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Xu, Mohan and Tang, Yao

Peking University, Peking University

2 April 2025

Online at https://mpra.ub.uni-muenchen.de/124270/
MPRA Paper No. 124270, posted 07 Apr 2025 05:50 UTC

What Explains the Greening of China's Energy ODI? The Role of Environmental Regulation, Endowments and Financial Factors *

Mohan Xu[†] and Yao Tang[‡]

April 2, 2025

Abstract

In the current study, we document a steady rise in the share of renewable energy projects in China's outward direct investment (ODI) in the energy sector. We examine the driving forces and find that both host country's environmental regulation and financial factors has generated different or even opposite effects on China's ODI in fossil fuels and renewable energy. Specifically, China's ODI in fossil fuels is positively correlated with endowments in fossil fuels, electricity consumption, low financing costs, and high exchange rate volatility. In comparison, ODI in renewable energy is more likely to occur in host countries with stricter environmental regulation and less likely to be impeded by tighter monetary policy. The results suggest that the combination of regulatory policies and financing conditions can have an important influence in the global transition to renewable energy.

JEL classification: F21, E43, Q40
Keywords: direct investment, fossil fuels, renewable energy, environmental regulation, monetary policy, exchange rate volatility

*The authors are grateful for the suggestions and comments from Longfei Gao, Juanjuan Meng, Runheng Li, Kehan Liu, Yue Lv, Minghui Ma, Hui Wang, and Meilan Zhang. Tang acknowledges the financial support from the National Social Science Foundation of China (Grant Number 22&ZD057). All errors are our own.

[†]Department of Applied Economics, Guanghua School of Management, Peking University, 5 Yiheyuan Road, Haidian District, Beijing 100871, China. E-mail: xu.mohan@stu.pku.edu.cn.

[‡]Corresponding author. Department of Applied Economics, Guanghua School of Management, Peking University, 5 Yiheyuan Road, Haidian District, Beijing 100871, China. E-mail: ytang@gsm.pku.edu.cn.

1 Introduction

China has emerged as an important participant in cross-border direct investments, with its stock of inward and outward direct investments ranking second and third in the world respectively by the end of 2023.[1] Outward direct investments (ODI) are pivotal in the globalization of China, facilitating China's access to factor inputs, enhancing general efficiency, and providing inroads to overseas markets. Given that China's domestic supply of crude oil and natural gas has fallen substantially short of the immense energy demand driven by its high-growth economy, projects in the energy sector constitute a dominant portion of China's ODI activities. While some researchers have examined how supply diversification, high fuel prices, and host country policy affect China's ODI in the energy sector (Wüstenhagen and Menichetti, 2012; Eyraud, Clements, and Wane, 2013), the overall understanding of China's energy ODI remains limited. A prevalent, albeit inaccurate, impression is that China's energy ODI predominantly concentrates on fossil fuels (Liedtke, 2017). As energy consumption is one of the most crucial factors in climate change—one of the leading challenges of our time, it is pressing to deepen the understanding of China's energy ODI.

In the current study, we first document an important yet usually neglected fact that China's ODI in renewable energy has been rising steadily. Starting from a baseline of zero cases of major ODI in renewable energy in approximately 2005, such investments had risen to constitute around 44% of China's total energy ODI cases by 2020. Secondly, we examine potential factors that can account for China's transition to greener energy ODI, which so far has received limited attention beyond a few number of policy reports.[2]

Analyzing 414 cases of direct investments in energy from the China Global Invest-

[1] The ranking of inward direct investment stock and outward direct investment stock was based on data from World Investment Report 2024.

[2] For instance, Ma and Ma (2023) reports that China has accelerated its overseas investment in renewables and ceased grid-connected coal-fired power project finance, following through on its 2021 pledge to stop building new coal power plants and support low-carbon and clean energy.

ment Tracker (CGIT) database from 2005 to 2020, we focus on whether and how the host country's environmental regulation, fossil fuel endowments, and financial factors affect energy ODI from China. These factors exhibit varying and sometimes opposing effects on China's ODI in the fossil fuel and renewable energy sub-sectors. To be specific, our analysis yields four main results. Firstly, the environmental regulation of the host country is positively correlated with China's ODI in renewable energy, but it has no significant effect on ODI in fossil fuels, consistent with the popular view that environmental regulation is in favor of green investment projects.

Secondly, there is some evidence that fossil fuel endowments attract China's investment in fossil fuel projects, which aligns with expectations. Meanwhile, the fossil fuel endowments of the host country are uncorrelated with China's investment in renewable energy.

Thirdly, financial factors are important in energy ODI. As predicted by the "stranded asset" hypothesis, reduced financing costs mitigate the risks associated with investments in fossil fuels, making them more viable in low-interest environments. In comparison, investments in renewable energy are less affected by a high-interest environment. We also find that higher volatility of the host country's exchange rate is positively correlated with ODI in fossil fuels, supporting the conjecture that investors seek to hedge against the exchange rate risk by internalizing the international trade of fossil fuels.

Fourthly, extending our analysis to China's ODI in the manufacturing and service sectors, we find a pattern similar to investments in fossil fuels and renewable energy. Tighter environmental regulation is associated with China's increased ODI in emission-light sectors, whether it is renewable energy or service. In comparison, emission-intensive ODI, such as those in fossil fuels or manufacturing, are drawn to countries with richer fossil fuel endowments and higher exchange rate volatility. The extended analysis lends additional support to our conjecture about the role of environmental regulation, fossil fuel endowment, and financial factors.

Our key findings remain robust when we address the endogeneity of environmental regulation by using instrumental variable (IV) regressions, and by applying the methods of Oster (2019) to bound the omitted variable bias. Furthermore, substituting the dollar value for the count of transactions as the metric for energy ODI yield similar results.

We contribute to the literature on China's energy ODI, by demonstrating that environmental regulations is a key determinant in the rapid expansion of China's ODI in renewable energy. Our findings underscore the significance of the host country's policy environment in understanding the composition of China's energy ODI. Our work is closely related to Lv and Spigarelli (2016) and Liu et al. (2020). In the context of Europe, Lv and Spigarelli (2016) suggest that a stable political environment, investment-friendly policies, and low trade barriers are positively related to Chinese ODI in renewable energy. Liu et al. (2020) demonstrates that the political environments, natural resource endowments, and energy efficiencies of host countries increase energy ODI from China. Compared to these studies, the current study analyzes of a more comprehensive set of determinants of energy ODI, including environmental regulation, financial factors, endowments, and gravity variables. We also examine our hypothesis across a larger sample of countries available.

The current study also contributes to the general literature on the determinants of ODI from China (Cheung and Qian, 2009; Huang and Wang, 2011; Kolstad and Wiig, 2012). Compared to ODI from developed countries, China's ODI exhibits three salient characteristics. First, the effect of institutional quality of the host country on China's ODI is the abiding interest of researchers. Some studies suggest that Chinese enterprises have comparative advantages in rent seeking in countries with inadequate institutions or non-transparent environments (Morck, Yeung, and Zhao, 2008; Wang, Du, and Wang, 2015). Second, resource-seeking motivations are particularly pronounced among foreign direct investment (FDI) in the manufacturing industry (Kang and Liu, 2016; Kolstad and Wiig, 2012). Third, China's international expansion, predominantly undertaken by state-owned enterprises (SOEs), challenges classical direct investment theories (Amighini, Rabellotti, and Sanfilippo, 2013; Huang et al., 2017) which are developed based on investments of private enterprises from developed countries. As SOEs are particularly attentive to bilateral relationships, the political relationship between countries emerges as a crucial factor in China's ODI decisions (Li and Liang, 2012). Besides, the international investment agreements between nations are also a crucial consideration in China's ODI, with the most influential being the Belt and Road Initiative (BRI) launched in 2013. Nugent and Lu (2021) reveal that China's FDI outflows to BRI countries have increased in sectors with overcapacity and pollution problems in China, which are closely linked to the energy sector. Relative to the general literature on China's ODI, our study highlights the important and nuanced roles of environmental regulation and financial factors.

We also add to the discussion about the balance between environmental protection and industrialization. Literature finds that China's extensive mode of industrial development and resource utilization from the late 1980s to the early 2000s have resulted in serious environmental damage (Zhang and Wen, 2008; Xie, Yuan, and Huang, 2017). Our findings suggest that stricter environmental regulations discourages ODI in emission-heavy industries. In other words, national environmental regulations can reshape the geographic distribution of high-emission industries across countries, and accelerate the transition to a greener development.

