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WP 2023.09

Suggested citation:

A. Desroziers, Y. Kirat, A. Reisinezhad (2023). Carbon curse: As you extract, so you will burn. *FAERE Working Paper, 2023.09.*

ISSN number: **2274-5556**

www.faere.fr

Carbon curse: As you extract, so you will burn

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Abstract

The "Carbon Curse" theory suggests that fossil fuel richness leads countries to have more carbon intensive development trajectories than they would otherwise. Using causal inference for cross-country panel data spanning 1950-2018, we globally estimate the effect of giant oil and gas discoveries on carbon emissions. Our findings show that the effect is sizable and persistent. Countries that discovered large fossil-fuel fields emit roughly 30% more pollution post-discovery than countries without these discoveries. This effect is stronger in developing countries, and is substantial from the date of the first giant discovery. By exploiting the randomness of the timing of discoveries, we provide the first plausibly-causal evidence in support of the "Carbon Curse".

Keywords: Carbon Curse, fossil-fuel, giant discoveries, CO_2 Emissions, Panel data

JEL classification: Q32 - Q53.

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1 Introduction

Greenhouse gas (GHG) emissions have triggered major environmental problems, including melting glaciers, sea-level rise, and ecological imbalances (Lee et al., 2024). As a consequence, the international community agreed to limit the global average temperature increase to 'well below' 2°C above pre-industrial levels and to pursue efforts to stay below warming of 1.5°C. However, current efforts seem insufficient to reach of the Paris agreement, with the World heading for a temperature rise of about 2.4 to 4.3 degrees by 2100 (Climate Action Tracker, 2019). The political response to this environmental crisis requires greater ambition than has been promised or undertaken to date. In the light of this climate issue, our work here contributes to the debate by identifying a pathway to effective global-emission reductions, which is one key priority for low-carbon sustainable development.

In tackling climate-change issues, it is important to understand supply-side climate change. The continuous rise in emissions is mainly due to industrial production, transport, and heating. In addition, the more fossil fuels continue to be an important part of the energy mix, the higher will be CO_2 emissions. However, regulating these emission sources may have negative consequences on growth, competitiveness, mobility, and individuals' purchasing power. This may lie behind public opposition to environmental regulation, and the reluctance of many countries to make strong commitments in this respect. We here argue that, in addition to the known drivers of CO_2 emissions, fossil-fuel abundance plays a crucial role. Fossil fuels and their associated sectors, such as extraction, energy production (refining), and the way fossil fuels are used, can clearly be one of the main explanations of greater pollution in fossil fuel-rich than fossil fuel-poor countries.

The various relationships between natural resources and economic growth have been widely-discussed in the literature. This has identified nexuses between both natural resources and economic growth (i.e. the resource curse) and between pollution and economic growth (the

Environmental Kuznets Curve, "EKC"). Our work is instead at the crossroads of these two fields, as we more-generally investigate the relationship between fossil-fuel resources and CO_2 emissions to illustrate the important (and somewhat neglected) role of fossil fuel-rich countries in the current climate-change debate. We do so by testing the carbon-curse hypothesis, which claims that fossil fuel-rich countries emit more CO_2 than do fossil fuel-poor countries.

The results based on descriptive statistics in Friedrichs and Inderwildi (2013) provide compelling initial cross-country evidence of a strong link between fossil-fuel abundance and CO_2 emissions. They propose the following key intuitions about the mechanisms behind the carbon curse. There is first a composition effect from the predominance of fossil-fuel sectors that are massive CO_2 emittors. Second, crowding-out in the energy-generation sector restricts the development of renewable-energy sources. Third, there are spillover effects in other sectors of the economy, which are combined with less-stringent environmental policies. Friedrichs and Inderwildi (2013) note that very-few fossil fuel-rich countries have avoided the carbon curse, apart from those that suffered from the resource curse. For example, the Dutch Disease argument that fossil-fuel resource booms, via real exchange-rate appreciation, reduce competitiveness in the traded (Manufacturing) sector (Corden and Neary, 1982; Sachs and Warner, 1995; Torvik, 2001; Van der Ploeg and Venables, 2013). Given that Manufacturing is likely carbon-intensive, lower output there may reduce carbon intensity.

