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# NATURAL RESOURCE WEALTH AND DEPLETION: EXPLORING THE ECONOMIC, ENERGY, AND ENVIRONMENTAL IMPACTS OF MINERAL RENTS AND MINERAL DEPLETION

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**ABSTRACT**

Natural resources play a crucial role in economic growth and policy formulation. Energy production and consumption are essential for economic development, while carbon dioxide damage poses significant challenges. Mineral rents can contribute to government revenue, but mineral depletion requires sustainable practices to ensure long-term viability. Balancing economic growth with environmental sustainability is crucial to ensure a resilient and prosperous future. This paper examines the impact of mineral depletion and rents on carbon dioxide damage in China from 1990 to 2021, considering the availability of clean fuels and technologies for cooking, energy use, and export value index as moderating variables. The long-run results of FMOLS explain that mineral depletion and mineral rents are 10% significant. Access to clean fuels, energy use, and export value index is 1% significant. Mineral depletion, access to clean fuels and technologies for cooking, and export value index are negatively associated with carbon dioxide damage in China. Mineral resource rents and energy use are positively associated with carbon dioxide damage in China. By adopting sustainable practices and considering mineral rents and depletion, the Chinese government can optimize natural resource utilization and ensure long-term development. Implementing appropriate policies and strategies will benefit China's economy and contribute to the global efforts towards a greener and more resource-efficient world.

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## INTRODUCTION

Natural resources are essential to the economy's growth. The formulation of policies, the production of and use of energy, and the mitigation of the effects of climate change Balsalobre-Lorente et al. (2023) can't be calculated without natural resources. As a result, it is essential to understand the link between mineral rents and mineral depletion if mineral exploitation is to achieve its full potential (Asif et al., 2020). It is important to recognize that natural resources exist, which have potential value, and when utilized, they contribute to a region's economic growth. The availability of natural resources drives the demand for power from industries.

Natural resources have a major potential for economic growth, and Governments are the principal players in harnessing this potential (Sharma and Mishra, 2022). Robust regulatory frameworks that support responsible resource extraction to enable equitable revenue sharing and smart investment in sustainable development can enhance the upside of the global mining sector while minimizing its negative environmental and social externalities (Kwakwa et al., 2020). One thing is clear: in the future, we need reliable sources of clean energy if we wish to respond to the growing energy demand while also satisfying global needs to reduce emissions of greenhouse gases. Renewable energies support the utilization of clean energies and their amalgamation into existing energy frameworks as encouraging alternatives in managing carbon discharges (Luo et al., 2023).

The emission of $CO_2$ into the air has several excesses due to an enhanced global temperature, extreme weather conditions, and environmental prompts (Abbasi and Riaz, 2016). Developing the quality of the environment requires direct regulation of the field, so compliance with these regulations is also a goal since compliance can only be achieved by securing inputs of environmental value at the point of development and the point of consumption (Abban et al., 2023; Nuţă et al., 2024; Shahbaz et al., 2023). To decrease the amount of $CO_2$ released, governments and industries should devise and adopt ways to cut greenhouse gases directly. Carbon pricing mechanisms, such as carbon taxes and trading systems, can encourage businesses to use cleaner and more sustainable methods (World Bank Group, 2021). Mineral rents are the money the state gains over and above costs for extracting natural resources as royalty or tax. These rents are the value that the resource generates beyond the costs it extracts (Ahmed et al., 2020). Depletion is typically a result of over-exploitation, natural erosion, and other continuous forms of degradation, or it is due to different reasons (Figure 1). The concept of mineral depletion is important for assessing the sustainability of resource exploitation, but the relationship it describes is entangled with that of mineral rents. Maximizing mineral rents without depleting resources and managing resources responsibly responsible resource-extraction policies, for example, licensing systems, environmental regulations, and resource-reserve monitoring, can reduce the rate of mineral-resource depletion. Moreover, it pays to invest in exploration research and development to find out where new mineral deposits are (Li et al., 2020).

From growth and policy, energy production and use, economic growth and policy, energy production and use, and carbon dioxide damage contribute to Natural Resources. Natural resources are essential for economic growth and development (Payne et al., 2017). The development of human societies depends on the extraction, exploitation and use of natural resources throughout human history. This paper looks at how natural resources affect economic growth, energy production and consumption, and harm from carbon dioxide (Murshed, 2021). They are the basic goods and services used in the production process and affect the competitiveness of economies.