The remainder of this paper is organized as follows: We introduce the main hypothesis in Section 2, and present the empirical research design and describe the data in Section 3. In Section 4, we report the empirical results regarding the determinants of ODI in different energy sub-sectors, and address the issues of endogeneity. The robustness of the results and the extension are explored in Section 5. In Section 6, we conclude the paper.

2 Hypothesis development

Improving access to resources, markets, and strategic assets, and enhancing efficiency are frequently cited as motivations behind China's ODI (Cheung and Qian, 2009; Huang and Wang, 2011; Kolstad and Wiig, 2012). ODI in the energy sector involves additional motivations, given that energy investments pertain to environmental impact, funding ability, and national security. Therefore, this study extends beyond bilateral factors typically considered in literature that capture the distance or relationship between China and the host country.[3] We focus on four important pull factors from host countries: environmental regulation, fossil resource endowment, financing costs, and the exchange rate volatility.[4] In this section, we formulate hypotheses concerning the expected effects of these factors.

2.1 Environmental regulation

A prevailing concern regarding the relationship between FDI and the environment is whether amid global capital mobility, polluting industries will relocate to countries with lax environmental regulations, creating 'pollution havens'. Early research on the Pollution Haven Hypothesis (PHH) (Pearson et al., 1987; Baumol and Oates, 1988; Motta and Thisse, 1994) suggests that FDI, particularly in 'dirty' industries, is inclined to move to countries with lenient environmental policies. However, empirical research to date has yielded mixed evidence, failing to support or reject the PHH conclusively(Rezza, 2015; Santos and Forte, 2021; Cole, Elliott, and Zhang, 2017).

In recent decades, environmental issues caused by the primary energy consumption have increasingly garnered global attention (Valadkhani, Smyth, and Nguyen, 2019).

[3] In the Ownership Location and Internalization (OLI) framework of Dunning (1980), these control variables about bilateral distance or relationship can be interpreted as the 'internalization' advantages by building internal networks via direct investment.

[4] Within the context of the OLI framework of Dunning (1980), our core independent variables can be interpreted as the 'location' advantages of the host countries.

More countries, including many developing countries, have become increasingly engaged in actions to protect the environment and mitigate climate change (Zhang and Wen, 2008; Moshiri and Daneshmand, 2020). Consequently, cross-border direct investments in fossil fuels are less welcomed by countries with strong environmental regulations (Woods, 2006; Konisky, 2007). We formally hypothesize that:

H1a: More stringent environmental regulations in host countries hinder China's direct investments in fossil fuels;

H1b: More stringent environmental regulations in host countries promote China's direct investments in renewable energy.

2.2 Fossil resource endowment

Dunning (2009) notes that since the 1970s, location factors such as the quantity of natural resources have significantly influenced FDI location decisions. China's low per capita endowment of crude oil and natural gas, coupled with its rapidly expanding manufacturing sector, has led to a large gap between the domestic supply and demand for fossil fuels. In 2022, China's import dependence ratio for oil reached 69.8%, and for natural gas, 44.7%. This heightened import dependence poses a significant threat to China's energy security (Chen, 2011). Given these circumstances, China's direct investments in energy sector is strongly motivated by access to resource, registering a large number of investments in fossil fuels in developing countries (Shoham and Rosenboim, 2009; Wang, Du, and Wang, 2015; Hurst, 2011).

The effect of fossil resource reserves in the host country on China's direct investments in renewable energy is ambiguous. On one hand, if the host country possesses sufficient fossil resource reserves to satisfy its domestic demand, its motivation to pursue renewable energy development may diminish. On the other hand, once Chinese energy firms establish a presence in the energy sector and acquire knowledge of the policy environment the host country, it would be easier for they to expand to the renewable energy projects (Tan, 2013; CNPC, 2022). Consequently, we hypothesize:

H2a: China's ODI in fossil fuels tends to be concentrated in countries with abundant fossil fuel reserves;

H2b: The effect of a country's energy endowment on China's ODI in renewable energy is ambiguous.

2.3 Financing costs

In addition to long-term economic factors like factor endowments, Dunning (2009) posits that the macroeconomic policies implemented by host governments during business cycles are increasingly influential in location choices of FDI. In the current and subsequent subsections, we contend that financing costs and exchange rate volatility significantly influence ODI decisions in the energy sector. Specifically, our investigation focuses on whether the two financial factors affect the composition of direct investments in the energy sector, namely the mix of fossil fuels and renewable energy investments (Schnabel, 2022).

The risk-adjusted returns of two types of energy assets are expected to diverge in the medium and long term. To achieve the temperature target set by the 2015 Paris Agreement on Climate Change, the initiative of Leaving Fossil Fuels Underground (LFFU) call for more than 80% of all proven fossil fuel reserves to be idled (McGlade and Ekins, 2015). For their part, many governments have tightened climate policies, leading to increased compliance costs and considerable uncertainties for fossil fuel (Ansari and Holz, 2020; Rempel and Gupta, 2021; Shukla et al., 2022). Therefore, many carbon-intensive assets likely may become "stranded", because future regulations and restrictions may cause their value to undergo considerable long-term devaluation (Curtin et al., 2019; Semieniuk et al., 2022). Simultaneously, the increase in environmental consciousness in the society is reshaping the consumer behavior, leading to a preference for cleaner energy over fossil fuels (Aldy, Kotchen, and Leiserowitz, 2012; Lazdins, Mutule, and Zalostiba, 2021). Taking these changes into consideration, Hansen (2022)estimates that fossil fuel reserves might suffer a devaluation of 37%-50%. Therefore, investors are reluctant to invest in fossil energy projects unless expected capital loss is mitigated by a low financing cost.

Concurrently, environmental policies, technological advancements, and shifting consumer preferences make investments in renewable energy more appealing. Under prevailing ESG standards, the comprehensive return on renewable energy projects is estimated to exceed their economic return over the long term (Wüstenhagen and Menichetti, 2012; Liu and Hamori, 2020; Lu and Li, 2024), rendering them more attractive even in economic environments of high interest rates. Moreover, technological progress and economies of scale have reduced or eliminated the green premium, i.e. the cost difference between of renewable energy and fossil fuels (Eyraud, Clements, and Wane, 2013). Thus, renewable energies such as solar and wind power have become more competitive in the market of energy supply.

When interest rates are sufficiently low, fossil fuel investments may remain attractive due to path dependence. As interest rates rise, the difference in expected return between the two types of energies will emerge as an decisive factor in investment decisions. In other words, the high financing cost render fossil fuel investments less profitable, thereby amplifying the negative impact of elevated interest rates on such investments compared to renewable energy projects. [5] Consequently, we hypothesize:

H3a: A tightening of monetary policy in the host country correlates with a reduction in China's ODI in both the fossil fuel and the renewable energy sector;

H3b: A tightening of monetary policy in the host country correlates with a relatively

[5] The small strand of early literature on the effect on monetary policies on green investments suggests that high interest rates deter investments in green energy, mainly for two reasons: first, the upfront cost of green investments is high; second, green investments are more capital-intensive (Eyraud, Clements, and Wane, 2013; Steckel and Jakob, 2018). However, in the current study we formulate the hypothesis from another perspective: the comparison of its impact on two types of energies. Since the technological and policy environments have shifted in favor of renewable resources, the constraining effect of high interest rates on renewable energy investments has diminished. Our empirical results show that the energy ODI from China is indeed turning green as the monetary policies tightens, especially after the Paris Agreement.

greater decline in China's ODI in the fossil energy sector compared to the renewable energy sector;

2.4 Exchange Rate Volatility

The uncertainty stemming from exchange rate volatility tends to dampen imports and exports (Perée and Steinherr, 1989; Rahman and Serletis, 2009; Auboin and Ruta, 2013). Therefore, if a firm internalizes international trade as intra-firm trade, as typical among subsidiaries of MNEs, then it will be able to mitigate the effect of exchange rate by adjusting trade prices. Therefore, they might choose direct investment over trade with unaffiliated trade partners (Dunning, 1988; Goldberg and Kolstad, 1995). [6] Existing empirical evidence suggests that exchange rate volatility has a positive, albeit quantitatively moderate, effect on FDI.

