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Coal Rents, Forest Rents, and Alternative Energy: Assessing Their Combined Impact on Environmental Degradation in China

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ABSTRACT

Environmental degradation is posing a permanent threat on the natural resources of our planet. It has been degraded by various factors that increased because of the impact could cause permanent harm to our world. Exploitation of natural resources such as coal, forests and other sources of energy is one of the most notable causes of this degradation. This paper adopts fossil fuel energy consumption as a moderating variable to determine the effects of coal rents, forest rents as well as alternative energy sources in China between 1971 and 2023. The outcome justifies that forest rents and alternative energy sources have negative associations with the CO_2 emission, whereas coal rents, alternative energy sources and fossil fuel energy consumption have positive associations with the CO_2 emission in China. Forest rents and coal rents are 5% significant, while alternative energy sources and fossil fuel energy consumption are 1% significant. Moreover, forest rents and alternative energy sources improve the environment, while coal rents and fossil fuel energy consumption deteriorate the environment in China. China should consider implementing a carbon tax, discouraging fossil fuel use, and reducing emissions. Finally, coal rent rise can trigger a radical increase in CO_2 emission in China and active action should be undertaken to reduce the effects of the rise. It is possible to have China take a step to lower its emissions and move towards a more sustainable energy future by enacting government policies and financial incentives as well as introducing a carbon tax.

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Research Highlights

- The Impact of coal, forest rents, and alternative energy on CO_2 emissions checked.
- Natural resources are under constant threat from environmental degradation.
- Forest rent and alternative energy are negatively correlated with CO_2 emissions.
- Coal rents and fossil fuel energy consumption deteriorate the environment.
- Forest rents and alternative energy sources improve the environment.

1. Introduction

Environmental degradation is a term that is applied to refer to the degradation of the natural environment as a result of human activities. It is a wide subject which covers a great number of problems, including air and water pollution, destruction of habitats, biodiversity. Over the last few years, this issue has been given increasing attention due to the growing impact of climate change being felt [1]. Environmental degradation can be brought about by industrial activities like mining, oil drilling and building, or by agricultural activities like cutting of forests and overgrazing. When the air is polluted heavily the results may include acid rain that destroys forests, lakes and rivers. It may also lead to global warming since some of the pollutants released into the atmosphere are trappers of heat and raise the temperature of the earth [2]. Climate change is the most apparent manifestation of environmental degradation and one of the largest ones. Climate change is shown through rising global temperatures, melting glaciers, rising sea levels, and extreme weather events. Additional effects are ocean acidification that can cause a catastrophe to marine organisms and invasion of exotic species [3].

Coal rents, forest rents and other forms of alternative and nuclear energy sources have great impacts on degradation of the environment. The mining of coal has been associated with land degradation, water pollution, and air pollution through the emittance of particulate matter, sulfur dioxide, among other pollutants [4]. Forest rents that are paid to utilize forests may result in deforestation, soil erosion as well as water pollution. Alternative and nuclear sources of energy may lead to environmental degradation when not well managed. To illustrate, nuclear energy may cause radioactive contamination, which may be long term environmental consequences. Also, other source of energy like wind and solar may pollute sound and cause land degradation. All these sources of energy are harmful to the environment and they result in environmental degradation. To minimize environmental degradation, one should be aware of the possible impacts that certain sources of energy have on the environment [5].

The consumption of fossil fuel energy includes a direct and harmful impact on the environment. The combustion of fossil fuel like coal, oil, and gas results in the emission of pollutants like carbon dioxide, sulfur dioxide, and nitrogen oxide. The ill effects of these pollutants on the environment are diverse and include pollution of the air, water, destruction of habitats and ecosystems. The largest contributor of air pollution in the world is burning of fossil fuel [6]. The air pollutants have been attributed to a number of human health concerns, such as respiratory diseases, cardiovascular diseases, asthma, and cancer. Moreover, global warming and climate changes are mostly caused by air pollution. Water pollutants including heavy metals, nitrogen, phosphorus, and other toxins are also caused by the burning of fossil fuels [7]. These wastes pollute water bodies causing destruction of aquatic life, alteration of food chain and death of aquatic organisms. Fossil burning also causes degradation and deforestation of the land and destruction of habitats. The mining and combustion of fossil fuels take a lot of land, which may complicate the displacement of local populations and the destruction of natural habitats. The direct and harmful effect of fossil fuel energy consumption is on the environment [8]. When the fossil fuels are burned, they emit pollutants into the air, water and land therefore causing air, water, habitat and ecosystem destruction and other types of environmental degradation [9].

The question of the level of coal rents in the degradation of the environment in China is the first significant question of this study. One of the causes of environmental degradation is coal rents. These rents are some of the most significant sources of revenue to the government made by miners paying the federal government to extract coal in the public lands. This money has been invested in financing of other projects but has also been associated with gross environmental degradation. Coal rents have extensive environmental effects [10]. They contribute to higher air pollution caused by coal-generated power plants, destruction of forests and lands used in mining activities, and low quality of water in mining sites. Also the coal fire emissions also cause global warming and climate change [11].

The second question that is of importance in this study is the extent to which the forest rents contribute towards environmental degradation in China. Forests are a valuable source of natural resources and offer a wide profile of advantages to the environment, yet they can also suffer environmental degradation because of the activities of the human being [12]. Forest rents are money given out by the individuals who use the forest resources, including timber and the money is meant to cover up the harm caused on the forest. These conservation efforts and restoration of the health of the forest can be financed through rent payments [13]. This is where it is necessary especially where the resource is extensively utilized and where the forest is damaged. Moreover, rents can be a motivator that people who use forest resources can make them practice more sustainable forestry [14]. Rent money can also be used to encourage the local people to conserve and preserve the forest in certain instances. This would be especially successful in developing nations, where societies are commonly dependent on forest revenue. The rent payments are also helpful because they help governments to control the forest resources and make sure that they are utilized in a controlled manner. As an illustration, the environmental assessments and the financial support of the forest management plans can be done on the basis of rent payments. By so doing, rent payments can assist governments in providing adequate attention to make sure that forests are not over exploited as a means of generating income [15].

The other face of this paper will be the extent to which alternative forms of energy contribute to the environmental degradation in China. The most common alternative sources include wind, solar, geothermal and hydroelectric energy. Such sources of energy could contribute to a safe,

reliable, and clean source of energy which does not require burning fossil fuels or other sources of pollution [16]. Solar panels, hydroelectric dams, wind turbines are becoming more common in the world and this shows that alternative sources of energy are essential. There are numerous environmental advantages of using these sources of energy. They do not produce any pollutants or greenhouse gases implying that they do not add to the accumulation of carbon dioxide, methane, and other gasses in the atmosphere [17]. This assists in curbing the level of air pollution in the environment which may have different effects on human health and environment. Moreover, none or minimal amounts of water are necessary to operate such sources of energy, which makes them conserve water resources that would be used in other activities [18].

Despite the several environmental advantages that come with alternative sources of energy, there are also some disadvantages associated with it. These sources of energy may be costly to install and the land area is very big to install. Moreover, they become untrustworthy many times and, subsequently, must be replaced with other sources of energy at particular times of the year or at the times when the weather conditions are unfavorable [19]. Regardless of these disadvantages, alternative energy sources are gaining more significance towards mitigating on environmental degradation. With the support of these sources of energy, it will be possible to minimize air pollution and to save water resources, contributing to the establishment of a more sustainable future [20].