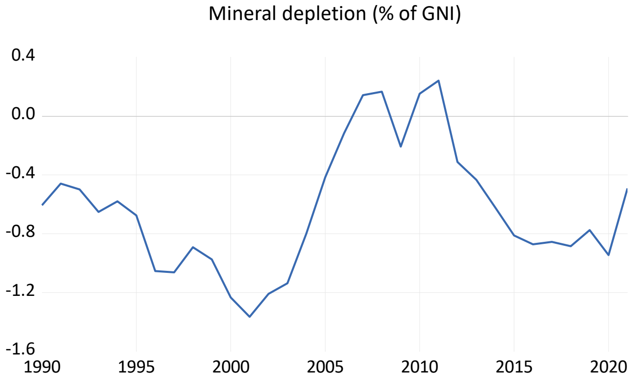


Figure 1. Mineral resource depletion.

Moreover, easily extracted natural resources can shape policymaking. The development and use of these technologies, known to governments as critical technology, are used to pursue a range of national economic growth and development strategies. For instance, oil-rich countries might focus on oil exploration and building energy infrastructure to help grow their economies (Safa and Samarasinghe, 2011).

The primary factor affecting what types of energy a country can use is the availability and accessibility of natural resources. For instance, countries with abundant oil resources may prefer an oil-based energy system, or if oil is accessible only in a small amount in certain countries, then those countries may prefer renewable energy. Fossil fuels, as a major part of natural resources, are the main driver of the greenhouse effect, enhancing the magnitude of impact on the environment due to $CO_2$ emissions. Abstracting and using natural resources, particularly those of fossil origin, is also a source of environmental hazards. The destruction of habitats, pollution and the release of greenhouse gases is associated with mining operations, oil drilling and deforestation. When implemented, these activities can adversely affect the local ecosystems and human health (Singh et al., 2023).

Recently, there has been increasing research about the negative consequences of $CO_2$ emissions on the environment and human health (Adebayo et al., 2021; Guo and Jiang, 2011; Jayanthakumaran et al., 2012; Mohmmed et al., 2019; Musarat et al., 2021; Worldometer, 2019; Zhang et al., 2013; Zhao et al., 2021). One of the most fundamental aspects of $CO_2$ damage is how it relates to mineral depletion. The quest to meet the increasing energy demand has increased the extraction of fossil fuels to cater for the growing energy requirements in the global society (Namahoro et al. 2021). Such extraction leaves resources like coal, oil, and natural gas that took millennia to develop (Bekhet and Othman, 2017). Mineral depletion has been documented as having severe detrimental effects in several studies (Church and Crawford, 2020; Franks et al. 2023; Huang et al. 2020; Ouédraogo et al. 2022; United Nations, 2020; Xiong et al. 2023; Yu et al., 2023). The findings of these studies indicate that the consumption of non-renewable sources that may be available will be low over time. As a result, ex-post societies could face rising costs and declining access to critical minerals through resource rentals. Other external damages from $CO_2$ are mineral rents (Zhironkin et al., 2023) and mineral depletion. Mineral rents are the economic benefits obtained from mineral extraction and sale. This, however, leads to a decline in the value of the financial benefits achieved from that resource as it is being over-exploited and lost too fast.

Indeed, previous research also confirmed this $CO_2$ damage effect on mineral rents (Abbasi et al., 2021; Bekun et al., 2019; Caglar et al., 2022; Isiksal et al., 2022; Kwakwa et al., 2020; Zhang et al., 2022). Revenue from the sale of minerals declines due to withdrawing minerals from the ground at unsustainable rates. It affects economic growth and financial stability and results in social and economic instability (Abbasi et al., 2021). Access to clean fuels and technologies for cooking is essential to human health and environmental sustainability (IEA, 2019a). Yet, the damage to $CO_2$ discourages using clean fuels and prevents the adaptation of cleaner cooking technologies. Many studies found a high contribution of the emissions of greenhouse gases from the burning of conventional biomass e., firewood charcoal (Bildirici and Özaksoy, 2016; Bui et al., 2021; Hung, 2022; International Renewable Energy Agency, 2018; Wang et al., 2020). Furthermore, Ajmi and Inglesi-Lotz (2020) have shown how much energy poverty limits sustainable development actions. Previous studies demonstrate the importance of providing clean cooking solutions (LPG, solar cookers) to help with any $CO_2$ damage.