The incentive to mitigate exchange rate fluctuations by direct investment likely varies between the fossil fuel and renewable energy. Products of the fossil fuel industry can be exported to China either as crude energy inputs or as intermediate products. Conversely, firms in the renewable energy industry primarily serve the local market, as it is challenging to transmit electricity—the main output of renewable energy firms—back to China. Therefore, high exchange rate volatility of the host country's currency is conducive to China's direct investments in fossil fuels, but have no effect on investments in renewable energy. Based on the aforementioned discussion, we propose the following hypothesis:

H4a: China's ODI in the fossil fuels increases with exchange rate volatility of the host country's currency;

H4b: China's ODI in the renewable energy is uncorrelated with exchange rate volatility of the host country's currency.

[6] The latter argument about the substitutability between international trade and FDI date back at least to Mundell (1957) and Kindleberger (1969).

3 Empirical Design

3.1 Data and context

Data on ODI in this study were obtained from the China Global Investment Tracker (CGIT) database, which is published by the American Enterprise Institute (AEI). AEI monitors and compiles data on China's major outbound investment and construction projects from news media, official announcements, and other public sources. The version of CGIT data used in our study encompasses 1,738 individual investments, each valued at over 100 million US dollars, across fourteen sectors from 2005 to 2020.[7] This study specifically focuses on 414 investments in the energy sector. Energy ODI cases constitute the largest category, accounting for 23.8% of the total ODI cases. Energy ODI also plays a significant role in the Belt and Road Initiative (BRI), launched in 2013, with energy ODI (242 transactions) representing 52.7% of total ODI cases within the BRI framework.

China's energy ODI exhibits two distinct characteristics. First, the investment, spanning 89 countries, showcases remarkable geographic diversification. We then examine the two major types of investments, fossil fuels and renewable energy projects. The former encompasses coal, petroleum, and natural gas, whereas the latter comprises hydroelectric power, wind energy, solar energy, and other renewable sources.[8] Figure 1 and Figure 2 elucidates China's energy ODI geographic distribution across major world regions. A total of 258 fossil fuel projects across 70 countries represent an aggregate investment of USD 289.75 billion, which are predominantly concentrated in West Asia, North America, and South America. The leading five recipient countries for fossil fuel investments are Australia (30 projects), Canada (26), the United States (19), Russia (16), and Indonesia (14). In contrast, 132 renewable energy ODIs, totaling USD 80.87 billion, span 47 countries. Australia (13 projects) leads in the number of investments, followed by Brazil (12), Laos

[7] While the cutoff value of 100 million dollars is apparently very high for investments in many industries, it is less of a concern for investments in the energy sector in which large fixed investments are common.

[8] Notably, the dataset does not record projects of nuclear.

(9), Pakistan (7), and the United States (7). China's renewable energy ODI are primarily situated in Europe, South America and West Asia. Because CGIT lacks energy type data for 79 of the 390 ODI transactions, we have undertaken a manual collection of supplementary data to classify these investments as either pertaining to fossil fuels or renewable energy. We omit 24 energy investments without clear classification from our regression analysis. The distribution of China's energy ODI appear to reflect its pursuit of secure energy supply and extensive involvement in global affairs. The diverse range of recipient countries furnishes a good context for empirical analysis.

Secondly, the proportion of renewable energy within the energy ODI has exhibited a consistent upward trajectory. As depicted in Figure 4, renewable energy ODI represents 44.44% of the total number of cases and 32.45% in terms of investment value. Fossil fuel ODI, predominantly focused on petroleum and gas projects, reached its high point around 2010, as shown in Figure 3, and subsequently underwent a significant decline post-2015. Conversely, renewable energy investments, chiefly in wind and solar projects, escalated until 2016 before witnessing a slight downturn. Table 1 indicates that, on average, the transaction value of renewable energy ODI is comparatively lower. Figure 4 further reveals that wind and solar projects are the predominant forms within the renewable energy ODI spectrum.

3.2 Regression Model and Measurement

To analyze the determinants of energy ODI, we estimate the following model:

$$ODI_{jt} = \alpha + \beta \cdot X_{jt} + \delta \cdot Z_{jt} + \gamma_j + \epsilon_{jt} \tag{1}$$

The primary dependent variable in this study, denoted as ODI_{jt}, represents the number of ODI investments executed by China in country j during year t. The sample includes countries in which China has made at least one energy investment, and it spans from 2005 to 2020. To account for the distinct determinants of ODI in fossil fuels and renewable energy, we conduct separate regression analysis for each category. X_{jt} and Z_{it} are the set of key independent variables and the set of control variables. γ_j and ϵ_{jt} are country fixed effects and the error term. Because environmental policies across countries are highly correlated in specific years, such as around passing of the Paris Agreement in 2015, we do not include year fixed effects as they would eliminate the information of such major policy events from regression analysis. Instead, we rely on macroeconomic variables such as GDP, monetary policy, and electricity consumption to account for macroeconomic environment.

We opted for the number of transactions over the monetary value of Outward Direct Investment (ODI) transactions as the primary dependent variable, as it more accurately reflects the frequency of investment decisions. Furthermore, considering the average ODI value in fossil energy is approximately 436.62 million USD—nearly quadruple that of renewable energy ODI, which averages around 100.38 million USD—the use of transaction counts facilitates a more equitable comparison between fossil fuel and renewable energy ODI in regression analyses. In robustness analysis, we employ the dollar value of investments as the dependent variable, and obtain similar results.

The primary independent variables (X_{jt}), discussed in the hypothesis development section, include environmental regulation, fossil fuel endowment, monetary policy, and exchange rate volatility within the host economy. We quantify environmental regulation using the Environmental Performance Index (EPI) published by Yale University. The EPI ranks 180 countries based on climate change performance, environmental health, and ecosystem vitality. It serves as a comprehensive national-level indicator of proximity to established environmental policy goals.

Fossil resource endowment is assessed via the average reserve-to-production ratio (R/P ratio) of coal, gas, and oil, a widely recognized metric measuring the duration of remaining reserves at current production rates. The data for proven reserves and production consumption are sourced from the BP Statistical Review of World Energy

2021.

Monetary policy is represented by the policy interest rate of the host country. Exchange rate volatility is measured by the standard deviation of monthly exchange rates against the Special Drawing Rights (SDR) currency basket for year t. Data for the latter two variables are extracted from the International Financial Statistics Database of the International Monetary Fund (IMF).

Control variables (Z_{jt}) include the GDP of the host country, bilateral economic distance, bilateral treaty (the host country's participation status in the BRI), bilateral trade connections, policy stance similarity in international affairs, China's comparative advantage in renewables relative to the host country, and the host's electricity consumption. The first four variables, typically referred to as gravity variables, are commonly used in empirical studies on foreign direct investment. Specifically, economic distance is calculated as the geographical distance between China and country j, weighted by the West Texas Intermediate (WTI) crude oil price. The bilateral treaty is a dummy variable that takes the value 1 if the host country j has joined BRI in year t, and 0 otherwise. The bilateral trade connection is quantified as the proportion of total trade between China and country j in country j's overall trade volume in year t.

The last three control variables are important determinants of ODI in the energy sector. Firstly, we include the S score, a measure of similarity policy stance of two countries, because ODI access in the energy sector, a sector of critical importance to national security, is heavily influenced by the geopolitical relation between the source and the host countries. We manually collect the voting records at the United Nations General Assembly to construct the S score by applying the formula detailed in the Appendix. The S score takes value in the range of [-1,1], and a positive value indicates that the voting pattern of host country is similar to that of China.

Secondly, the relative revealed comparative advantage (RCA) is included to control for the technological gap between China and the host economy. The RCA index is a commonly used measure of the relative ability of a country to produce a good vis-à-vis its trading partners. In this paper, we choose the Bilateral Balassa Index (see French (2017) for a comprehensive review) to measure China's relative advantage in the renewable energy and we obtain the data from the UN COMTRADE database.