The paper also evaluates the extent to which the consumption of fossil fuel energy affects the degradation of the environment in China. Consumption of fossil fuel energy is also a significant cause of environmental degradation. When fossil fuels burn, greenhouse gases are emitted into the atmosphere and these include carbon dioxide and methane. The gases trap the heat and cause more solar radiation to be trapped by the atmosphere resulting in rise in the global average temperature and climate change [21]. Air pollution causes and other associated health problems are caused by the emission of pollutants during the burning of fossil fuels, which include sulfur dioxide, nitrogen oxides, and chemicals [22]. Furthermore, mining of fossil fuels, including coal, oil and gas, may lead to severe destruction of the ecosystem. Mineral mining may destroy the habitats of wildlife; it may lead to soil erosion and pollute water. Also the transportation of fossil fuel may lead to release of more pollutants in the environment, thus resulting in further degradation. On the whole, the consumption of fossil fuel energy contributes significantly to the environmental degradation process, and it is significant to lessen our dependence on these sources of energy . One of the ways to lessen our impact on the environmental degradation is by investing in such sources of renewable energy as solar, wind, and hydroelectric. One should also conserve energy and minimize wastage of energy that may contribute to the reduction of fossil fuels used. The current situation can be responded to in order to save the planet to future generations [23].

This research has made a special contribution to the literature since it is the first to compare the environmental impact of coal rents and forest rents. This study examines the connection between the rent paid by the natural resources extraction activities and the environment. It also looks at the effect of the rent-seeking on the environment and its influence on the environment. This paper explores the connection between rent-seeking and environmental degradation in detail by delving into the environmental effects of rents of coal and forest rents. The study also illuminates on the externalities related to activities of the extraction of natural resources and the ways through which the externalities can be minimized or alleviated. Besides this, the research is a good source of information on how rent-seeking is an effective policy instrument to minimize environmental harm and better environmental results. The given study is a contribution to the literature because it also implies the investigation of the alternative energy sources, which would minimize the impact of human activity on nature. Renewable sources of energy like solar, wind and hydropower can be used to mitigate the emission of carbon dioxide and other greenhouse gases that are emitted into the atmosphere. Also, this paper shows how it is possible to enhance energy efficiency by use of energy-efficient technology and practices. This paper demonstrates that the sources of emissions can be limited through renewable energy sources and energy efficiency, which contributes to preserving the environment as it is not destroyed anymore. In addition, this research provides an economic and social analysis of the implication of using alternative sources of energy, thereby giving a holistic picture of the benefits and demerits of the various sources of energy. Lastly, the research offers a paradigm on which to conduct further studies, as it will be possible to discover how other sources of energy may be utilized to the advantage of the environment.

2. Literature Review

One of the biggest world issues has been environmental degradation which has been attributed to various causes such as coal rents, forest rents, and energy sources. This literature review will highlight the conclusions reached by different researchers which have been carried out regarding the impact of these factors on environmental degradation. The study [24] discuss the effects of coal rent on the environmental state and economic development of the BRICS countries. As they articulated, a rise in coal rents does not raise CO_2 emissions in these nations as opposed to rising consumption of coal. It is because there is less dependence on coal in production of energy and other sources of energy are present. Moreover, the BRICS nations have implemented tough environmental policies that encourage use of renewable energy sources and shun use of coal. Moreover, the BRICS have pledged to cut down on their CO_2 emissions aiming to fight global climatic change. This is something that has been undertaken in the Paris Agreement, where all nations

are expected to cut their emissions by a specified number. Moreover, the energy efficiency of the BRICS countries is also growing and they are less dependent on fossil fuels. Another research [25] studied the restoration of degraded places with artificial gypsum and waste products of agriculture industries in coal mines. They proved that coal is an extremely abundant source of fossil fuel located in the world, is the most abundant and widely spread fossil fuel in the world. Formation of coal comes with the compression of organic material that takes millions of years to form and it consists of carbon mainly. It has been exploited to thousands of years to heat and provide energy and it is highly used today with the same aim.

Direct and substantial impacts can be seen on the environment by rent paid to the government or the landowner by a coal mining company. Rent paid may influence the number of finances that the company is forced to spend on environmental protection and safety and health regulations. When the rent is low, there is an increased threat of the company compromising on safety costs, which leads to increased pollution and degradation of the environment. Also, the quantity of rent paid may influence the quantity of jobs to provide to the company and the salaries to pay. It may cause the reduction of wages of workers and motivation to treat the environment [26]. Land owners and governments ought to put into consideration the possible environmental effects when they determine the price that coal mining companies would pay. The high rents might decrease the profitability of the company and lead to a decrease in the number of jobs, yet they can also encourage the company to invest more in the environmental protection. This would favor the environment and the local economy in terms of creating more employment and also since the chances of environmental degradation will be minimal. Finally, the direct and substantial effect is the rent the government or the land owner has on the environment by a coal mining company. The price of rent should be calculated in manner that takes into account the environmental hazards that coal mining could have. This may guarantee a healthier environment and a more successful economy [2].

Deforestation has environmental impact that is also a matter of concern when measuring the potential benefits of the system. A number of researches have been carried out to measure the environmental effects of forest rents [15, 27, 28]. Such studies have established that the forest rent can have impacts, good and bad on the environment.

The study [29] articulated that among the most major positive effects of forest rents is the fact that it is likely to expand the forest cover. The owners have the opportunity of getting revenue off the land by renting out forest land without clearing them to be used as agricultural land. This is capable of assisting in preserving the existing forest cover and minimizing the level of deforestation that is taking place. Simultaneously, [30] was able to show that even the forest rent may have an adverse effect on the environment. Indicatively, other studies have observed that forest rents may cause excessive exploitation of resources. When the resources are being leased off cheaply, it might lead to over exploitation of the resources in the land. This may contribute to land degradation, and damaging of the environment.

Similarly, [28] have cited soil erosion as the possible environmental impact of forest rents. The soil is also exposed to other activities when it is leased as forest land and this may cause soil erosion. This has the potential of lowering the fertility of the land and affect the environment in the long run. In general, the environmental effects of forest rents are a complicated problem. On the one hand, there exist positive effects, including the increase of the forest cover, and, on the other hand, the negative ones, including erosion of the soil and overexploitation of resources. These impacts are noteworthy to take into account when assessing the possible value of forest rents [31].

The alternative energy sources play a significant role in addressing the environmental degradation. The alternative sources of renewable energy such as solar, wind, and geothermal can be used as an alternative to fossil fuels to decrease the effects of air pollution and global warming [32, 33]. Also, the reliance on the exhaustible resources such as oil and coal can be minimized by using alternative energy sources to make sure that the future generation will enjoy a healthy environment [34, 35]. The study [36] articulated that alternative source of energy is increasingly gaining popularity and is becoming more affordable, and thus it can be considered by companies and households. Both solar panels, e.g., can serve as a major source of electricity requirements, and in certain cases, it is even possible to heat water with their help. Renewable energy utilized by homes and businesses may also be generated by wind turbines [37].