$CO_2$ harm is partially attributed to the energy used in different sectors and households (Shahbaz et al., 2016). Fossil fuel combustion is undoubtedly a significant contributor to global warming, with a dominant method of fuel being coal petroleum products (Uddin et al., 2018). Various studies have also researched the impact of $CO_2$ damage on energy use (Gielen et al., 2019; IEA, 2019b; Sohag et al., 2015). This research demonstrated that energy management and environmentally responsible practices offer a promising way to minimize greenhouse gas emissions through energy efficiency measures. Furthermore, Režný and Bureš (2019) described Carbon dioxide damage as a major concern concerning global warming (Bento and Moutinho, 2016). Higher global temperatures cause several weather issues like heatwaves, hurricanes and droughts. Climate events have consequences in the energy system that can be so severe that they can result in power supply interruption and large-scale power failure (Munir et al., 2020).

An export value index indicates a country's ability to maintain and expand its export-oriented industries. However, $CO_2$ damage can degrade this index by lowering the value of exports. Several studies have discussed the link between $CO_2$ damage export value indices (Khan et al., 2020). These results indicate that countries that cannot address their $CO_2$ release might struggle to sustain their competitiveness in world markets. These extra costs dampen the ability to compete in international markets (Qi et al., 2013), making it less attractive for those who desire to purchase sustainably and safely. Export industries, which the country largely supports, bear a heavy moorage in the cost of $CO_2$ damage mitigation. Accordingly, they may be unable to sell as many goods to other countries, harming economic growth.

The existing literature shows significant gaps in our understanding of linkages between natural resources, economic growth, policy role, energy production and use, and damage due to carbon dioxide emissions. Although different aspects related to these issues have been studied in various papers, there is an absence of a systematic analysis to look at the linkages between mineral rents and mineral depletion in connection with economic growth, policy, energy production and carbon damage in a unified framework. This literature study aims to invoke further studies in this field to have a good understanding of how these natural resources have contributed to economic growth and policy, leading to the connection with energy production, consumption and resulting damage, mainly with carbon dioxide emissions and major emphasis on mineral rents and depletion.

## METHODOLOGY

### Theoretical Linkages and Model Development

The resources are extracted and used in many fields, including industry, agriculture, and also by households. On the other hand, it hurts the environment through natural resource extraction and depletion, creating several problems, such as climate change. Natural resources are a blessing to a country; they are a godsend, and if harnessed well, they can help the country achieve various economic milestones. Economic growth is the rising trend in the national income measured by a given physical measure over time. Economic growth is associated with the steady flow of innovation and technological advancement. Mineral resources are used to produce goods we use daily, such as steel, electronics, and jewellery. Inessive Iron Insurgency These minerals are often exported, bringing revenue into the country. These minerals can be extracted and exported to earn foreign exchange, provide employment and stimulate economic growth. These generate electricity, power up industries, and provide support for transportation. Governments typically prioritize fossil fuel discovery and exploitation to meet the rising demand for energy and aid economic growth.

Energy production and use are directly concerned with natural resources and economic expansion. Energy is needed to fuel many industries, transportation, and financial activities. World population growth and the ever-increasing trend of providing more and better goods and services to each inhabitant also increase energy demand. Economic activities and the Industrial Revolution were supported by these fuels that provided cheap energy everywhere. In recent years, renewable energy sources have found their importance. One way renewable energy contributes to economic growth is by creating jobs while promoting innovation and sustainable development.

Greenhouse gas, in turn, is caused by the greenhouse effect and global warming, where $CO_2$ emissions are one such kind of gas. Not only is this disrupting the natural climate system of our planet, but it is also causing the loss of biodiversity, the rise of sea levels, and the worsening of hot and cold circumstances. The impacts of these - on economic growth and human well-being are dire. Efforts are being made to reduce greenhouse gas emissions and move towards clean, renewable opportunities to help curtail and adapt to climate change effects. Energy efficiency, renewable energy uptake, and carbon pricing mechanisms are policy areas where government policy and regulation have a role to play. These actions are driven to encumber the harmful influences of $CO_2$ discharges on the financial system and sustainable growth. Mineral rents can be distributed to the state and the individuals or companies involved in resource extraction. Mineral rents, aside from contributing to economic growth, can also, if properly handled, generate extra revenue for the government to invest in the areas of infrastructure development, education, and health care.

