 2009, but post 2014 there was a sharp decline. This could be because of the implementation of the Perform-Achieve-Trade policy, a Government of India initiative to improve the energy intensity of high energy consuming industries using market-based mechanism. Since most of the fossil fuel energy consumption comes from the industrial sector, an improvement in the energy intensity of this sector will make a major contribution in reducing the overall carbon dioxide emissions.

Table 2 below gives the empirical results from the polynomial regression model, with growth of carbon dioxide emissions as the dependent variable and energy intensity and square of energy intensity as the independent variables. It is a panel data analysis for the CUIRJG countries for a sample period of 2000-2020.

Table 2. Relation between growth of CO_2 emissions and energy intensity

Variables	Model 2
Energy Intensity	-32.74*
	(17.217)
(Energy Intensity)^2	1343***
	(504.2)
Constant	0.0127
	(0.0664)
Observations	120
R-squared	0.734
Year fixed effects	Yes
Country fixed effects	Yes

, and ***: Null hypothesis rejected at 10%, 5% & 1%; levels of significance respectively.*

Robust Standard Errors in parenthesis.

(Growth of carbon dioxide emissions) is the dependent variable

Empirical results show that as energy intensity increases, there is a fall in the growth of carbon dioxide emissions, and this fall occurs at an increasing rate. Both the effects are statistically significant. This means that countries are taking steps to work towards energy efficiency improvements, because this is also a period where GDP has recorded a rising trend for all the six countries. Clearly, fall in energy intensity is not due to a fall in GDP.

Specifically in the Indian case, one of the steps taken is the formulation of Perform-Achieve-Trade policy to bring about an improvement in energy intensity of the industrial sector. The next section gives a brief description of this policy.

3. Energy Intensity in India: Perform-Achieve-Trade policy

India is committed to meeting its targets to reduce carbon dioxide emissions, while balancing its economic development goals. Way before the Paris Agreement came into effect, Government of India set up the Energy Conservation Act in 2001. The objective of the Act was to reduce energy intensity in the country. The Act also set up the Bureau of Energy Efficiency in 2002 under the Ministry of Power, with the purpose of promoting energy efficiency in the country through market based policies.

A first of its kind step for India was taken in the form of Perform-Achieve-Trade scheme or PAT scheme, that was launched in the year 2008 by the Government of India and the Bureau of Energy Efficiency. It is defined as *a market based mechanism to enhance cost effectiveness of improvements in energy efficiency in energy-intensive large industries and facilities, through certification of energy savings that could be traded* (PAT, Ministry of Power, GoI, 2012). The first cycle was implemented from April 2012 to March 2015. Eight high energy consuming industries, viz., Aluminium, Cement, Chlor- Alkali, Fertilizer, Iron & Steel, Paper & Pulp, Thermal Power Plant and Textile, were selected for implementation. Within each of these industries, only a select few plants were brought under the purview of the scheme. These plants were called designated consumers. They were selected on the basis of their annual energy consumption, i.e., plants consuming more than the threshold level were identified as designated consumers. A total of 478 designated consumers were selected from the eight industries. Each plant was given a unique specific energy consumption target to be met by the end of the implementation year, March 2015, where specific energy consumption is defined as the ratio of net energy input used by the designated consumer to total quantity of output produced by the designated consumer. Energy saving target under PAT Cycle-I was 6.686 million tonnes of oil equivalent (Mtoe). If the plant met the given target, it would be given energy saving certificates or ESCerts that can be traded and sold to the plants that failed to meet their targets. One ESCert is equal to 1Mtoe. The trade would take place in the Indian Energy Exchange and the Power Exchange of India. In the first PAT Cycle, the industries exceeded their targets by 30%, achieving energy saving of 8.67 Mtoe. This helped in reducing emissions by 31 million tonnes of CO_2. Trade in ESCerts started on 26th September 2017 and almost 1.3 million ESCerts were traded (Bureau of Energy Efficiency, Ministry of Power, GoI).