Lastly, another aspect of cutting environmental degradation is recycling. Recycling assists in the minimization of waste material and resource conservation. It also has the ability to minimize the pollution which is caused by manufacturing process. On the whole, a healthier and more sustainable environment can be developed using alternative energy sources and other means of mitigating environmental degradation. Such practices can assist in the decreased reliance on limited resources, polluting as well as energy conservation. Such steps can be taken to make sure the future generations will enjoy a healthy environment. Studies on forest rents have also revealed that there is a relationship between the forest rents and environmental degradation. Indicatively, studies in Brazil revealed that forest rents were associated with the increased deforestation and soil erosion. In another study, it was also established that rents in the forest are also associated with the acceleration in the intensity and frequency of natural calamities in the area. There is also the connection of environment degradation to alternative sources of energy such as solar, wind and hydroelectricity. Indicatively, a research study in the United States has established that solar energy was correlated with increased air pollution. On the same note a research in China discovered that wind energy was associated with an increase in the water pollution

level. All in all, the studies have shown that the rent that coal, forest and other energy sources can have a major influence on the degradation of the environment. Consequently, all these factors should be put into consideration whenever coming up with strategies that can minimize environmental degradation.

3. Methods

3.1. Theoretical Understanding

The connection between the coal rents and the forest rents and the alternative sources of energy is unquestionable in terms of the impact it has on the environment. Coal rents are the amounts paid to have the right to mine coal whereas forest rents are the amounts paid in order to extract timber in a forest [38]. The two are finite resources hence their exploitation has a direct impact on the environment. To illustrate, coal is burned to release harmful emissions to the atmosphere and deforestation may occur as a result of timber cutting. Some of the sources of energy that have been regarded as being more sustainable in energy production are solar power, wind power and hydro power. The sources of alternative energy are renewable and do not have to be extracted as opposed to coal and forest rents as these are limited resources. In this way, they will have a possible effect of decreasing the environmental impact of the production of energy and emissions. It is evident that relationships among coal rents, forest rents, and other sources of energy have a direct impact on the environment. Deforestation, air pollution and other environmental problems may be caused by burning of coal and cutting of timber whereas the sources of renewable energy have the potential of providing a more sustainable alternative. That being the case, these linkages should be taken into account when examining how the environmental impact of the energy production can be reduced [32].

Alternative energy sources impact so much on the environment. Solar, wind, and hydro power sources are renewable energy sources that do not emit to the atmosphere. This contributes to the decrease in air pollution and the alleviation of climate change. Moreover, the reliance on fossil fuels can be minimized because of the influence of these sources of energy which may cause adverse effects on the environment in terms of their production and utilization. There are other reasons why the alternative energy sources are good to the environment [39]. As an example, solar and wind power do not need much of land to be utilized in the generation and this can be used to conserve land resources. Moreover, solar energy does not need to produce water, which will save useful water reserves. Hydropower may also be useful in the minimization of water wastage since it does not waste the water through evaporation. Noise pollution can also be mitigated by use of alternative sources of energy. Wind turbines produce noises, but most often, they are placed in the isolated locations and therefore, the noise does not bother people. Also, the alternative energy sources would help to decrease the probability of oil spills and other environmental catastrophes related to the manufacturing and transportation of fossil fuels. The employment of other sources of energy will assist in generating employment in the energy sector. The process of developing, construction, and maintenance of renewable energy sources usually involves more labour and people than is required by the traditional energy sources. This will generate employment, and it may contribute to economic development within the localities [40].

The use of fossil fuel has really impacted the environment. Fossil fuels like coal, oil and natural gas are formed out of remnants that used to be living organisms millions of years ago. These fuels are nonrenewable, and their mining and combustion cause a burst of greenhouse gases to the atmosphere, which leads to climate change. Electric and transport are primarily powered by fossil fuels [41]. However, their emissions have been associated with severe health issues like respiratory diseases, acid rain, smog and destruction of wildlife habitats. Another significant cause of air pollution is the burning of fossil fuel. This is the case since the burning of these fuels emits different types of pollutants such as carbon dioxide, sulfur dioxide, nitrogen oxides and particulate matter. These wastes may lead to respiratory diseases, not to mention environmental damages. Moreover, these fuels produce carbon dioxide that is a greenhouse gas that causes global warming when burned. Water pollution is also caused by fossil fuel. This is attributed to the fact that mining activity and oil and gas drills may pollute waterways with heavy metals and other pollutants. Moreover, burning of such fuels may emit pollutants that may pollute water supply [4].

3.2. Models

This paper uses fossil fuel energy consumption as moderating variable to examine the impact of coal rents, forest rents, and alternative energy sources in China from 1971 to 2023.

$$\mathrm{CO}_{2_t} = \beta_0 + \beta_1 FR_t + \beta_2 CR_t + \beta_3 AN_t + \beta_4 FF_t + e_t \quad (1)$$

where CO_2 is the CO_2 emissions measured in kilotons (kt) is the dependent variable proxy to measure environmental degradation. Forest rents (FR) as percent of GDP, coal rents (CR) as percent of GDP, alternative energy sources (AN) as percent of total energy use, and fossil fuel energy consumption (FF) as percent of total energy consumption are the independent variables. Data is collected from the World Development Indicators (WDI), a comprehensive database maintained by the World Bank.

3.3. Phillips-Perron Unit Root

This paper applies the Phillips-Perron Unit Root Test Phillips and Perron (1988), which is an econometrics method of trend testing that examines the existence of unit root in a time series. The test is formulated on augmented [42] but this time the Phillips-Perron test was estimated to adjust serial correlation and heteroskedasticity of data.

Phillips-Perron test is regarded as one of the precise tests to test a unit root in a time series. It is possible to establish whether a time series is non-stationary or stationary using the Phillips-Perron Unit Root Test outcomes. In case the test results in the non-stationarity of the time series, one may have to take additional measures to convert the time series to be stationary in order to be able to conduct additional analyses.

The Phillips-Perron test uses a modified augmented Dickey-Fuller (ADF) regression model to test for unit roots in a time series. The equation used is:

$$Y_t = \delta Y_{t-1} + \gamma X_t + \theta_t \tag{2}$$

and Y_t is the time series, X_t is a set of independent variables, and *d* is the coefficient of lagged dependent variable. The coefficient of the independent variables is the coefficient *g*. The proposed hypothesis is that the coefficient d equals one. When the test statistic of the equation is more than the critical value, it indicates that the null hypothesis is true and it is said to be a unit root time series.

3.4. Phillips-Ouliaris Cointegration

The [43] Phillips Ouliaris cointegration test is employed in this study to test the relationship between two or more variables in terms of time series. The test is based on statistical techniques that show whether or not there is a long-run equilibrium between the variables. It is founded on cointegration: non-stationary time series variables are likely to be moving in the same direction in the long-run, and have a statistically significant common stochastic trend. Phillips-Ouliaris Cointegration Test determines the extent of cointegration among two or more variables that are not stationary and the long-run relationship between the variables is statistically significant. The test comes in handy especially when the correlation between economic variables such as inflation and unemployment is to be tested. Phillips-Ouliaris Cointegration Test is an effective instrument of comprehending the long-term equilibrium connection of variables. It is crucial to understand the way in which economies operate and how they react to different policy changes.

The Phillips-Ouliaris equation tests for a cointegrating relationship between two or more time series. It can be expressed as:

$$Y_t - Y_{t-1} = \alpha_0 + \alpha_1 Y_{t-1} + \alpha_2 Y_{t-2} + u_t \tag{3}$$

where Y_t is the current period's value of the series, Y_{t-1} is the previous period's value, Y_{t-2} is the value two periods prior, α_0 is a constant, α_1 and α_2 are coefficients, and u_t is the error term.