On the other hand, the recovery and consumption of mineral resources, however, creates foundations for new problems. Definition: Mineral depletion is the dynamic version of the static concept of a mineral reserve. It refers to the decrease in the availability of the ore minerals in a rock required to extract the metal. This can deter economic growth and development (impacting countries that depend on these resources for economic growth) and ultimately--if natural resources are the immediate source or input for producing goods and services manufactured to ensure resources for global development--resource depletion over the long-term.

This paper examines the impact of mineral depletion and rents on carbon dioxide damage in China from 1990 to 2021, considering the availability of clean fuels and technologies for cooking, energy use, and export value index as moderating variables.

$$LOGCOD_t = \beta_0 + \beta_1 LOGMD_t + \beta_2 LOGMRE_t + \beta_3 LOGACC_t + \beta_4 LOGENG_t + \beta_5 LOGEX_t + \mu_t \quad (1)$$

LOGCOD is adjusted savings: carbon dioxide damage (% of GNI), LOGMD is adjusted savings: mineral depletion (% of GNI), LOGMRE is mineral rents (% of GDP), LOGACC is access to clean fuels for cooking (% of population), LOGENG is energy use (kg of oil equivalent per capita), and LOGEX is export value index (2000 = 100). One metric used commonly in mining to measure the depletion of mineral resources is the mineral depletion ratio.

### Test for Equality of Means between Series

The test for equality of means is employed to evaluate if two or more sets of series have differences in the means. Null: The means of the samples in the two series are the same. Alternative: The means of the two series' samples are unequal. If the means between the two groups are the same, the data indicate that there is no reason to believe the means differ and, thus, no reason to refute the null hypothesis. Otherwise, if the two group means are unequal, a substantial difference exists between the two datasets. A wide range of methods is frequently used to test the equality of means between test series. A frequently used example is the significance of the difference between two independent means, tested using the t-test for two samples. The t-test is used to say whether the two means between the groups are the same if the t-test value calculated > critical value indicates a significant difference in the means of two groups.

$$t = (mean1 - mean2) / (sd1 / n1 + sd2 / n2) \quad (2)$$

Where, t: The t-test statistic, mean1: The mean of the first group, mean2: The mean of the second group, sd1.

### Unit-Root Test

The DF-GLS unit root test is extremely useful when the time series has both a trend and seasonal components, making detecting a unit root difficult when using other unit root tests". Another fractional unit root test (fractional Dickey-Fuller) is the DF-GLS unit root test. The DF test assumes that the time series follows a normal distribution. A GARCH model is incorporated to deal with non-normality in the DF-GLS unit root test. The GARCH model specification permits the accommodation of non-normality and volatility in the time series, thereby making the test powerful in determining whether or not the series contains a unit root

$$DF - GLS = (Xt - Xt - 1)\hat{}2/((Xt - Xt - 1)\hat{}2 + (Xt - 2 - Xt - 1)\hat{}2) \quad (3)$$

**Engle-Granger Co-integration Test**

The common errors and the common trends are bound to the Engle-Granger test. When driving, we would look for a test of the co-integration relationship among the variables by estimating a system of equations combining both variables and the error correction term. This was devised by Engle and Granger in 1982, and it has become the most popular method in this area of econometrics. The Engle-Granger test is particularly useful when the variables of interest are measured on different scales, have different frequencies, or exhibit structural breaks. It is conducted in two main phases. The first phase involves testing the time series data for stationarity to determine whether the variables have a constant mean and variance over time. This is essential because cointegration analysis requires that the variables be non-stationary in levels but stationary in their differences. In the second phase, cointegration analysis is performed to assess whether a long-term equilibrium relationship exists among the non-stationary variables. If such a relationship is found, it implies that the variables move together over time despite short-term deviations. The co-integration test aims to estimate the error correction model comprising the variables and the error correction term. With these in mind, the first test we are introduced to is a co-integration test introduced by Engle and Granger, which is derived through t-statistics (Student's t-test) to test the statistical significance of the estimated coefficients. The t-statistic determines whether the variables are cointegrated: the higher the absolute value, the greater the likelihood that the variables are cointegrated.

$$z\_t = a + bx\_t + cy\_t + d * e\_t \quad (4)$$

Where, z_t is a cointegrating variable, and e_t is again the error term.

**Long-run Model**

Fully Modified Ordinary Least Squares (FMOLS) augments Ordinary Least Squares (OLS), enabling additional leeway regarding model specification and is somewhat more robust against assumptions. One exception is cases where the relationship is non-linear or if there are interaction terms. The residuals from a regression model must conform to a normal distribution, and the observations should be independent. This assumption is relaxed in the models concerning unobserved factors, such as panel models or models that account for serial correlation in the errors.