To the best of our knowledge, only few contributions have explicitly analyzed the carbon-curse hypothesis.[1] Among these, Inglesi-Lotz and Dogan (2018) examine the determinants of CO_2 emissions in the ten largest electricity-generating countries in Sub-Saharan Africa over the 1980-2011 period. Using panel estimation techniques robust to cross dependence, they find a long-run positive significant relationship between the countries' fossil-fuel rents

[1] Poor data quality in terms of heterogeneity across countries and periods, endogenous measures of fossil-fuel resource endowments, and identification issues have made it difficult to produce robust empirical evidence. The current paper tackles these challenges to present further evidence regarding the carbon curse.

and CO_2 emissions. Applying the Augmented Mean Group (AMG) estimator to 1990-2015 data, Baloch et al. (2019) consider the fossil fuel resource-CO_2 emissions nexus for BRICS countries, showing that fossil-fuel resources exacerbate emissions in South Africa, China, Russia and Brazil, but not India. Bekun et al. (2019) apply $PMG-ARDL$ estimation techniques to data from 15 EU countries over the 1996-2014 period to investigate the causal effect of fossil-fuel rents (as a % of GDP) and renewable and non-renewable energy consumption on CO_2 emissions. They come to the same conclusion that fossil-fuel resource endowments increase CO_2 emissions. Using GMM estimation, Khan et al. (2020) conclude that fossil-energy abundance increased CO_2 emissions in Belt & Road Initiative (BRI) countries. Last, Chiroleu-Assouline et al. (2020) analyze the carbon curse for a panel of 29 developed countries from 1995 to 2009 at the country and sector levels. They estimate a U-shaped relationship between CO_2 emissions per unit of GDP and natural resource abundance, with the carbon curse appearing only after the turning point of the U.

This article investigates the carbon curse hypothesis, and contributes to the literature by (i) using a unique cross-country data set that combines CO_2 emissions with global oil and gas discovery data, (ii) considering a panel dataset of 104 countries covering the 1950-2018 period, (iii) introducing three proxy indicators of giant oil and gas discoveries[2] (a dummy variable for countries with oil and gas discoveries, the discovery cumulative volume barrels per capita, and the discovery cumulative net present value in dollars (NPV) per unit of GDP and capita), and (iv) taking a difference-in-differences approach to produce causal evidence of the carbon curse. We tackle endogeneity and omitted-variable biases by using discoveries, which provides a quasi-experimental design as opposed to the rest of the literature. This design allows us to examine within-country behavior before and after an event, while controlling for countries that did not have fossil-fuel discoveries (the untreated observations). Our results show that giant oil and gas discoveries lead to a large permanent rise in the country's

[2] To qualify as giant (and thus be included in the dataset), a field must contain ultimate recoverable reserves (URR) of at least 500 million barrels of oil equivalent ($MMOBE$).

CO_2-emissions intensity. Countries with giant discoveries emit roughly 30% more pollution post-discovery than those without discoveries. A doubling in size of discoveries, in terms of cumulative volume in barrels or cumulative net present value in dollars per capita, produces a roughly 10% increase in CO_2 emissions per capita. These effect sizes are larger in developing than developed countries. Last, the carbon curse seems to be triggered as soon as the first giant oil and gas discoveries appear. Overall, the results suggest that more attention should be focused on fossil fuel-rich countries in order to adhere to the Paris Agreement.

The remainder of the paper is organized as follows. Section 2 provides some stylized facts, and Section 3 discusses the data and sets out the empirical strategy. The results appear in Section 4, and last, Section 5 concludes.

2 Stylized facts

This section intuitively illustrates how CO_2 emissions are related to fossil-fuel resource wealth, which is the main proposition of the carbon curse. To highlight this relationship, we consider a country to be fossil fuel-rich when it had at least one giant discovery between 1950 and 2018.

Figure 1 depicts total annual CO_2 emissions in tonnes by country level of development and fossil-fuel endowments from 1950 to 2018. The combined annual volume of CO_2 emissions, from both developed and developing countries, has grown every year since 1950. It is clear that fossil fuel-rich countries pollute more than do fossil fuel-poor countries, and since 1970 CO_2 emissions in fossil fuel-rich developing countries have clearly been above those in fossil fuel-poor developed countries. This suggests that large fossil-resource endowments are probably a key factor explaining the growth towards high levels of pollution emissions.