3.5. Long-run Estimates

Canonical Cointegrating Regression (CCR) (Park, 1992) will be used in this study to examine the long-run relationship between two variables. CCR is a form of multiple regression analysis which allows us to test the availability of a linear, long run relationship between two variables. It achieves this by forecasting a cointegrating vector and a linear combination of the two series that is not based on short-run dynamics and stochastic tendencies. The presence of a long-run relationship between the two series can be tested using CCR and the strength of the relationship and its direction can be estimated. Also, more long-run relationships between the two series can be tested using the CCR. This renders CCR to be handy in determining and measuring long-run relationships between variables.

CCR equations are expressed in the form of two regressions with each variable being an equation. The equations are as follows:

First Equation:

$$Y_t = \alpha + \beta_1 Y_{t-1} + \beta_2 X_{t-1} + \varepsilon_t \tag{4}$$

Second Equation:

$$X_t = \gamma + \delta_1 Y_{t-1} + \delta_2 X_{t-1} + \mu_t \tag{5}$$

where Y_t and X_t are the dependent variables, Y_{t-1} and X_{t-1} are the lagged values of the dependent variables, $\alpha, \beta_1, \beta_2, \gamma, \delta_1, \delta_2$ are coefficients, and ε_t and μ_t are the error terms.

Furthermore, this paper employs significant methods of analysis to investigate the data and reveal facts. Also, the least squares regression, which is the most powerful, is used to analyze the data to ensure the findings. This method will give a broad picture of the data, and we will be able to make reliable conclusions regarding the existing trends and correlations. The robust analysis together with the robust least squares regression gives a comprehensive and reliable way of analyzing the data.

Figure 1 illustrates the long-term movement of carbon dioxide emissions and forest rents in China. Carbon dioxide emissions show a steady and continuous upward trend, reflecting rapid industrial growth and increasing fossil fuel use. In contrast, forest rents decline over time, indicating reduced economic returns from forest resources and possible pressure on forest ecosystems.

Figure 2 presents histograms for carbon dioxide emissions, coal rents, forest rents, and fossil fuel energy consumption. The distributions show that emissions and fossil fuel consumption are concentrated at higher values, demonstrating their consistent rise. Coal rents and forest rents exhibit wider spread and variability, reflecting fluctuations in natural resource-based economic activity.

Figure 3 displays the combined trends of major variables, including carbon dioxide emissions, coal rents, forest rents, fossil fuel energy consumption, and alternative and nuclear energy. Coal rents fluctuate considerably, while carbon dioxide emissions and alternative energy follow smoother increasing patterns. Fossil fuel consumption rises steadily, whereas forest rents decline, showing contrasting movements among the variables.

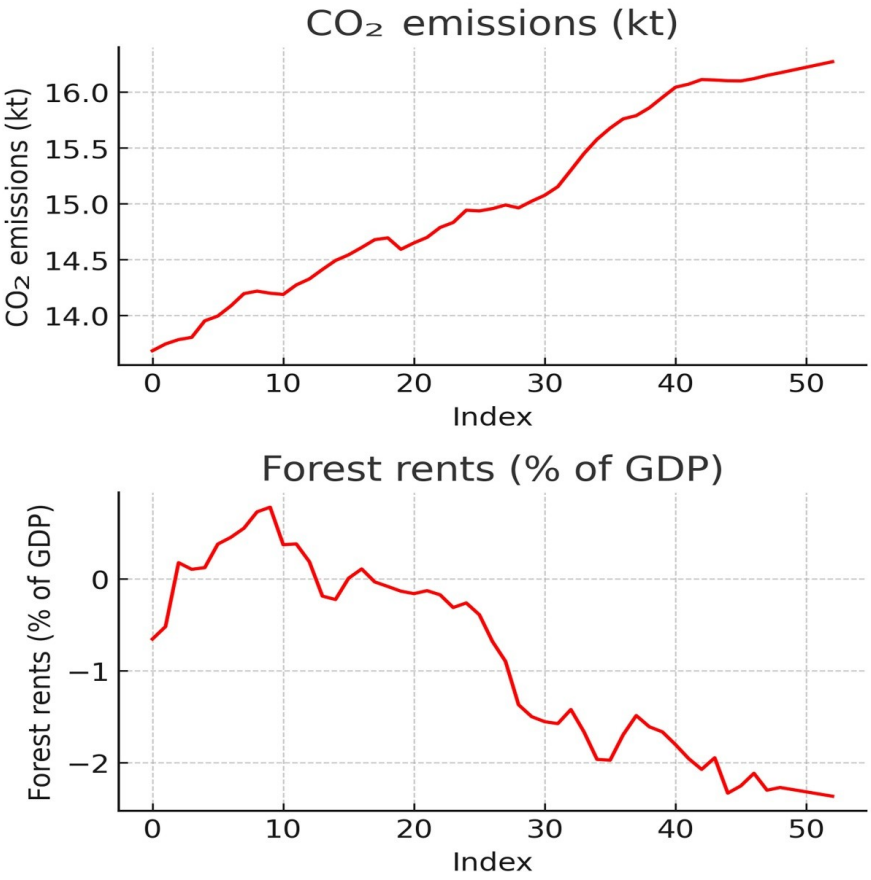

Figure 1. Trends of Carbon Dioxide Emissions and Forest Rents in China Over Time.

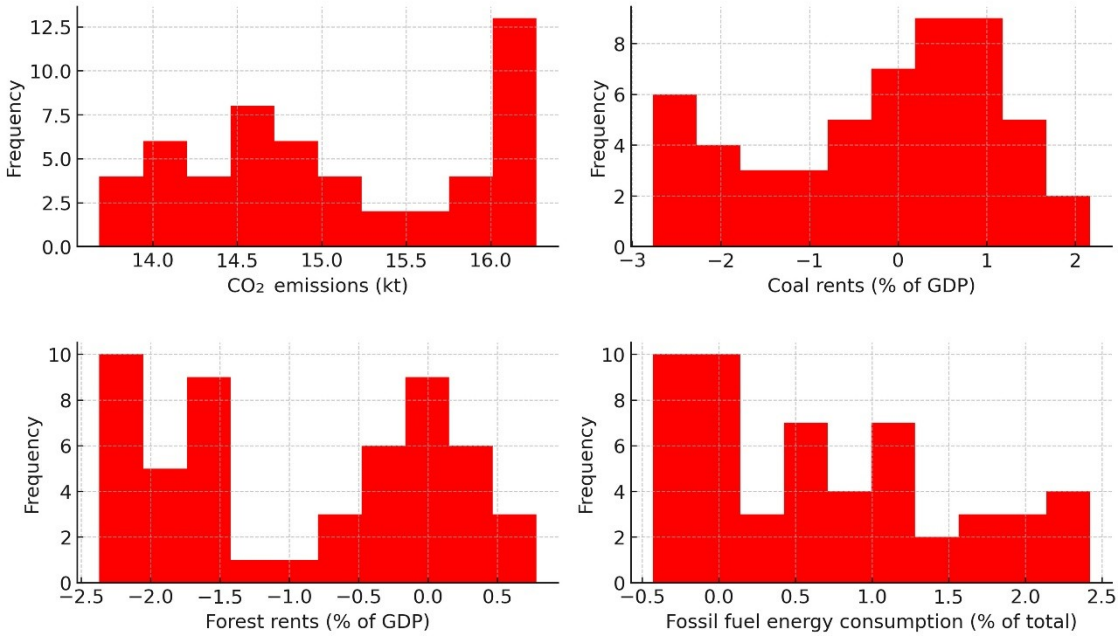

Figure 2. Frequency Distributions of Key Environmental and Energy Variables.