FMOLS versus other regressions FMOLS has numerous advantages over other regression techniques. It is insensitive to heteroscedasticity and non-normality in the error terms. And there is no restriction for linear relationship and constant variance. Also, FMOLS does not place any demands on the nature of the relationships and does not require the full specification of error terms.

$$y = X\beta + u \quad (5)$$

Where y represents the response variable, X represents the design matrix, which contains the values of all independent variables, β represents the parameter vector.

**RESULTS AND DISCUSSION**

Descriptive statistics are presented in Table 1. The means and medians are similar for carbon dioxide damage, mineral depletion, access to clean fuel, technology, and energy use. Therefore, most of this case study will be centred on the central value, which should be controlled. Mineral depletion has a higher standard deviation than mineral resource rents and energy use. The standard deviation value of mineral depletion is around 0.429064, that of mineral resources rents is 0.381769, and that of energy use is 0.194993. As indicated by the relatively high standard deviation of mineral depletion, this phenomenon varies more widely globally than other indicators. It shows much more variation in the total mineral resource use and depletion rate. This variation was observed through changes in technology, consumption habits, and variability in resource availability. The skewness of mineral depletion and mineral resource rents were calculated to be 0.486625 and 0.528304, respectively. These distributions are not from a standard normal distribution as per the Jarque-Bera probability values (a test for normality). Skewness is used to measure the symmetry of a distribution.

This was illustrated in Table 2, mapping the result of covariance analysis. It suggests a negative relationship between mineral depletion and $CO_2$ damage, as indicated by the negative covariance of -0.004316 (the number reported for the unstandardized covariance in Table 4). The more minerals are missing, the less likely carbon damage is caused. This relationship reinforces the belief in conserving and managing forest resources to check climate change. The data for mineral resource rents and carbon dioxide damage showed a positive correlation; their covariation was 0.003764. This covariation suggests an association between the two variables. There are several ways to interpret the covariation between these two variables. A low positive correlation exists between energy use and mineral depletion of 0.027364. That is, if the use of energy increases, it tends to deplete some minerals. This connection can be seen internationally and in many businesses requiring high energy and exploiting natural resources to satisfy those needs.

Table 1. Descriptive statistics.

| Statistics | LOGCOD | LOGMD | LOGMRE | LOGACC | LOGENG | LOGEX |
|---|---|---|---|---|---|---|
| Mean | 0.669668 | -0.633049 | -0.372100 | 1.693417 | 3.138397 | 2.380384 |
| Median | 0.714887 | -0.664433 | -0.434468 | 1.682971 | 3.162315 | 2.537568 |
| Maximum | 0.922108 | 0.240625 | 0.373319 | 1.920123 | 3.379763 | 3.005705 |
| Minimum | 0.438669 | -1.365295 | -0.903569 | 1.453318 | 2.867380 | 1.396475 |
| Std. Dev. | 0.144259 | 0.429064 | 0.381769 | 0.144705 | 0.194993 | 0.562569 |
| Skewness | -0.028079 | 0.486625 | 0.528304 | 0.026648 | -0.051510 | -0.327294 |
| Kurtosis | 1.749986 | 2.503501 | 2.333755 | 1.739524 | 1.307351 | 1.561125 |
| Jarque-Bera | 2.087585 | 1.591634 | 2.080403 | 2.122187 | 3.834232 | 3.331797 |
| Probability | 0.352117 | 0.451212 | 0.353384 | 0.346077 | 0.147030 | 0.189021 |
| Sum | 21.42938 | -20.25757 | -11.90722 | 54.18934 | 100.4287 | 76.17228 |
| Sum Sq. Dev. | 0.645131 | 5.706969 | 4.518181 | 0.649126 | 1.178689 | 9.811015 |

Table 2. Covariance analysis: ordinary.

| Covariance | LOGCOD | LOGMD | LOGMRE | LOGACC | LOGENG | LOGEX |
|---|---|---|---|---|---|---|
| LOGCOD | 0.020160 | | | | | |
| LOGMD | -0.004316 | 0.178343 | | | | |
| LOGMRE | 0.003764 | 0.153307 | 0.141193 | | | |
| LOGACC | -0.019490 | 0.009556 | -0.000137 | 0.020285 | | |
| LOGENG | -0.025176 | 0.027364 | 0.011930 | 0.026657 | 0.036834 | |
| LOGEX | -0.072029 | 0.072960 | 0.031952 | 0.076701 | 0.104717 | 0.306594 |