Thirdly, we include electricity consumption which is a domain-specific measure of the size of energy market in the host country. We obtain electricity data from IEA Database and compute the domestic net electricity consumption as: *domestic net electricity consumption = total net electricity generation + electricity imports - electricity exports - electricity losses during transmission and distribution.*

A summary of the key variables is presented in Table 1. Our dataset spans from 2005 to 2020. On average, each host country receives 0.38 and 0.19 investments in fossil fuels and renewable energy from China, respectively, valued at approximately 435.62 million and 100.38 million US dollars. Notably, zero values constitute 76.99% (338 out of 439) of the observations in the fossil fuel sample and 85.48% (359 out of 420) in the renewable sample, indicating the absence of major Chinese investments in the energy industry in these cases. Based on current production depletion rates, the reserves for the three primary domestic fossil energy sources are projected to last an additional 46 years. The Environmental Performance Index (EPI) exhibits significant variation, ranging from 27.44 to 90.43, reflecting diverse environmental quality and regulatory standards among host countries. The average interest rate associated with monetary policy was 6.71% in the fossil fuel sample and 6.03% in the renewable energy sample, with standard deviations of 6.72% and 6.37%, respectively. Exchange rate volatility is comparable across both samples, with a standard deviation of 0.04 against the Special Drawing Rights (SDR). China's Relative Comparative Advantage (RCA) score of 1.85, significantly higher than the mean score of 0.49 among all countries in our sample, indicates a considerable comparative advantage in the renewable energy sector. The average S score, measuring alignment in global and regional policy stances, is 0.60 and 0.58 in the fossil fuel and renewable energy samples, respectively. The lowest recorded S score, is -0.71, which is the score between the USA and China in 2007.

3.3 Estimation Method

We begin our analysis with linear regressions because the coefficients are straightforward to interpret, and because standard instrumental variable approach can be applied in the linear framework to address the endogeneity issue. As the number of ODI cases is count data in nature and zero values are prevalent in our sample, we then apply the pseudo-Poisson maximum likelihood (referred to as PPML hereafter) which is our preferred method of estimation. Relative to the classic Poisson model, the key advantage of PPML is that it makes minimal assumptions about the distribution function of the outcome variable (Correia, Guimaraes, and Zylkin, 2019). To further address the issue of prevalence of zeros, in the section of robustness check, we use the zero-inflated Poisson (ZIP) model as an alternative model for count data.

4 Main Results

4.1 Baseline Regression Results

Table 2 presents the estimation results of the regression model specified in equation (1). Two aspects of the investment decisions are analyzed. First, we estimate a model of whether there are positive Chinese investments in host country j in year t. Second, a model of the number of investment cases is fitted to the data. To be specific, the first column contains results from a linear probability model, i.e. the OLS regression of an indicator variable for positive China investments in fossil fuels in host country j in year t on independent variables. The second and the third columns report the regressions of the count of Chinese investment cases in fossil fuels, estimated with OLS and PPML, respectively. We repeat the same specifications for investments in renewable energy in columns (4) through (6).

We first examine the empirical evidence regarding the effects of EPI on energy investments. As the coefficients on EPI in the second and third columns are positive but insignificant, H1a is not substantiated in the context of investments in fossil fuels. Conversely, in columns (4) to (6) in Table 2, coefficients on EPI are all positive and significant. Thus, the results support H1b which posits a positive relationship between EPI score of the host country and China's investment in renewable energy projects.

Second, for the effects of fossil fuel endowment, the coefficients on the corresponding variable are positive but not significant in the first three columns. The evidence fails to support H2a that China's fossil fuel energy investments are attracted to countries with more abundant endowments of fossil fuel resources. Consistent with H2b which suggests an ambiguous relation between fossil fuel endowment and investment in renewable energy, we find that the coefficients on fossil fuel endowment are insignificant in the last three columns.

Third, regarding monetary policy, an increase in interest rate is estimated to reduce the incidence of fossil fuel energy investments from China in column (2) and (3), which is our preferred regression model for the count of investment cases. Consequently, this provides partial support for H3a which conjectures a negative effect of higher interest rates on investments in both fossil fuel and renewable energy projects. In column (5), the positive and marginally significant coefficient on the interest rate variable lends some support to H3b that renewable energy investments are more viable in high-interest rate environments.

Lastly, the positive and statistically significant coefficient on exchange rate volatility in columns (2) and (3) support H4a. Namely, China seeks to mitigate the costs associated with exchange rate fluctuations by internalizing supply of fossil fuels through direct investment. In comparison, the coefficient on exchange rate volatility is negative and statistically insignificant, which is supportive of H4b that renewable energy investments—primarily catering to local energy demands—are less affected by exchange rate volatility.

The effects of financial factors are considerable. For instance, based on the OLS result in Column (2), a one standard deviation reduction in interest rate is associated with a 0.314 increase in the cases of investments in fossil fuels,[9] and a one standard deviation increase in exchange rate volatility is associated with a 0.168 increase in the cases of investments in fossil fuels. These effects are substantial, particularly when compared to the mean of the number of investments, 0.38.

Overall, the empirical evidence supports most of our hypotheses to different extent, confirming that the drivers behind fossil fuel and renewable energy investments are different. Investments in fossil fuel energy is negatively related to policy interest rate, and positively correlated with exchange rate volatility. In comparison, higher values of EPI and policy interest rate are positively correlated with renewable energy investments.

To test whether the effects of key independent variables are statistically different across energy sub-sectors, we include interactions between EPI, fossil fuel endowment, interest rate and exchange rate volatility and an indicator for renewable energy investment in a pooled sample of ODI in the both sub-sectors. In Table 3, the interactions involving EPI and interest rate are positive and significant across all three specifications, thus their effects on ODI in renewable energy are significantly larger than on ODI in fossil fuels. Notably, the interactions involving the interest rate provides further support for H3b, which conjectures that a high interest rate would deter fossil fuel investments more than renewable energy investments. The sum of the interest rate and its interaction term approaches zero, suggesting that rising interest rates exert a negligible constraining effect on China's ODI to renewable energy projects.[10] The interaction between exchange rate

[9] The number 0.063 is obtained by multiplying the standard deviation of interest rate in the sample of fossil fuel investments, 6.72%, with the coefficient of -0.0467 in the first column.

[10] In Table 3, the combination of the interest rate and its interaction term represents the marginal impact

volatility and the renewable energy investment is negative in all three regressions and significantly at 10% in the first, providing marginal evidence that the effect of exchange rate volatility is heterogeneous. Meanwhile, the coefficients on interaction involving fossil fuel endowment are highly insignificantly. Table 4 summarizes the hypothesis testing results drawn from Table 2 and Table 3. On the balance, more stringent environmental regulation as indicated by higher EPI is an important factor that is positively correlated with the rise of China's ODI in renewable energy.

In our regression models, we incorporate typical control variables frequently utilized in direct investment literature. As shown in Table 2, the economic distance between the host country and China is positively correlated with China's ODI in fossil fuels, suggesting that distance, as a proxy for shipping costs, does not substantially impede these investments. The coefficient for the BRI dummy is positive but insignificant across all 6 regressions. Consistent with the premise that strong energy consumption drives investment in fossil fuel, the host country's electricity consumption exhibits a positive correlation with fossil fuel investments. The coefficient for the Relative Comparative Advantage (RCA) in renewable technology is significantly negative, indicating that China's pronounced advantage in renewable technology correlates with reduced fossil fuel investments. Meanwhile, the host country's GDP and bilateral trade connections with China are positive and significant in some regressions, which are consistent with expectation. Somewhat surprisingly, voting pattern alignment at the United Nations (indicated by the S score) appears to have negative effects on China's investment.

4.2 Addressing the Endogeneity of EPI

Omitted variables pose the main threat to causal interpretation of our empirical results. Because direct investments are influenced by both firm-level considerations and

of monetary tightening on renewable energy. We conduct a joint test on the sum of the two coefficients and find that it approaches zero ($\beta = 0.003$, SE = 0.004) and is statistically insignificant at conventional levels (p = 0.492).

country-specific factors, omitting some of these variables from the regressions can introduce endogeneity bias in regressions. The primary concern in our study is the endogeneity of EPI, stemming from unobserved heterogeneity that correlates with independent variables. In particular, if households' undisclosed attitudes simultaneously influence both environmental policy and their views on energy investments from China, then a direct regression of energy investment on environmental policy would yield biased results. Compared to EPI, fossil fuel endowment, monetary policy, and exchange rate volatility are arguably exogenous.

Another potential threat to establishing causality is the presence of reverse causality. However, we consider this unlikely in our context, as it is implausible that a limited number of energy ODI projects from China could significantly influence the host country's environmental or other policy stances. To address the possible endogeneity of EPI, we employ three methodologies: Two-Stage Least-squares (TSLS) regression based on an instrumental variable (IV), Poisson regression based on IV, and the bounding procedure proposed by Oster (2019) to account for unobserved factors.