Figure 4 illustrates the association between carbon dioxide emissions and coal rents. The pattern forms an upward-sloping and almost smooth line, indicating a strong positive relationship. As coal rents increase, carbon dioxide emissions also rise, highlighting the close link between coal-driven economic activity and higher emissions levels.

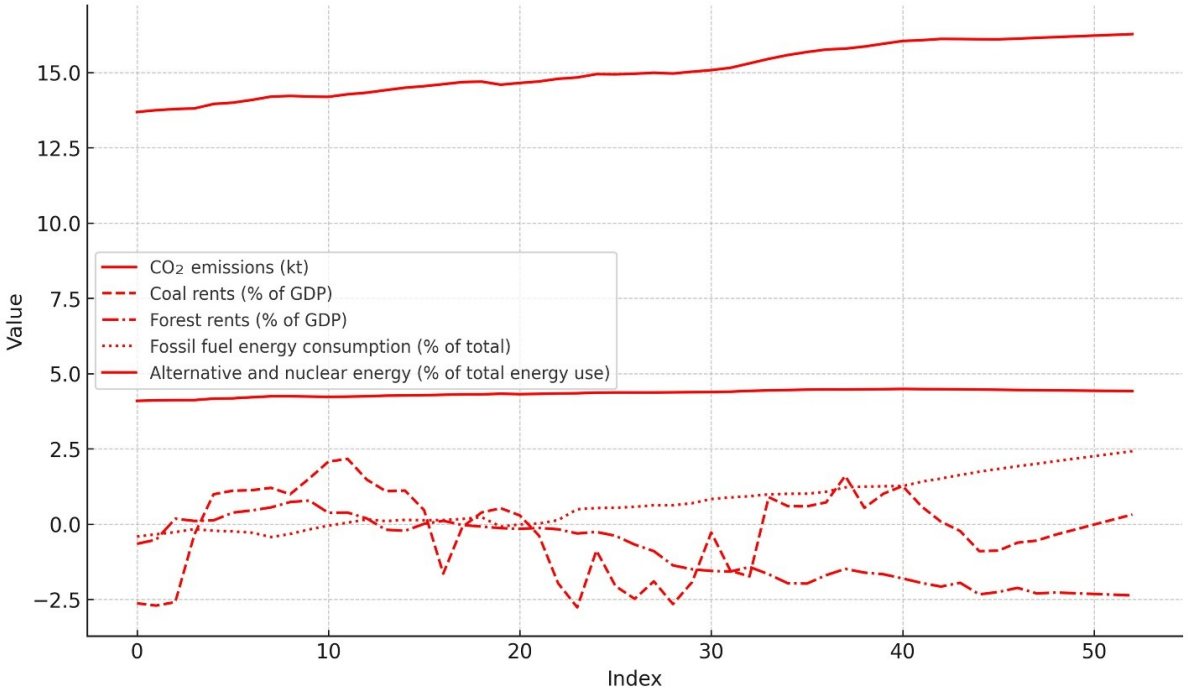

Figure 3. Joint Time-Series Trends of Environmental and Energy Indicators.

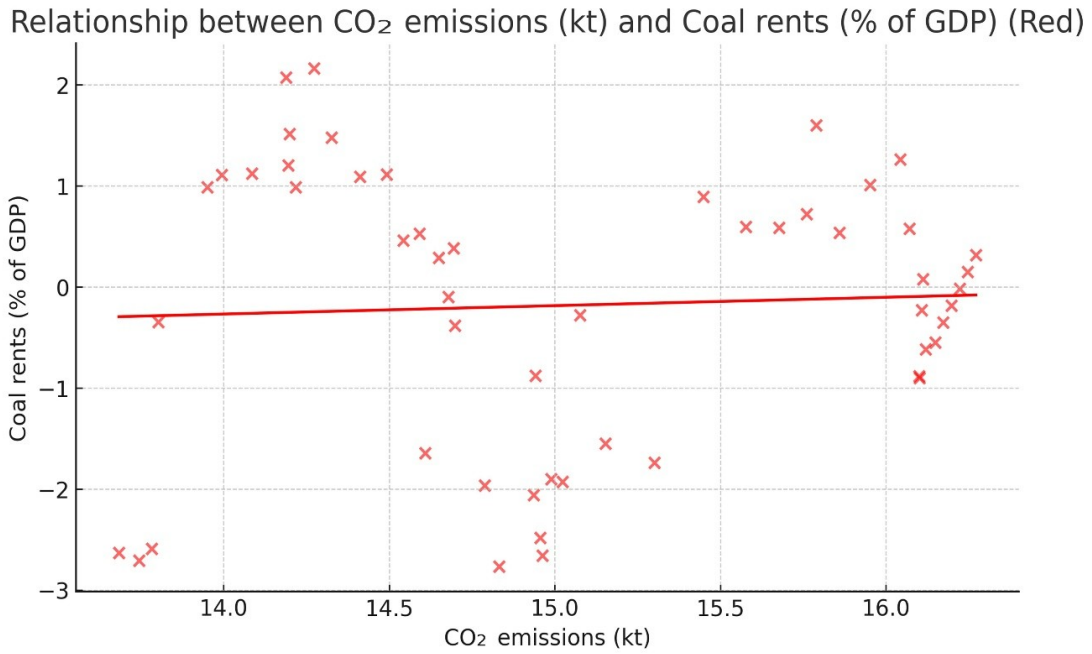

Figure 4. Relationship Between Carbon Dioxide Emissions and Coal Rents.

Figure 5 provides a step plot showing the time evolution of carbon dioxide emissions, coal rents, forest rents, and fossil fuel energy consumption. Carbon dioxide emissions and fossil fuel consumption display rising steps over time, while forest rents show a consistent downward shift. Coal rents change irregularly, reflecting sectoral volatility.

Figure 6 presents boxplots for carbon dioxide emissions, coal rents, forest rents, and fossil fuel energy consumption. Emissions and fossil fuel consumption display higher median values with more compact distributions, suggesting steady growth. Coal rents and forest rents have wider spreads, indicating greater variability and shifts in resource rents over time.