Table 3 presents tests for equality of means across series for the variables carbon dioxide damage, mineral depletion, mineral rents, access to clean fuels and technologies for cooking, energy use, and export value index. Table 3 indicates that the means of $CO_2$ damage with energy use series are significantly different as $p < 0.05$, implying a rejection of the null hypothesis. This puts the average country well above the average energy consumption, and such a gap is huge. By contrast, none of the means of the other series are significantly different, which also means that the countries show similar points concerning the intra-differences in mineral depletion, mineral rents and the export value index. According to independent samples for different series t-tests, the means of the various series for some variables, such as carbon dioxide damage, mineral depletion, mineral rents, access to clean fuels, and technologies for cooking and energy use, are different.

Table 4: DF-GLS unit root results in the short run, mineral resource rents are fixed at a stable rate. Although resource rents are probably not very sensitive to the underlying technology or resource quality in the short run, they mainly vary in the same direction as the changes in resource quantities and prices determine their resource prices. Mineral resource rents stay constant in the short run, with no increase or decrease in their growth. Price controls, no regulations, and market constraints are some of the mechanisms in the mineral industry that helped maintain this stability. In the short and long run, carbon dioxide damage, mineral depletion, energy use and explore value index are at the first difference, stationary data.

Engle-Granger co-integration test (Table 5) Results of the co-integration analysis indicate that carbon dioxide damage, mineral depletion, mineral rents, access to cleaner energy, energy use, and export value index are cointegrated. So, cointegrated variables are variables that move together in the long run despite having variance in the short run. The knowledge that the availability of energy resources and economic growth are correlated could help policymakers consider other dependent variables when designing policies and their objectives to implement climate policies for addressing energy depletion and a useful tool to save energy to meet sustainable energy needs for the future. This can help policymakers see if there is feedback and, eventually, the long-term implications by identifying and studying the co-integration of these variables. This interconnectedness implies that policymakers must consider the relationships among these variables when developing policies and interventions.

Table 6 provides the result of fully modified least squares (FMOLS) and the findings of variance inflation factors in Table 7. A 1% increase in mineral depletion in China reduces 0.158455% of carbon dioxide damage. Mineral depletion may involve decreasing the concentration of minerals in a metal, mineral, or environment. This can affect many industries as well as ecosystems. This article focused on studying the impact of the gradual depletion of mineral resources on carbon dioxide damage in China. The mining of a particular mineral type may go on so rapidly that the reservoir of the mineral type is depleted before reclamation can occur. This hurts numerous industries, including those that use these minerals in their manufacturing stage. Mineral depletion greatly contributes to the damage done by carbon dioxide in China.

If mineral resource rents grow by 1%, then the increase in damage to carbon dioxide in China is 0.128950%. Mineral resource rents are the largest source of revenue for governments and are critical to economic development. On the flip side, mining and processing of mineral resources may have positive environmental impacts. Empirical research on the effect of mineral resource rents on carbon dioxide damage in China: By considering mineral resource rents with $CO_2$ damage, they found that a 1% increase in mineral resource rents led to a roughly 0.025% increase in carbon dioxide damage in China. Nonetheless, even a minor climb over the horizon can have long-term effects. Higher rents of mineral resources can be associated with greater mining activity, higher carbon emissions, and greater flow of pollutants into the atmosphere. Mineral resource rents are growing, which could result in more economic activities that increase energy use. Moreover, mining mineral resources can have direct environmental repercussions, such as forest clearing, wildlife loss, and soil erosion.

Table 3. Test for equality of means between series.

| Method | | df | Value | Probability |
|---|---|---|---|---|
| Anova F-test | | (5, 186) | 607.6278 | 0.0000 |
| Welch F-test* | | (5, 84.4292) | 968.5018 | 0.0000 |
| Analysis of Variance | | | | |
| Source of Variation | | df | Sum of Sq. | Mean Sq. |
| Between | | 5 | 367.6656 | 73.53312 |
| Within | | 186 | 22.50911 | 0.121017 |
| Total | | 191 | 390.1747 | 2.042800 |
| Category Statistics | | | | |
| Variable | Count | Mean | Std. Dev. | of Mean |
| LOGCOD | 32 | 0.669668 | 0.144259 | 0.025502 |
| LOGMD | 32 | -0.633049 | 0.429064 | 0.075848 |
| LOGMRE | 32 | -0.372100 | 0.381769 | 0.067488 |
| LOGACC | 32 | 1.693417 | 0.144705 | 0.025580 |
| LOGENG | 32 | 3.138397 | 0.194993 | 0.034470 |
| LOGEX | 32 | 2.380384 | 0.562569 | 0.099449 |
| All | 192 | 1.146119 | 1.429265 | 0.103148 |