To address the endogeneity of EPI, we utilize temperature anomaly as an instrumental variable (IV). The variable is measured as the deviation of a host country's annual average temperature from its reference value, as per the International Monetary Fund's (IMF) Annual Surface Temperature Change Dataset. These temperature deviations are inherently exogenous and influence energy Outward Direct Investment (ODI) exclusively through the endogenous EPI, thus satisfying the criteria for a valid IV. Furthermore, we incorporate lagged values of trade connections, the S score for voting alignment, and electricity consumption to mitigate potential endogeneity in these variables.

Table 5 presents the outcomes of the IV regressions, which are to be compared to the linear regression results in Table 2. Column (1) and Column (2) demonstrate that the EPI coefficient remains insignificant in the TSLS regressions of fossil fuel investments.

Conversely, the EPI effect is significantly positive in the renewable energy investment regressions (as depicted in Column (4) and Column (5)). Both findings are consistent with the baseline regressions presented in Table 2. In the IV-Poisson regressions presented in Column (3) and (6), results are analogous to those from the TSLS regressions.[11]

In addition to instrumental variable (IV) regressions, we further apply the bounding methods of Oster (2019) to evaluate whether the positive impact of EPI on renewable energy investment remains robust after considering potential selection biases from omitted variables. Oster's approach leverages the sensitivity of the goodness of fit (measured by the R-squared value) to additional control variables as an indicator of the potential magnitude of omitted variable bias. Under the assumption that the explanatory significance of any omitted variable should not exceed that of carefully-selected additional controls, Oster (2019) provides a framework to approximate the extent of this bias.

In our analysis, the most probable unobserved factor is the environmental awareness of residents. To apply the method proposed by Oster (2019), we incorporate two sets of predetermined supplementary control variables. The first set comprises two variables retrieved from the World Values Survey. They are responses to two queries: 1) "how much confidence you have in environmental organizations" and 2) "which issue should be given top priority, environment protection or economic growth". The responses offer insights into the environmental attitudes of the populace. The second set encompasses two demographic indicators from the World Bank Database: the proportion of the population under 15 years old and the urbanization rate. These variables are recognized in existing literature as being positively associated with a nation's inclination towards stronger environmental protection Duroy et al. (2005); Chen, Huang, and Lin (2019); Calculli et al. (2021). In the rest of this subsection, we refer to the supplementary control variables as observed variables (related to the environmental awareness).

[11] The χ^2 and other statistics from the first stage regressions indicate that we do not suffer from a weak IV problem.

To apply the first of three tests suggested by Oster (2019), we calculate the δ value associated with a hypothetical zero true treatment effect of EPI under the assumption that the omitted variables could boost the R^2 by 30% compared to the current level. Here, δ represents a value of the relative degree of selection on observed and unobserved variables, or the selection proportionality. As shown in the first row of Table 6, the estimate of δ in our paper is 2.754, indicating that a zero-treatment effect would only be plausible if unobserved variables were approximately 2.754 times as influential as the observed ones. Apparently, such a high level of explanatory power of the omitted variable is improbable, as we compare the δ value of 2.754 to the critical value of 1 suggested by Oster (2019). Thus, it's unlikely that the true treatment effect is zero or negative.

The second test, under the assumptions that the correlation between the observed variables and EPI is equivalent to that of the omitted variables, requires the construction of the confidence interval for the effect of EPI. The confidence interval is denoted as $\beta^*(R_{max}, \delta)$ in Table 6. As reported in the second row of the table, the interval spans [0.009, 0.011], which notably excludes 0. The exclusion of 0 from the interval implies that it is unlikely that the effect of EPI is zero or negative. Consequently, the first and second tests suggest that the effect of EPI on renewable energy investments remains positive, evenafter considering potential biases from omitted variables.

The third test examines whether the unobserved variables possess greater explanatory power than the observed variables. As shown in the third row of Table 6, when we introduce the observed variables, the R-square improves from 0.041 to 0.112. The improvement indicates that the chosen observed variables are powerful in explaining the outcome variable. Consequently, it is improbable that unobserved variables contribute to substantial bias. Overall, the application of the bounding methods of Oster (2019) alleviates the concern that the OLS estimates suffer from substantial bias.

5 Robustness check

5.1 Alternative Dependent Variable

In the first robustness analysis, we replace the number of investment cases with the dollar value of ODI as the dependent variable in the regression. Compared to the basic model, the majority of coefficients in Table 7 display identical signs and comparable levels of statistical significance. A notable difference in estimated results is observed in the coefficient of EPI on the volume of ODI in renewable energy, which not only enlarges but also gains greater statistical significance. This finding suggests that the EPI score not only influences the frequency but also the amount of investment.

5.2 Analysis of ODI in Manufacturing and Service Sectors

In this subsection, we extend our analysis to include China's ODI in the manufacturing and service sectors as documented in the CGIT dataset. This expansion is justified by the sectors' resemblance to the fossil fuels and renewable energy sub-sectors in terms of energy intensity; the former is high, while the latter is low. We estimate both the OLS and PPML models for the number of ODI cases in these sectors, with the results detailed in Column (1) through Column (4) of Table 8.

The regression coefficients for the manufacturing sector display a pattern similar to those observed in ODI within the fossil fuels sector, with manufacturing ODI favoring host countries endowed with abundant fossil resources. Moreover, heightened volatility in a host country's exchange rate is associated with a higher likelihood of Chinese direct investments in manufacturing, again aligning with the internalization premise of Dunning (1980).

In the service sector, the determinants of ODI resemble those observed in the renewable energy sub-sector. The EPI is positively correlated with ODI in the service sector. This result lends further support to of H1b, which posits that stringent environmental policies encourage the development of emission-light industries. Concurrently, there is marginal evidence that China ODI in the service sector is less affected by the volatility of the exchange rate. Lastly, the policy interest rate does not significantly influence ODI in either the manufacturing or service sectors.

The extended analysis indicates that natural resources and exchange rate volatility are positively correlated with ODI in emission-intensive industries, whether it is fossil fuels or manufacturing. In comparison, stricter environmental regulations promote ODI in emission-light industries, whether it is renewable energy or service. We test the statistical difference of the effects of the key independent variables between the two sectors, by interacting them with an indicator for service sector in a pooled sample of ODI encompassing both the manufacturing and service sectors. In the last two columns of Table 8, the interactions involving EPI and fossil resources are statistically significant in both the OLS and PPML regressions. Thus, the effect of EPI on ODI in the service sector is more positive than in the manufacture sector, while the effect of fossil resources on ODI in the service sector is less positive. There is also evidence that exchange rate volatility is less likely to motivate ODI in the service sector.

6 Conclusion

Since its opening to the world economy in 1978, China has become a significant player in the realm of cross-border direct investments. ODIs in the energy sector constitute a substantial portion of the country's overall ODI. The Western media used to critique China for its extensive investment in fossil fuel projects, which contribute to increased CO2 emissions. Contrary to popular impression, this study documents a shift towards sustainability in China's energy sector ODI, evidenced by the rise of renewable energy investments to approximately 44% of total energy ODI cases by 2020. Our empirical analysis investigates how environmental regulations, fossil fuel endowments, and financial factors affect the greening of China's ODI in the energy sector.

Our empirical results demonstrate that ODIs in renewable and fossil fuel energy are shaped by different factors. The main driver of China's ODI in the renewable energy sector is environmental regulations. In contrast, the main determinants of fossil fuel ODIs are abundant fossil resource endowments, low interest rates, and great exchange rate volatility. Monetary tightening in host countries imposes more pronounced capital-cost impediments on fossil fuel investments relative to renewable energy. When we extend the the analysis to China's ODI in the manufacturing and service industry, we also find that stringent environmental regulations favor ODI in emission-light industries while deter ODI in emission-heavy industries.

These findings underscore the crucial role of policies in different areas in the global shift toward renewable energy. EPI, as expected, promote emission-light ODI. Financial factors also have important effects on energy ODI, which is previously neglected. A loose monetary policy might adversely affect environmental efforts, as lower financing costs could render otherwise unprofitable fossil fuel investments economically viable, particularly when there is a future risk of these assets becoming stranded.

While the findings carry important potential policy implications for encouraging the energy transition in the context of climate change mitigation, it is important to acknowledge some limitations. Our analysis is based on the China Global Investment Tracker database which cover investments exceeding 100 million USD. Future research would benefit from utilizing datasets with broader coverage and greater details. Additionally, examining ODI from other global economies is essential to validate the generalizability of our conclusions.