Encouraged by the success of PAT Cycle-I, Government of India extended the scheme in its second phase to include more designated consumers withing the existing eight industries, and also added three new sectors, namely, Railways, Refineries and Power distribution companies or DISCOMS. The implementation period ran from 2016-17 to 2018-19. A total of 621 designated consumers were notified, with the overall target of 8.869 Mtoe in energy saving. PAT Cycle-II exceeded its targets by 33%, achieving total energy saving of 13.28 Mtoe. This has helped to reduce emissions by 61.34 million tonnes of CO_2.

Now the scheme is being implemented on a rolling basis and currently it's in its sixth phase. Figure 9 summarizes the successive PAT Cycles with their designated consumers and energy saving targets.

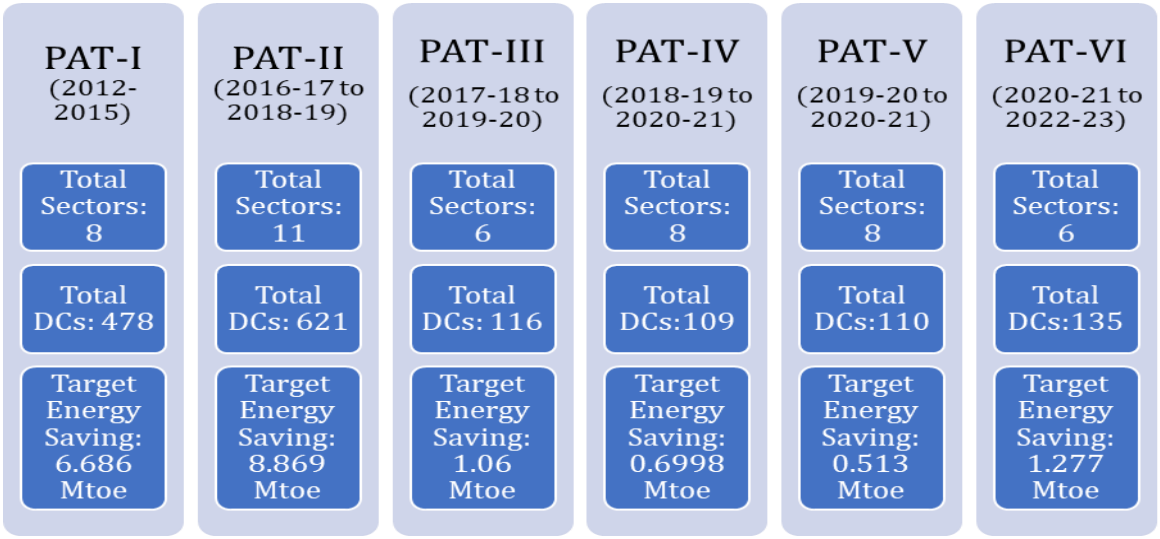

Figure 9. PAT Cycles

Source: Bureau of Energy Efficiency, Ministry of Power, Government of India

Specifically, four industries, viz., Cement, Iron and Steel, Pulp and Paper and Textile industries have been a part of all the six PAT Cycles, since these are among the most energy consuming sectors. However, the number of designated consumers identified from these industries have declined substantially after PAT-II, as shown in the bar chart in Figure 10.