Table 4. DF-GLS unit root.

| Methods/Variables | At-Level | | At-First difference | |
|---|---|---|---|---|
| | t-Statistic | Prob. | t-Statistic | Prob. |
| LOGCOD | -0.167099 | 0.8685 | -3.723840*** | 0.0008 |
| LOGMD | -1.536490 | 0.1349 | -3.849439*** | 0.0006 |
| LOGMRE | -1.749839* | 0.0904 | -3.602329** | 0.0012 |
| LOGACC | -0.809466 | 0.4262 | -2.403466* | 0.0247 |
| LOGENG | -1.168301 | 0.2525 | -1.829596* | 0.0776 |
| LOGEX | -0.181311 | 0.8574 | -4.076421*** | 0.0003 |

***,**, and * show significance at 1%,5%, and 10%.

Table 5. Engle-Granger cointegration test.

| Dependent | tau-statistic | Prob.* | z-statistic | Prob.* |
|---|---|---|---|---|
| LOGCOD | -3.380350 | 0.5955 | -16.36173 | 0.6385 |
| LOGMD | -5.579684 | 0.0286 | -31.68437 | 0.0243 |
| LOGMRE | -5.632324 | 0.0260 | -31.18697 | 0.0287 |
| LOGACC | -1.680450 | 0.9915 | -7.879876 | 0.9784 |
| LOGENG | -4.164481 | 0.2691 | -23.11747 | 0.2371 |
| LOGEX | -2.312896 | 0.9433 | -9.579512 | 0.9495 |

| Intermediate Results: | LOGCOD | LOGMD | LOGMRE | LOGACC | LOGENG | LOGEX |
|---|---|---|---|---|---|---|
| Rho - 1 | -0.527798 | -1.022076 | -1.006031 | -0.254190 | -0.745725 | -0.309017 |
| Rho S.E. | 0.156137 | 0.156137 | 0.183178 | 0.178617 | 0.151263 | 0.179068 |
| Residual variance | 0.000870 | 0.000870 | 0.003258 | 0.003592 | 0.000116 | 0.000282 |
| Long-run residual variance | 0.000870 | 0.003258 | 0.003592 | 0.000116 | 0.000282 | 0.003538 |
| Number of lags | 0 | 0 | 0 | 0 | 0 | 0 |
| Number of observations | 31 | 31 | 31 | 31 | 31 | 31 |
| Number of stochastic trends** | 6 | 6 | 6 | 6 | 6 | 6 |

If access to clean fuels and technologies used for cooking increases by 1%, carbon damage in China will decrease by 1.781765%. This results from lower $CO_2$ emission rates in developing clean fuel and technological growth. For a similar category, natural gas stoves have lower $CO_2$ emissions than stoves using firewood or coal. In addition, combustion efficiency improves by using clean fuels and technologies, resulting in less fuel being utilized to produce one unit of energy. Which, in turn, cuts down the amount of total $CO_2$ emissions that are released into the atmosphere. Clean fuels and technologies also often have better insulation and ventilation, which can further reduce the carbon footprint in cooking. Not only does it reduce the impact of $CO_2$ emissions, but it is also a sustainable economic development, job creation, and public health benefit.

The most important result of the empirical analysis is the almost zero income elasticity of public health, as the large effect of economic growth on carbon dioxide damage applies only to energy use, on which the elasticity is 1. Similarly, a 1% increase in energy use increases the $CO_2$ damage ratio in China by 1.325747%. If energy consumption increases by 1%, the related damage of carbon dioxide emissions is predicted to increase by 1.325747%. It is envisaged that the carbon intensity of energy sources, the conversion efficiency of energy vectors and the implementation of renewable will affect that relationship. Please remember that increased $CO_2$ damage occurs not only in China but worldwide. The changing climate will have various impacts, from increased temperatures and altered precipitation patterns to more severe storms and the decimation of biodiversity. The country's sustainable development depends on the transition to a low-carbon and energy-efficient economy in response to the need to reduce the accumulative effects of carbon dioxide and minimize the negative impact of global climate change. This can be achieved by promoting renewable energy sources, bettering energy efficiency in industries, switching to sustainable transportation, etc.