Declaration of AI-assisted technologies in the writing process

During the preparation of this work the authors used GPT4.0 developed by OpenAI in order to improve readability and language. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

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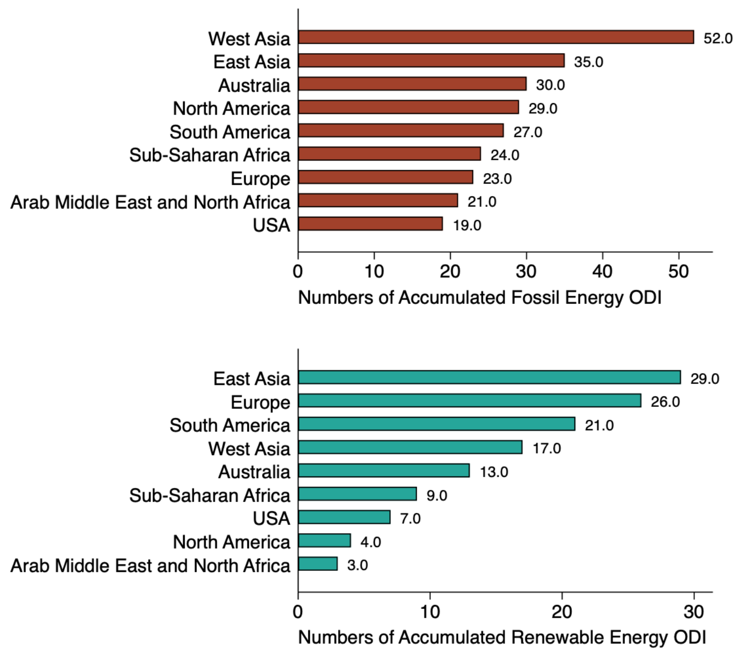

Figure 1: Energy ODI in Different Regions around the World

Source: authors' calculation based on the CGIT database.

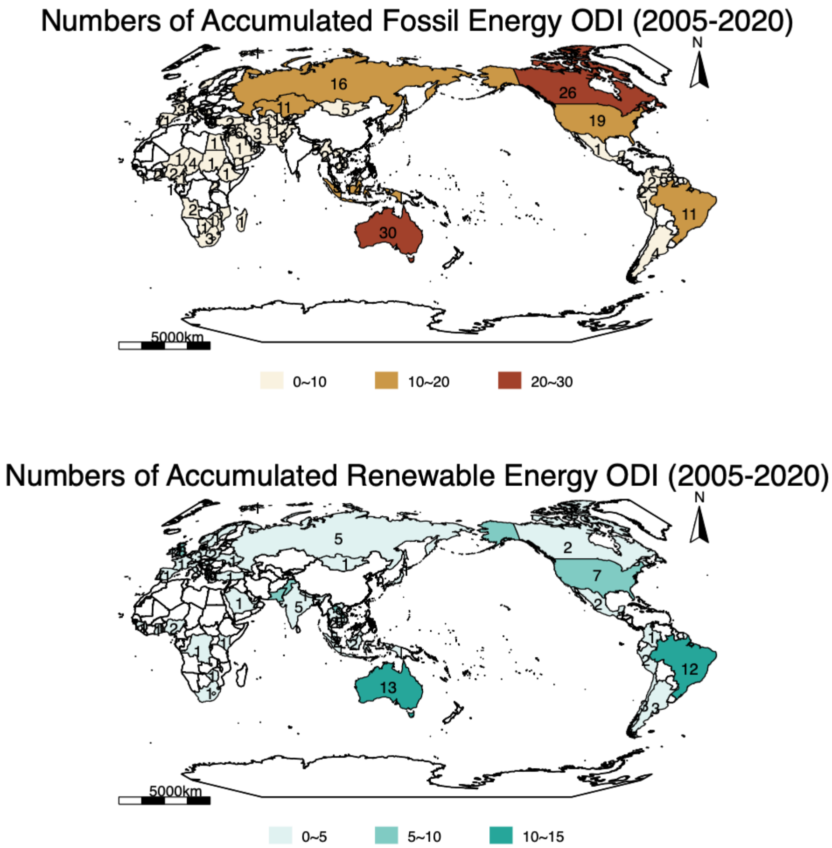

Figure 2: Energy ODI in Different Countries around the World
Source: authors' calculation based on the CGIT database.

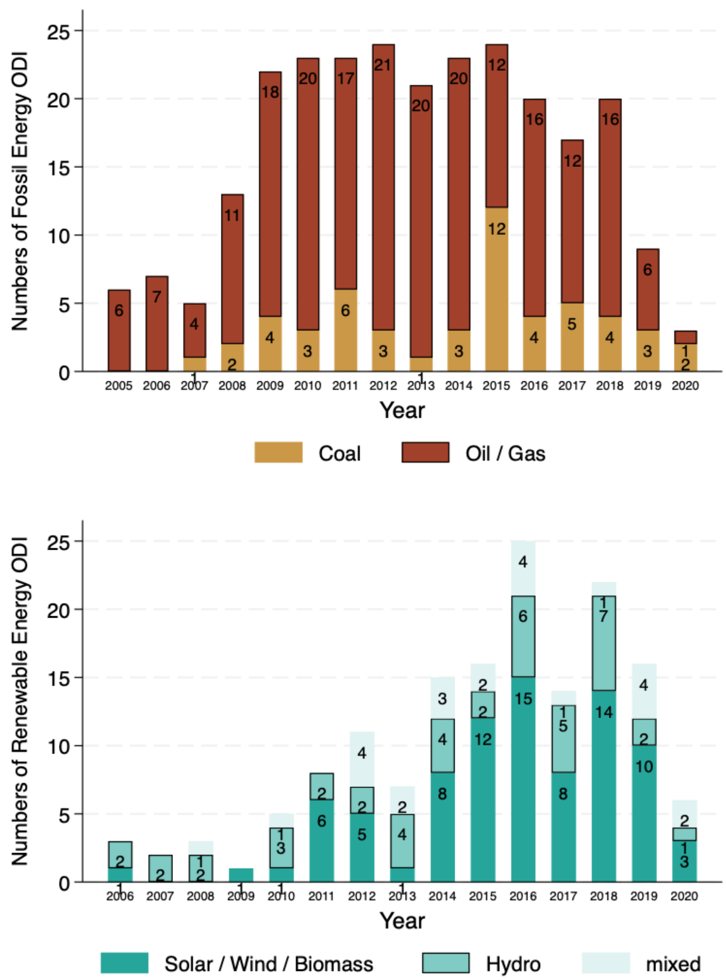

Figure 3: Numbers of ODI of Different Sources of Energy
Source: authors' calculation based on the CGIT database.

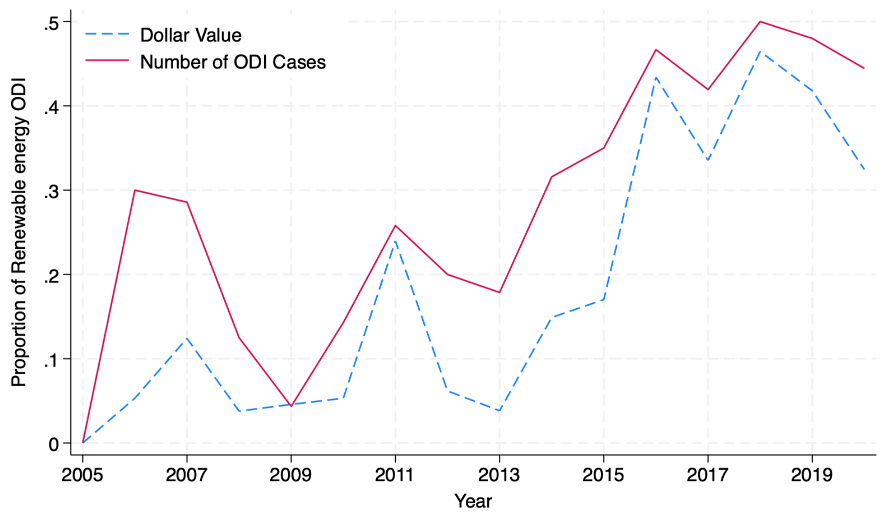

Figure 4: Proportions of Renewable Energy ODI in the Energy Sector
Source: authors' calculation based on the CGIT database.