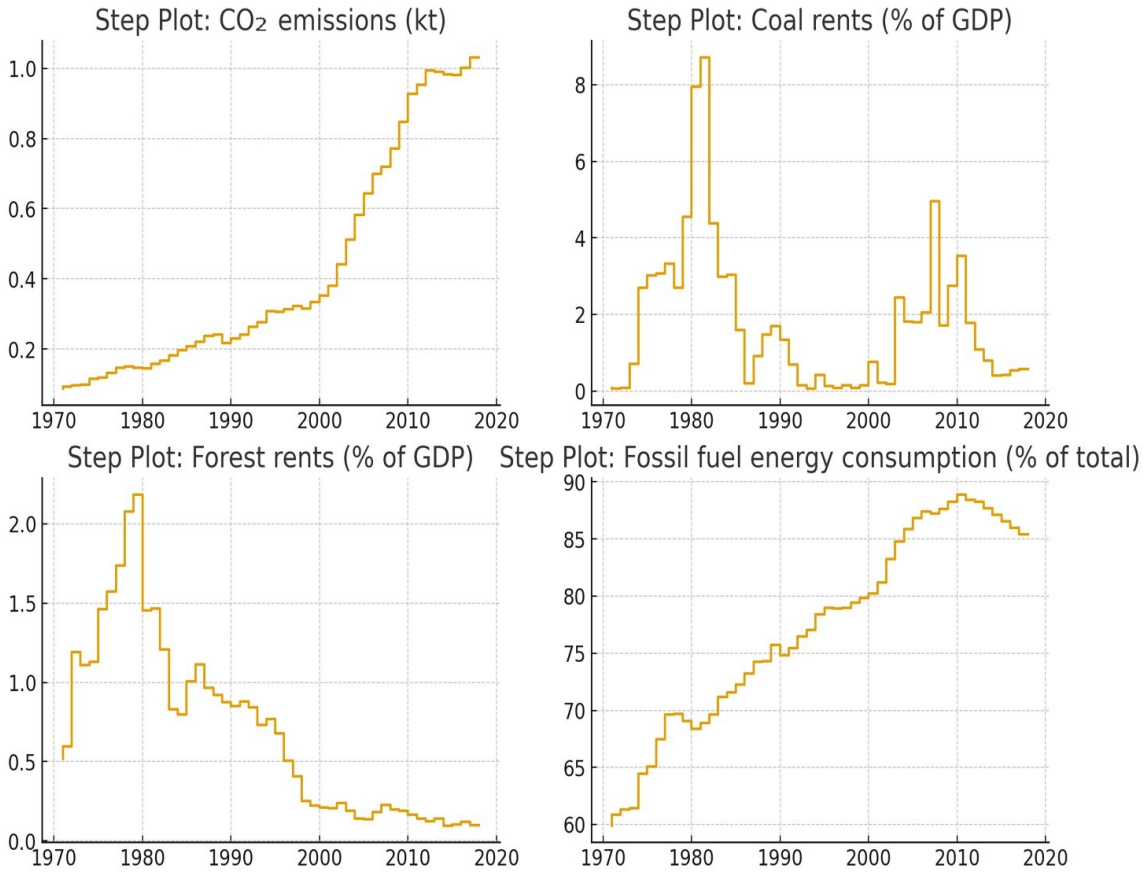

Figure 5. Step Plot of Key Energy and Environmental Variables in China.

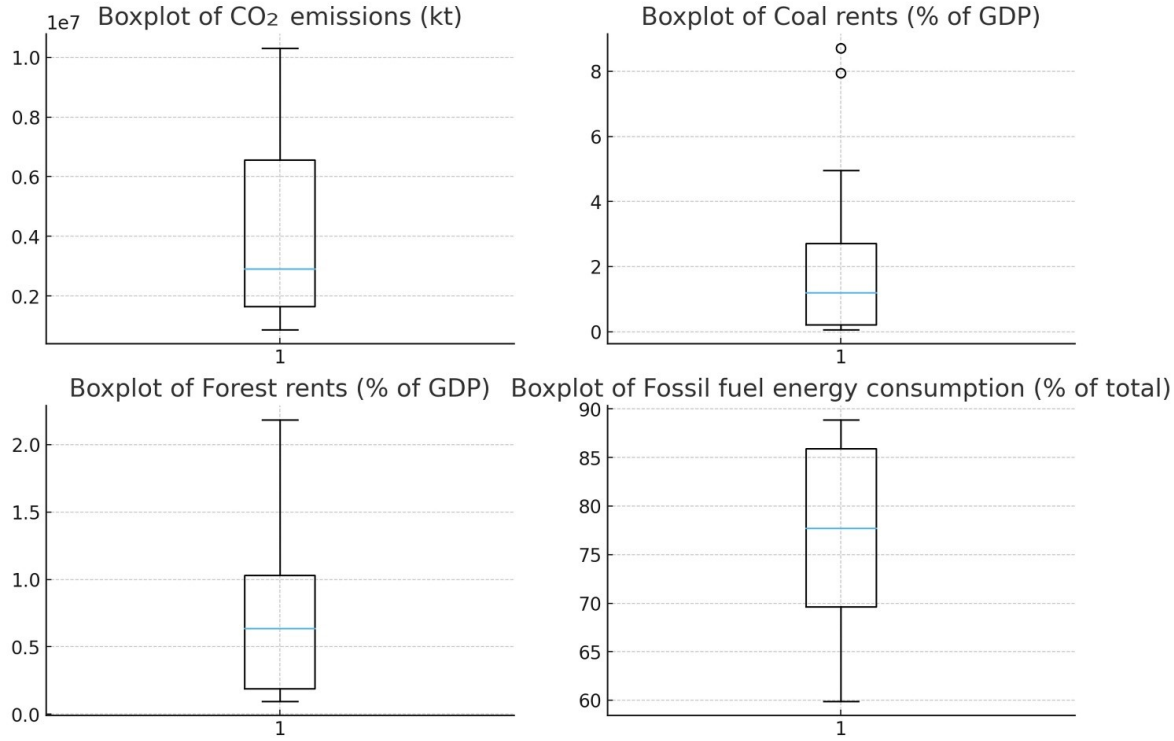

Figure 6. Boxplot Comparison of Environmental and Energy Variables.

4. Results and Discussion

The result of descriptive statistics of mean, median, maximum, minimum as well as standard deviations of CO_2 emissions, forest rents, coal rents, alternative energy sources and fossil fuel energy consumption in China is shown in Table 1. The average, median, maximum and minimum values of CO_2 emissions, forest rents, and fossil fuel consumption of energy are the same. This implies that all the three are equally distributed with equal value. This is a peculiar case because normally there is always a difference in the values of these three categories. Probably, it is because of some hidden influence that drives them to be equal. This may be either because of a certain policy or business model existing or it may be because of geographical or economic factors. In any case, the homogenization of the values is an intriguing phenomenon. It may be a sign of an effective system or it may be a sign of imbalance. More studies would be required to establish the cause. The difference in the manner of the mean, median, minimum, and maximum of the values of coal rents and the sources of alternative energy is an interesting process. The behavior of coal rents is varied because it can be high or low depending on the producer and the costs of the producer. An example is that, some producers will rent higher than others because of increased cost of production. In the same vein, the median values of the coal rents are quite different according to the market. Alternatively, the lowest and highest values of coal rents also differ due to the varying production costs of the various producers. Standard deviation of coal rents is the highest when compared to other resources. This value indicates the spread of the data set, that is how far apart the rents lie. It is significant to learn this, because it can influence the economic viability of coal exploitation. A square root of the variance is used to obtain the standard deviation of coal rents. The variance is determined as the difference between the average of the coal rents and each of the data points squared and then divided by the total number of data points.

The Phillips-Perron Unit root test result is given in Table 2. At the level and first differentiation, coal rents and consumption of fossil fuel energy are at standstill. At level, they are at rest at a 10 percent level of significance and at the first difference, these variables are also at rest at a level of 1 percent level of significance. CO_2 emissions, forest rents and alternative energy sources are not at level and these variables are at first difference. On the whole, the results of the analysis indicate that all the variables are at the first difference, though none of them are at the second difference. This would mean that any further differencing on the data would not leave a stationary series, the data would require to be differenced in a different manner in order to be stationary. This may involve data transformation by a transformation that is like logarithms or data differentiation based on the seasons. Finally, the decision would be determined by the problem under analysis.

Table 1. Descriptive Analysis.