Table 6. Method: fully modified least squares (FMOLS).

| Variable | Coefficient | Std. Error | z-Statistic | Prob. |
|---|---|---|---|---|
| LOGMD | -0.158455* | 0.073270 | -2.162619 | 0.0399 |
| LOGMRE | 0.128950* | 0.074451 | 1.732028 | 0.0951 |
| LOGACC | -1.781765*** | 0.308451 | -5.776491 | 0.0000 |
| LOGENG | 1.325747*** | 0.136908 | 9.683505 | 0.0000 |
| LOGEX | -0.221049*** | 0.041680 | -5.303507 | 0.0000 |

***and**show significance at 1%, and 5%.

Table 7. Variance inflation factors.

| Variable | Coefficient Variance | Uncentered VIF |
|---|---|---|
| LOGMD | 0.005368 | 109.2461 |
| LOGMRE | 0.005543 | 54.45885 |
| LOGACC | 0.095142 | 9625.905 |
| LOGENG | 0.018744 | 6468.992 |
| LOGEX | 0.001737 | 368.2128 |

The Chinese carbon dioxide damage decreases by 0.221049%, with a 1% increase in the export value index. This shows an honest relationship between China's export performance and carbon dioxide reduction. As the export value increases, carbon dioxide emissions to the atmosphere decrease. This lower carbon dioxide damage is due to several things, such as improved energy efficiency in export-based industries, cleaner technology, and the shift to greener behaviour. The authors of this study say the findings show how international trade can encourage sustainable development while lowering greenhouse gas emissions. More export-driven growth will also enhance China's standing as a responsible global citizen. It should be pointed out that this analysis gives a rough estimate, and there could be more explanations for the relationship between the export value index and carbon dioxide impact.

**CONCLUSIONS AND POLICY IMPLICATIONS**

Natural Resources are vital in supplying raw materials, energy and ecosystem services that sustain a wide range of industries and human endeavours. These inputs are used in producing goods and services through which a ready material is provided for many sectors. This includes minerals, e.g., Iron ore and coal, which are also important for steel making and infrastructure! Natural resources are frequently used to generate energy, a fundamental input for many manufacturing and industrial processes. Natural resources are also used in policy formulation and decision-making. Because they are so important in energy production and use, natural resources are diggers of energy. We use them for everything from fueling our transportation systems to powering our cities and infrastructures. Yet, the harvesting and burning of fossil fuels also result in damage from $CO_2$. Besides, they are cleaner and more eco-friendly resources for generating electricity. Risks to food security, water availability, and infrastructure from climate change can result in other catastrophic natural disasters like floods and droughts, which can have dramatic economic and social impacts. Tackling the damage $CO_2$ causes will help us and the environment in the long term in a more sustainable and adaptable way. Thus, natural resource endowments impact economic performance, energy production and utilization, and carbon dioxide damages. They are an essential input in various financial processes and are needed to produce energy. Yet their extraction and burning are linked to global warming and ecologic destruction.

The improvement of natural resource allocation efficiency in China and optimizing growth resource contribution should be given corresponding policy implications. Mineral rents are like a tax imposed on minerals production forced to pay more than required to bring these minerals to market. China has to efficiently utilize mineral rents to ensure the maximum contribution of the minerals sector to economic growth and development. Mineral depletion is the reduction or exhaustion of mineral reserves over time as these minerals are extracted from this virtual mineral inventory in the lithosphere. Another question is what kind of policies China can implement to deal with mineral depletion while maintaining a sustainable natural resource base. Energy Production involves ensuring that it can produce energy from resources such as coal, oil, natural gas, renewable energy, and nuclear power in the age of water cycling. It will help the nation produce more electricity to keep up with rising energy requirements and the least environmental degradation. China should push for an energy-efficient economy to decrease energy consumption per unit GDP. This will be achieved by adopting strategies that support technological innovation, conservation measures, and implementing renewable energy options. China needs comprehensive carbon-reducing policies to decrease greenhouse gas emissions. Such policies can include carbon pricing, specific subsidies for renewable energy or research and development for clean energy technologies. China can also look for $CO_2$ capture and safe-keeping prospects through Carbon Sequestration Technologies. The release of carbon dioxide into the atmosphere can be controlled to curb climate change.

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