Table 1: Summary Statistics

	Unit	Obs.	Mean	S.D.	Max	Min
Fossil fuel sample						
ODI cases	transaction	447	0.38	0.88	7.00	0.00
ODI value	million USD	447	435.62	1490.90	20790.00	0.00
EPI	\	447	57.47	13.16	88.48	27.44
Fossil resources	year	447	0.51	0.70	3.85	0.00
Interest rate	%	447	6.71	6.72	59.25	-0.75
Exchange rate volatility	\	447	0.04	0.04	0.43	0.00
GDP	billion USD	447	1138.50	3007.07	21433.22	0.14
Economic distance	km*USD/bbl	447	622428.08	379613.97	1923378.50	41370.13
BRI	\	447	0.14	0.35	1.00	0.00
Trade connection	%	447	0.14	0.13	0.71	0.01
Voting similarity	\	447	0.60	0.32	0.96	-0.52
RCA (Renewable)	\	447	0.60	9.28	195.42	0.00
Electricity consumption	GWh	447	360304.03	1158554.18	6583955.01	215.00
Renewable energy sample						
ODI cases	transaction	420	0.19	0.55	6.00	0.00
ODI value	million USD	420	100.38	468.96	5790.00	0.00
EPI	\	420	58.05	12.05	90.43	31.23
Fossil resources	year	420	0.56	0.69	3.85	0.00
Interest rate	%	420	6.03	6.37	59.25	-0.50
Exchange rate volatility	\	420	0.04	0.03	0.26	0.00
GDP	billion USD	420	1343.58	3137.77	21433.22	10.74
Economic distance	km*USD/bbl	420	654305.37	409511.58	1923378.50	50737.93
BRI	\	420	0.14	0.35	1.00	0.00
Trade connection	%	420	0.13	0.10	0.66	0.02
Voting similarity	\	420	0.58	0.34	0.96	-0.71
RCA (Renewable)	\	420	0.13	0.85	13.55	0.00
Electricity consumption	GWh	420	70453.23	123905.90	689190.77	456.00

Notes: ODI cases is the number of energy ODI transactions, and ODI value is the dollar value of the ODI. EPI is the Environmental Performance index. Fossil resources is the average reserve-to-production ratio across coal, gas and oil. Interest rate is the monetary-policy interest rate. Exchange rate volatility is determined by the standard deviation of monthly exchange rates against the Special Drawing Rights (SDR). GDP is the Gross Domestic Product of the host country. Economic distance is the geographical distance between China and the host country, weighted by the West Texas Intermediate (WTI) crude oil price. BRI is a dummy variable that takes the value of 1 if the host country had joined China's Belt and Road Initiative. Trade connection is the share of total trade between China and the host country in the total trade volume of the host country. Voting similarity is the proximity of policy stances between China and the host country. RCA measures the relative advantage of China in renewable energy, compared to the host country. Electricity consumption is the domestic net electricity consumption in the host country.

Table 2: Baseline Regressions for ODI in Fossil and Renewable Energy

	(1)	(2)	(3)	(4)	(5)	(6)
Subsector:	Fossil Fuels			Renewable Energy		
Dependent Variable:	Indicator	Case	Case	Indicator	Case	Case
Model:	OLS	OLS	PPML	OLS	OLS	PPML
EPI	0.00133	-0.000611	-0.00786	0.00625**	0.0342*	0.0535**
	(0.00395)	(0.0109)	(0.0190)	(0.00266)	(0.0175)	(0.0244)
Fossil resources	0.0691	0.199	0.750	-0.212	-0.696	0.00514
	(0.229)	(0.470)	(0.931)	(0.203)	(0.560)	(1.156)
Interest rate	-0.00945	-0.0467*	-0.0737*	0.00901	0.0796*	0.0551
	(0.00708)	(0.0247)	(0.0406)	(0.00619)	(0.0419)	(0.0558)
Exchange rate volatility	1.602	4.205**	11.27**	-0.0321	-2.120	-0.734
	(1.040)	(2.048)	(5.408)	(1.069)	(5.289)	(7.386)
GDP	-0.0186	0.356	0.223	0.170	3.050***	3.874***
	(0.217)	(0.484)	(0.741)	(0.139)	(0.728)	(1.289)
Economic distance	0.361**	0.601	0.761	-0.0401	0.108	0.103
	(0.171)	(0.439)	(0.661)	(0.121)	(0.554)	(0.801)
BRI	0.0688	0.280	0.0709	0.0235	0.0641	0.142
	(0.113)	(0.388)	(0.572)	(0.0979)	(0.440)	(0.582)
Trade connection	-0.413	-1.576	-3.847	2.309*	9.909**	10.91*
	(0.890)	(2.791)	(5.140)	(1.324)	(3.922)	(6.079)
Voting similarity	-1.443	-1.552	-4.642**	-0.395	-4.165***	-4.140
	(1.323)	(1.193)	(2.142)	(0.380)	(1.609)	(2.608)
RCA (Renewable)	-0.0232*	-0.288*	-0.280	-0.0112	-0.0428	-0.0442
	(0.0136)	(0.160)	(0.469)	(0.0118)	(0.136)	(0.199)
Electricity consumption	0.138	0.783*	1.354*	-0.224	-0.0216	-0.596
	(0.101)	(0.444)	(0.719)	(0.147)	(0.767)	(1.211)
Country FE	Y	Y	Y	Y	Y	Y
Constant	-4.418	-25.04**		-2.002	-88.15***	
	(5.827)	(12.21)		(3.037)	(19.76)	
Observations	447	434	434	420	385	385
Mean	0.380	0.392	0.240	0.193	0.210	0.158
Wald chi2		25.49	22.56		48.07	58.75
Pseudo R-squared		0.292	0.0757		0.270	0.242
Within R-squared	0.0371			0.107		

Notes: 1) The variables EPI, Interest rate, Fossil resources and Exchange rate volatility are measures of the environmental regulations, the monetary policy-related interest rates, the fossil resource endowment, and the fluctuation of the exchange rate between the national currency and the SDR.
2) Robust standard errors are reported in parentheses.
3) ***, **, * denote significance at the 1%, 5% and 10% level, respectively.

Table 3: Pooled Regressions

	(1)	(2)	(3)
Dependent Variable:	Indicator	Case	Case
Model:	OLS	OLS	PPML
EPI	-0.00340	-0.00337	-0.00462
	(0.00275)	(0.00381)	(0.0110)
EPI × Renewable	0.0122***	0.0147***	0.0440***
	(0.00346)	(0.00510)	(0.0135)
Fossil resources	0.110	0.0793	0.353
	(0.0872)	(0.154)	(0.421)
Fossil resources × Renewable	-0.0252	-0.183	0.0821
	(0.133)	(0.268)	(0.172)
Interest rate	-0.0106**	-0.0138*	-0.0416*
	(0.00525)	(0.00747)	(0.0239)
Interest rate × Renewable	0.0134**	0.0220**	0.0846***
	(0.00646)	(0.00894)	(0.0258)
Exchange rate volatility	1.657***	1.830*	4.912***
	(0.577)	(1.059)	(1.881)
Exchange rate volatility × Renewable	-1.665*	-1.896	-6.365
	(0.904)	(1.421)	(5.088)
Control variables	Y	Y	Y
Country FE	Y	Y	Y
Constant	-3.285**	-5.777	-41.96***
	(1.523)	(3.628)	(11.50)
Observations	859	859	834
Mean	0.189	0.289	0.297
Wald chi2			83.68
Pseudo R-squared			0.260
Within R-squared	0.0736	0.0442	

Notes: 1) The variables EPI, Interest rate, Fossil resources and Exchange rate volatility are measures of the environmental regulations, the monetary policy-related interest rates, the fossil resource endowment, and the fluctuation of the exchange rate between the national currency and the SDR. To conserve space, we do not report the coefficients on the control variables in this table.
2) Robust standard errors are reported in parentheses.
3) ***, **, * denote significance at the 1%, 5% and 10% level, respectively.

Table 4: Hypothesis Test

Variable	Hypothesis	Fossil Fuel		Renewable Energy	
		Hypothesis	Result	Hypothesis	Result
EPI	H1a	*negative*	*insignificant*	—	—
	H1b	—	—	*positive*	*positive*
Fossil resources	H2a	*positive*	*insignificant*	—	—
	H2b	—	—	*ambiguous*	*insignificant*
Interest rate	H3a	*negative*	*negative*	*negative*	*insignificant*
	H3b	—	—	*less negative*	*less negative*
Exchange rate volatility	H4a	*positive*	*positive*	—	—
	H4b	—	—	*uncorrelated*	*insignificant*

Notes: 1) The variables EPI, Interest rate, Fossil resources and Exchange rate volatility are measures of the environmental regulations, the monetary policy-related interest rates, the fossil resource endowment, and the fluctuation of the exchange rate between the national currency and the SDR.