Variable	CO_2	FR	CR	AN	FF
Mean	14.95070	−0.766938	−0.196471	0.542097	4.337728
Median	14.88384	−0.455341	0.182586	0.512712	4.353285
Maximum	16.14896	0.781247	2.165667	2.001277	4.487494
Minimum	13.68384	−2.335613	−2.767838	−0.430799	4.092666
Std.Dev	0.770008	0.968801	1.439531	0.700631	0.115996
CO_2	1.000000				
FR	−0.893400	1.000000			
CR	0.035502	0.172175	1.000000		
AN	0.967678	−0.924839	−0.048726	1.000000	
FF	0.966962	−0.828134	0.040553	0.898437	1.000000

Table 2. Phillips-Perron Unit Root Test.

Methods/Variables	Level	Difference
	Adj.t-Stat	Adj.t-Stat
CO_2	−0.547275	−4.571430 ***
FR	−0.015839	−5.374055 ***
CR	−2.691569 *	−7.011544 ***
AN	0.922021	−5.736549 ***
FF	−2.855165 *	−4.795060 ***

*** and * show significance at 1% and 10%.

The Phillips-Ouliaris Cointegration Test has yielded the results of CO_2 emissions, forest, and coal rents of China as the alternative energy sources and the fossil fuel energy consumption, as shown in Table 3. The test indicates that all the variables have a strong cointegration, and the p-value is 0.000, and thus, there is a long-term relationship between them as well as they are cointegrated. The findings show that the CO_2 emissions, forest rents, coal rents, alternative energy sources, and fossil fuel energy consumption are strongly positively related. This implies that the attempt by China to decrease its CO_2 emissions and make use of more alternative energy sources will positively impact its forest and coal rents in the long-term. The findings also show that there is an inverse relationship between the energy consumption of fossil fuel and the other variables implying that a reduction in the fossil fuel consumption would result to a reduction in the emission of CO_2 as well as the forest and coal rents.

Table 4 shows the result of Canonical Cointegrated Regression and the robust least square regression as long-run estimations. CO_2 emissions have negative relation with forest rents, and alternative energy sources, whereas these energy sources are positively related to the CO_2 emissions in China, and coal rents, fossil fuel energy consumption, and alternative energy sources are negatively related to the CO_2 emissions. The forest rents and coal rents are 5 percent worthy and the other energy sources and the consumption of the fossil fuel energy are 1 percent worthy. Besides, rents on the forest and alternative energy sources enhance the environment whereas the consumption of coal rents and fossil fuels worsen the environment in China.

Table 3. Phillips-Ouliaris Cointegration Test.

Dependent	**tau-statistic**	**Prob.***	**z-statistic**		**Prob.***
CO_2	−2.527951 *	0.6644	−10.62737		0.07457
FR	−3.387012 *	0.2641	−16.52790		0.03898
CR	−2.945086 *	0.4592	−13.84887		0.05482
AN	−3.484707 *	0.2286	−15.53690		0.04461
FF	−2.523951 *	0.6663	−10.60963		0.07467
Intermediate Results:					
	CO_2	FR	CR	AN	FF
Rho - 1	−0.180994	−0.308591	−0.301650	−0.278944	−0.180592
Bias corrected Rho - 1 (Rho* - 1)	−0.226114	−0.351657	−0.294657	−0.330572	−0.225737
Rho* S.E.	0.089446	0.103825	0.100050	0.094864	0.089438
Residual variance	0.002107	0.048828	0.773907	0.006004	0.000185
Long-run residual variance	0.002773	0.058829	0.751566	0.007944	0.000243
Long-run residual autocovariance	0.000333	0.005001	−0.011171	0.000970	2.92E-05
Bandwidth	NA	NA	NA	NA	NA
Number of observations	47	47	47	47	47
Number of stochastic trends **	5	5	5	5	5

* Show significance at 10%.

Table 4. Long run Analysis.

Method: Canonical Cointegrating Regression (CCR)				
Variables	**Coefficient**	**Std. Error**	**z-Statistic**	**Prob.**
FR	−0.021173 *	0.048871	−0.433254	0.0670
CR	0.030040 *	0.013126	2.288668	0.0272
AN	−0.587536 ***	0.091473	−6.423073	0.0000
FF	3.150742 ***	0.350354	8.993018	0.0000
C	0.968942	1.491767	0.649527	0.5195
Robust Leas Square				
FR	−0.038695 *	0.039576	−0.977736	0.0282
CR	0.024990 *	0.010334	2.418237	0.0156
AN	−0.537676 ***	0.066231	−8.118146	0.0000
FF	3.225848 ***	0.274948	11.73255	0.0000
C	0.643445	1.170753	0.549599	0.5826

*** and * show significance at 1% and 10%.

Findings clarify that an increase in forest rents in China, by 1 percent, may result in CO_2 emission by 0.021173 percent. This is a significant conclusion as it demonstrates that the emphasis on forest management and land use may be one of the effective measures in terms of emissions decrease in the country. This means that such policies that strive to raise the rents of forests would be effective in minimizing the number of emissions in the nation. The results of the study are important since they demonstrate that forest management and land use could be effectively applied to reduce emissions. This may be significant to policymakers in China as it demonstrates that hiking the rents of forests may be a solution to cut down on the emission. The results would also be applicable in informing policy decisions in other countries since the findings could be applied to other settings. Furthermore, this observation shows that renting forests can be a useful instrument in mitigating CO_2 emissions and generate economic prospects to populations. Forest rents provide an economic incentive to conserve forests since the fee is paid to use forest resources thereby minimizing the quantity of CO_2 emitted into the atmosphere. Moreover, the revenue obtained in the form of rent may be used to support local development projects and, consequently, to decrease the amount of CO_2 emissions.

The researchers determined that the rise in coal rents led to the rise in incentive to produce more coal, which in turn led to the rise of the rate of carbon dioxide emission of 0.030040%. That is, the greater the rents the greater the coal produced and the greater the emissions. This finding is probably due to the fact that an increase in coal rents will make production of coal more profitable, and more fuel sources will be produced. This, on the other hand, causes increased CO_2 emissions since more coal is burnt in order to generate the energy. The outcome of the research is a lesson of the need to ensure that coal rents are controlled in a manner that will minimize emissions. It will also be a reminder of the importance of the need to invest in renewable sources of energy to minimize the emissions. We can lower the level of CO_2 gaseous emissions being released into the atmosphere by lowering the level of coal produced. Coal is a significant source of energy and one of the significant sources of rising carbon dioxide emissions. The past years have recorded an increment of coal rents, which have enhanced the emission of CO_2. This is so because the demand of coal has gone up resulting in coal companies increasing production. This, in its turn, increases the number of CO_2 emissions into the atmosphere. Increased CO_2 emissions can also be attributed to increased cost of coal since the companies involved in coal production will have to increase their prices in order to make ends meet. This causes high coal consumption and, therefore, more CO_2 emission. The impacts of the rise in CO_2 emissions of coal are long-distance. It has also been attributed to global warming, which may result in the extreme weather conditions of floods, drought, and heat waves. It may also be disruptive with regard to ecosystems whereby it results in biodiversity loss and habitat destruction.