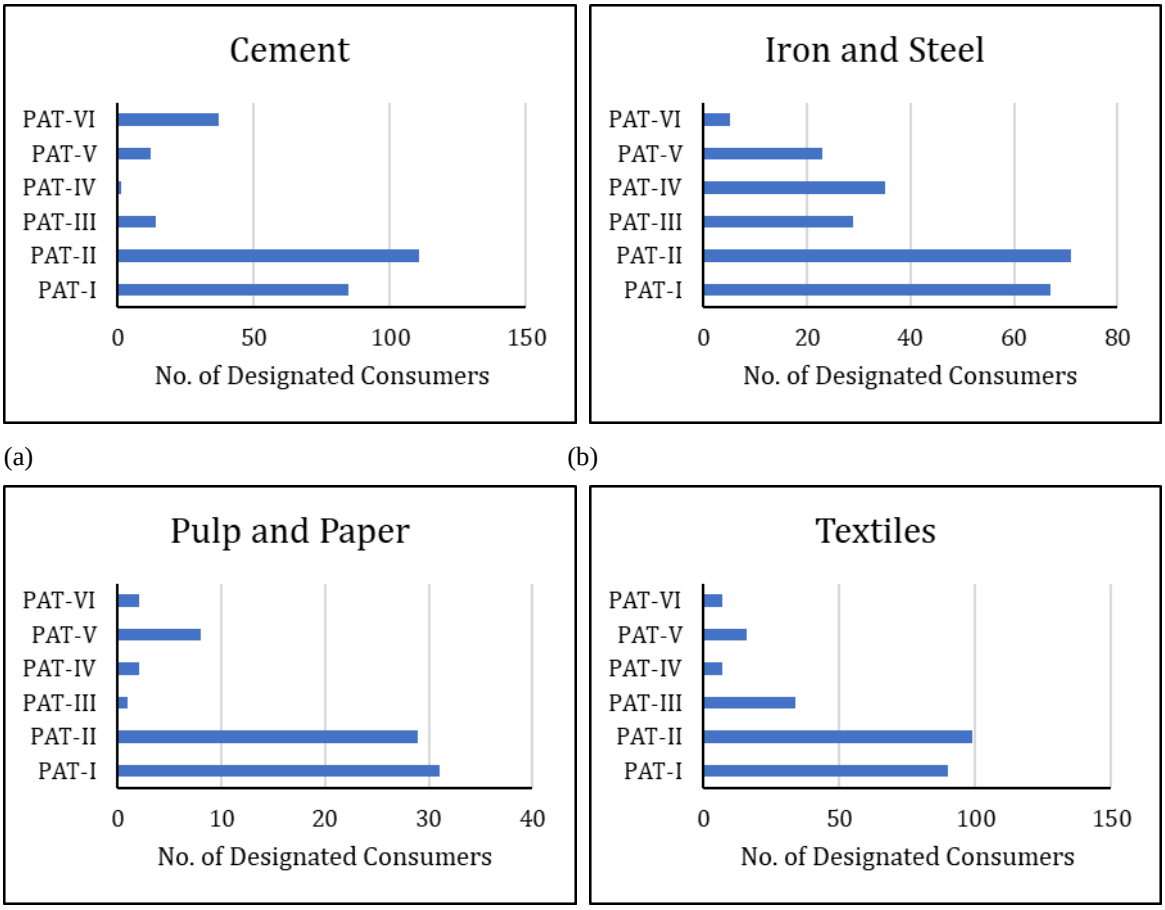

Figure 10. Designated consumers from four industries under successive PAT Cycles

Source: Bureau of Energy Efficiency, Ministry of Power, Government of India

This can be due to the success of the first two cycles that have caused plants to overachieve their targets. In fact at the national level Figure 7(c) for India shows a decline in energy intensity after the PAT scheme was implemented. Therefore, if efficiency can be achieved in the use of fossil fuels, then a major step is taken in the direction of emission reduction.

4. Conclusion

China, USA, India, Russian Federation, Japan and Germany or the CUIRJG countries have had the highest carbon dioxide emissions in the last decade. These countries are also dependent substantially on fossil fuels, though there are differences in the type of fossil fuels consumed. But various policies are being implemented at national levels by these countries, like India's PAT policy, China's 13th Five Year Plan that has national target to reduce energy intensity 15% below 2015 levels by 2020, etc. to strike a balance between economic and environmental goals. Empirical analysis also shows that the rate of growth of carbon dioxide emissions is falling overtime. There has been an improvement in energy intensity of these countries, brought about by greater efficiency in the use of fossil fuels as an energy source. This has also helped growth of emissions to record a declining trend.

But initiatives to slow down emissions have to be extended to the rest of the world as well. Since it is a common global crisis, greater cooperation between countries in terms of sharing of technologies, resources, policies, etc. will help to achieve the objectives of the Paris Agreement more efficiently.

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