Table 5: IV Regressions

	(1)	(2)	(3)	(4)	(5)	(6)
Subsector:	Fossil Fuels			Renewable Energy		
Dependent Variable:	Indicator	Case	Case	Indicator	Case	Case
Model:	2SLS	2SLS	ivpoisson	2SLS	2SLS	ivpoisson
EPI	0.000955	-0.000702	0.00906	0.00624**	0.00712***	0.181***
	(0.00437)	(0.00670)	(0.0403)	(0.00251)	(0.00227)	(0.0579)
Fossil resources	-0.311	0.0554	0.811***	0.453	0.351	-0.0528
	(0.510)	(0.560)	(0.173)	(0.700)	(0.521)	(0.259)
Interest rate (MP)	-0.0259**	-0.0176	0.0153	0.0239*	0.0231	0.0362
	(0.0123)	(0.0177)	(0.0342)	(0.0136)	(0.0156)	(0.0321)
Exchange rate volatility	1.592*	1.148	-0.774	-0.417	-0.911	13.70
	(0.910)	(1.423)	(2.855)	(0.348)	(0.691)	(10.16)
Control variables	Y	Y	Y	Y	Y	Y
Observations	415	415	293	396	396	289
Mean	0.241	0.398	0.464	0.154	0.205	0.176
chi2	27.44	26.03		21.04	22.48	

Notes: 1) The variables EPI, Interest rate, Fossil resources and Exchange rate volatility are measures of the environmental regulations, the monetary policy-related interest rates, the fossil resource endowment, and the fluctuation of the exchange rate between the national currency and the SDR.
2) Robust standard errors are reported in parentheses.
3) ***, **, * denote significance at the 1%, 5% and 10% level, respectively.

Table 6: Tests of Bias Based on Oster (2019): ODI in Renewable Energy

Criteria	Estimated Value	Pass or not
$\delta > 1$	2.754	Yes
True interval excludes 0	$\beta^*(R^2_{max}, \delta) \subset [0.009, 0.011]$	Yes
R-squared improves	from 0.041 to 0.112	Yes

Notes: 1) R^2_{max} denotes the hypothetical R^2 that could be obtained if the omitted variables are included in the regression.
2) The coefficient of proportionality δ measures the degree of correlation between the additional controls with the treatment variable relative to that of the omitted variables.
3) The bounds of treatment effect, $\beta^*(R^2_{max}, \delta)$, are constructed for the 95% confidence level.

Table 7: the Dollar Value of Energy ODI

Dollar Value:	(1)	(2)	(3)	(4)	(5)	(6)
Subsector:	Fossil Fuels			Renewable		
Model:	OLS	PPML	2SLS	OLS	PPML	2SLS
EPI	-0.0115	-0.00128	-0.0187	0.0379***	0.0418**	0.0211
	(0.0189)	(0.0113)	(0.0217)	(0.0131)	(0.0183)	(0.0210)
Fossil resources	0.475	0.480	-1.159	0.508	-0.0693	-2.819
	(0.587)	(0.364)	(2.361)	(0.681)	(0.549)	(4.471)
Interest rate (MP)	-0.0736**	-0.0499**	-0.0575	0.0272	0.0569	0.0833
	(0.0332)	(0.0226)	(0.0750)	(0.0277)	(0.0406)	(0.0657)
Exchange rate volatility	10.02***	5.517***	7.520	-1.038	-2.186	0.304
	(3.591)	(1.773)	(7.200)	(4.954)	(5.263)	(2.892)
Control Variables	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y
Constant	-27.74*	-27.73**		-20.63	-87.12***	
	(16.33)	(11.02)		(12.36)	(19.06)	
Observations	439	427	415	420	385	396
Mean	1.563	1.607	1.640	0.855	0.933	0.907
Wald chi2		35.72			52.13	
Pseudo R-squared		0.271			0.288	
Within R-squared	0.0617			0.127		

Notes: 1) The variables EPI, Interest rate, Fossil resources and Exchange rate volatility are measures of the environmental regulations, the monetary policy-related interest rates, the fossil resource endowment, and the fluctuation of the exchange rate between the national currency and the SDR.
2) Robust standard errors are reported in parentheses.
3) ***, **, * denote significance at the 1%, 5% and 10% level, respectively.

Table 8: ODI in Manufacture and Service

	(1)	(2)	(3)	(4)	(5)	(6)
Industry:	Manufacture		Service		Pool	
Model:	OLS	PPML	OLS	PPML	OLS	PPML
EPI	-0.000496	-0.00236	0.0159**	0.0283***	0.00248	-0.00338
	(0.00435)	(0.00760)	(0.00788)	(0.00924)	(0.00469)	(0.00699)
EPI × Service					0.0105*	0.0286***
					(0.00622)	(0.00796)
Fossil resources	0.140	0.513*	0.211	-0.476	0.337*	0.385
	(0.190)	(0.306)	(0.288)	(0.426)	(0.178)	(0.260)
Fossil resources × Service					-0.322***	-0.276**
					(0.114)	(0.110)
Interest rate	-0.00508	-0.000696	-0.00721	-0.0461	-0.00491	0.000139
	(0.00806)	(0.0169)	(0.00787)	(0.0302)	(0.00851)	(0.0166)
Interest rate × Service					-0.00247	-0.0156
					(0.00730)	(0.0207)
Exchange rate volatility	1.842	3.390**	-1.424**	-3.161**	1.480	1.897
	(1.347)	(1.566)	(0.633)	(1.610)	(1.231)	(1.520)
Exchange rate volatility × Service					-2.542*	-4.474
					(1.382)	(3.663)
Control Variables	Y	Y	Y	Y	Y	Y
Country FE	Y	Y	Y	Y	Y	Y
Constant	-13.86**	-41.07***	-6.768	-53.41***	-10.07*	-42.31***
	(5.662)	(8.863)	(6.307)	(11.00)	(5.044)	(7.441)
Observations	561	536	561	440	1122	1098
Mean	0.560	0.586	0.406	0.518	0.483	0.494
Wald chi2		45.80		101.8		158.4
Pseudo R-squared		0.297		0.308		0.290
Within R-squared	0.0559		0.115		0.0908	

Notes: 1) The variables EPI, Interest rate, Fossil resources and Exchange rate volatility are measures of the environmental regulations, the monetary policy-related interest rates, the fossil resource endowment, and the fluctuation of the exchange rate between the national currency and the SDR.
2) Standard errors are reported in parentheses.
3) ***, **, * denote significance at the 1%, 5% and 10% level, respectively.

Appendix

In our study, we employ the 'S score' as a metric to gauge voting alignment between China and host countries. Originally proposed by Signorino and Ritter (1999), the S score is designed to assess the similarity of two column vectors. This measure has gained widespread acceptance in international relations research, particularly for evaluating bilateral interest alignment, as evidenced in studies by Bennett and Rupert (2003); Sweeney and Keshk (2005); Häge (2011).

The S score is utilized to consolidate the voting outcomes from the United Nations General Assembly (UNGA), a standard data source for assessing state preferences on global matters. We employed Python to systematically gather voting records from 2005 to 2020 housed in the UN Digital Library. During this period, 193 UN member states cast votes on a total of 6,894 agenda items presented in the UNGA, spanning diverse topics like economic cooperation, environmental protection, and human rights. Consequently, the S score, derived from UNGA voting records, serves as an extensive indicator of the congruence in policy stances between two nations on international issues.

For each session, a country could be in one of four alternative states: $\{yes(p_k^i = 1), abstain(p_k^i = 2), no(p_k^i = 3), non-voting(p_k^i = missingvalue)\}$. We apply the following formula to aggregate the voting results:

$$S(P_i, P_j) = 1 - \frac{2d(P_i, P_j)}{d^{max}} \tag{2}$$

where P_j and P_i refers to a country's stance, $d(P_i, P_j)$ is the stance distance between the host country and China, and d^{max} is the maximum possible distance; the latter two factors are calculated as:

$$d^{max} = (3 - 1)N \tag{3}$$

$$d(P_i, P_j) = \sum_{k=1}^{N} \left| p_k^i - p_k^j \right| \tag{4}$$

By synthesizing voting data, the S score effectively captures the variances in diplomatic stances between two countries on pivotal international matters. This score spans from -1 to 1, where a higher value signifies greater alignment with China's position on global issues, and a lower score denotes a more pronounced opposition to China's stance.