The consumption of other sources of energy has been broadly known as a move towards cutting down the emissions of the carbon dioxide. Our finding indicates that China has discovered that a 1 percent increase in substitutive sources of energy will reduce the total CO_2 emission by 0.587536. Such a percentage is not that big but it is a big step towards the right direction. The Chinese government has also made steps towards promoting the use of alternative energy in China. Such steps entail subsidies and incentives on businesses and individuals that invest in alternative energy sources. This has seen a gradual rise in the consumption of renewable sources of energy in the nation. This reduction in the amount of CO_2 emissions that are emitted by the increase in the usage of other energy sources is positive to the environment. With the increasing number of individuals who are becoming convinced of the need to minimize carbon emissions, there is a high likelihood that the use of alternative energy sources is only going to rise even higher. This will cause further reduction of CO_2 gases in China and eventually to a healthy and sustainable environment. The renewable energy sources include solar, wind, geothermal and hydropower which can be used as alternative sources of energy. The sources of energy are free of any carbon emission and thus are more environmental friendly. Moreover, they are able to produce energy and drive our households and companies. Utilizing alternative sources of energy is beneficial in two aspects as it minimizes carbon emissions. To begin with, it decreases the production of electricity using fossil fuels. Secondly, it decreases the use of fossil fuel which emits more carbon dioxide. It should also be mentioned that alternative energy resources are increasingly becoming affordable. This implies that now a lot of individuals and companies are able to change their sources of traditional energy to renewable sources. This will assist in further cutting down of carbon emission.

Studies indicate that a 1 percent rise in energy consumption of fossil fuels in China causes a rise in CO_2 emission by 3.150742%. This is a huge increment and this underscores the fact that China should invest more in renewable energy sources. This rise in CO_2 emissions is also contributed by burning of fossil fuel and also the rising energy demand in China. China is the most consuming energy in the world and the most producing country of CO_2. Consequently, the level of CO_2 emission in the country will be greatly affected by the growth of fossil fuel energy. China needs to make investments in renewable energy sources so that the quantity of CO_2 emissions generated will be minimized. This would cut the use of fossil fuels and aid in cutting down the level of CO_2 gases emitted during the combustion of the fossil fuels. Moreover, the country should consider investing in renewable sources of energy that would ensure that the total cost of energy is lowered. The consumption of fossil fuels should be minimized in order to minimize the emission of CO_2. This can be through the introduction of renewable energy sources such as wind, solar and geothermal energy. There is also need to minimize the overall energy consumption, which

assists in minimizing the need of fossil fuels and consequently the emission. Also, it is possible to mitigate fossil fuel emissions with the help of different technological solutions, e.g., carbon capture and storage, and enhance efficiency in combustion.

5. Conclusions and Policy Implications

The contributions of natural resources to environmental degradation are great in the form of coal, forest rents and other sources of energy. Coal is fossil fuel, which means that the consumption of coal entails burning it to generate energy. This results in emission of both harmful pollutants like carbon dioxide, nitrogen oxides, among others. Forest rents are fees paid to owners of land to use their forests, but they may cause the destruction of forests in the region and also the habitat of most species. In the meantime, the other sources of energy used like solar, wind, and hydro electricity emit a significantly lower number of emissions and would contribute to minimizing environmental degradation. Use of natural resources may tend to have a tremendous impact on environmental degradation.

It may cause air pollution, water pollution and habitat destruction in some instances. This is the reason why numerous bodies and governments are striving to minimize the consumption of such resources and encourage the adoption of other forms of energy. The need to educate and create awareness of the possible effects of the exploitation of natural resources is also significant in curbing environmental damage. Finally, the natural resources like coal rents, forest rents and the other sources of energy are very important factors that influence the degradation of the environment. Their use and the effects they bring with themselves in minimizing environmental degradation should be noted. Governments and other organizations should collaborate to ensure that alternative sources of energy are encouraged and exploitation of natural resources minimized.

The use of alternative energy sources has gained importance because the need to minimize environmental degradation has been on the increase. Renewable energy sources like solar, wind, and hydro power can be used to minimize the release of harmful greenhouse gas and destruction of the burning of fossil fuel. Solar energy is among the most common renewable energy and this has been on a tremendous increase in the recent past. The solar panels tap the sunlight and utilize it to produce electricity that can be consumed at home and in the business. Solar energy has been a favorable energy source since it is renewable, clean and it does not release greenhouse gasses.

It is also a less expensive alternative to energy saving and clean air. Another source of alternative energy that is gaining popularity is the wind power. The wind turbines harness the kinetic energy that is stored in the wind. The wind is a clean and efficient renewable source of energy which is also reliable. Wind power will be able to limit emissions and preserve the environment. Another source of alternative energy that is popular is hydroelectricity. It involves the streaming water and its energy to produce electricity. Hydroelectricity is renewable and clean energy that can be utilized to minimize emissions and save the environment. The other sources of energy can be a potent means to the deterioration of the environment. By using renewable sources of energy, we can cut on emissions and save the environment. Also, these energy sources are economical and could assist in minimizing the use of energy. China should still utilize and exploit other sources of energy to minimize the environmental degradation.

The long-run estimates indicate that the rents of forests enhance and reduce environmental degradation in China. The policies of renting forests by China have influenced positively on minimizing environmental degradation. With the implementation of a financial incentive on conserving and sustainable management of forests, China has managed to greatly reduce deforestation and reforestation. There can be numerous considerations to be included in the policy implications to forest rents. First, the government is supposed to charge a reasonable price to the rent depending on the value of the forest resources. This will provide the competitive rent, which will promote the highest possible sustainable forestry. Second, renting should be produced in a way that encourages sustainability in forestry and environmental conservation. As a case in point, the rent must promote sustainable forestry practices like less application of chemicals, better soil conservation practices, and less harvesting of the timber. Third, the government ought to take into account the economic value of forest rents. These advantages are the ability to generate more income to the rural communities, better local economies and more job opportunities. Forest rents can serve to conserve the environment besides the economic gain. The governments can utilize the rents to finance projects that lead to reforestation, better wildlife habitats, endangered species and better quality of water. Conservation may also be funded through forest rents, including the development of conservation areas and wildlife corridors. Governments and other stakeholders should pay attention to policy implications of forest rents.

The Chinese policy implications on the rise in the rent in coal have extensive impacts on CO_2 emissions. In a country where coal is highly used as the source of energy production, the rise in rent can result in an increase in the price of energy which means that a greater amount of fossil fuel will be used hence a rise in the amount of emissions. This is also enhanced by the fact that china is the largest producer of CO_2 emissions with respect to energy and hence this issue is of even more significance. China must take the initiative to integrate renewable energy source to counter the effects of rent increment on the level of CO_2 emissions. This may be in form of government policies encouraging the use of clean energy sources like solar energy subsidy, wind energy subsidy and subsidies of research and development of renewable energy technologies.

Also, China will want to introduce a tax on carbon that would deter the consumption of fossil fuels, and will lower carbon emission. To sum up, the growth of coal rents can lead to the drastic increase of the CO_2 emissions in China, and measures ought to be undertaken in advance to reduce the effect of the rise. China can do this by implementing government policies and monetary incentives, and it can do this by introducing a carbon tax to minimize its emission and move onto a more sustainable energy future.

One of the weaknesses of this study is that it does not factor in the growth and development factor of forest and coal rents but instead, it focuses on the environmental factor. The next research can address the economic advantages of forest and coal rents, including the augmented income of the local governments, the jobs the rent will provide, and the enhanced access to resources of the local population. Also, the environmental effects of forest and coal rents, including the loss of natural habitats, release of greenhouse gases, and disturbance of local ecosystems can be included in future research. Moreover, the social implications of forest/coal rents can also be taken into consideration in the studies, including the extermination of the traditional community, interference of the cultural norms and the impact of corporate mining to the community. Through these factors, the future researches can present a more detailed insight on the effect of forest and coal rents.

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Use of AI and AI-Assisted Technologies

During the preparation of this work, the author has not used AI-assisted technologies.

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