A further analysis of Figure 1 shows that since 1950, CO_2 emissions in developing countries have grown steadily, while those in developed countries have progressively slowed (or even more-recently fallen). We can distinguish three periods: 1950-1970, 1970-2000 and 2000-2018. From 1950 to 1970, only fossil-resource poor developing countries had low emission levels, and emissions increased everywhere else. The largest increase was in fossil fuel-rich developed countries, which doubled their annual CO_2 emissions over this period. This period is marked by relative economic prosperity and the baby boom in developed countries. From 1970 to 2000, the various oil-price shocks, followed by increasing globalization, seem to have completely redesigned the carbon trend in all regions. While emissions in developed countries began to stabilize, the growth rate of those in developing countries accelerated, and more so in fossil-resource rich countries. Over the period, CO_2 emissions in fossil-rich developing countries grew by a factor of four. From 2000 to 2018, the 1970-2000 trends became even more pronounced. Developed countries slowly started to reduce their emissions, probably as a result of the 2008 oil crisis and the growing impact of environmental and energy considerations, while those in developing countries continued to grow. In particular, emissions from fossil fuel-rich developing countries reached unprecedented heights. As developed countries started to reduce their emissions, fossil fuel-rich developing countries overtook them to reach an annual figure of 18,000 tons of CO_2 emitted in 2018.

Overall, Figure 1 suggests that the climate-change mitigation debate should first focus on the comparison of fossil-rich and fossil-poor countries, rather than the classic contrast between developed and developing countries.

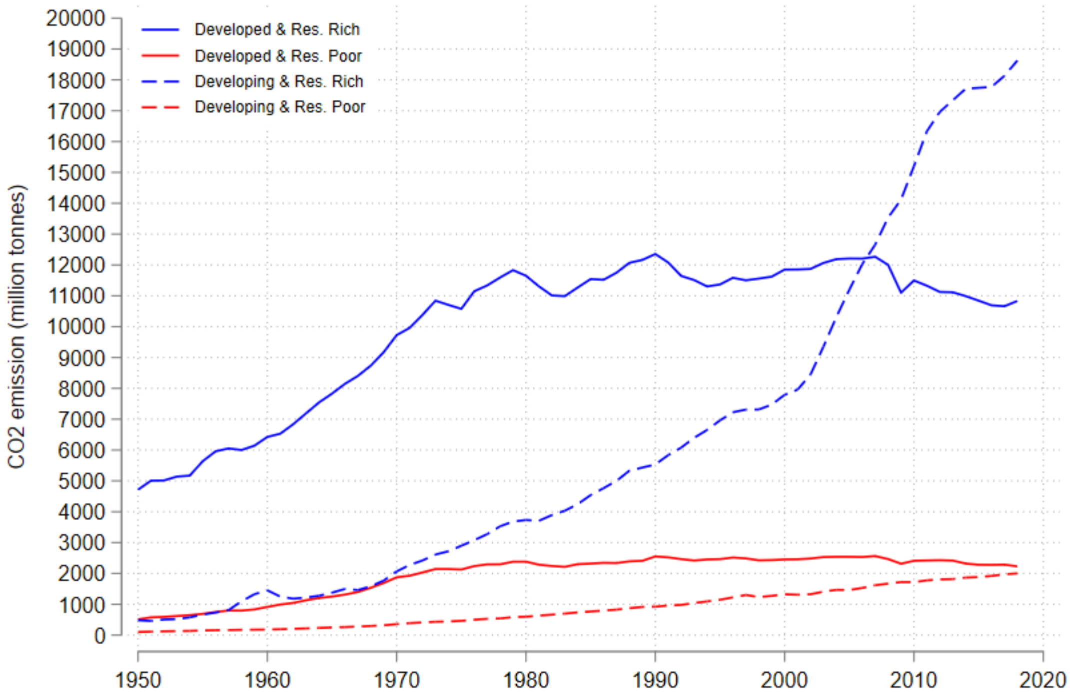

Figure 1: Stylized facts (Carbon emissions from 1950 to 2018)

This Figure plots annual carbon emissions by country development and fossil-fuel endowments from 1950 to 2018. The solid and dashed lines refer to developed and developing countries respectively, according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. The blue and red lines refer to fossil fuel rich and poor countries respectively, where the former had at least one giant oil and gas discovery between 1950 and 2010. The list of countries and other country characteristics appear in Table A1.

To illustrate economic growth and pollution at a more-granular level, Figure 2 plots the average annual change in CO_2 per unit of GDP versus the average GDP growth rate according to the country's development level and fossil-fuel endowments over the three previous key periods: 1950-1970, 1970-2000 and 2000-2018. In each period, developed and developing countries are classified as either emission-reducing (green) or emission-increasing (orange or red). The former refers to countries where GDP growth is associated with a fall in CO_2 emissions,[3] and the latter is split into groups with decreasing intensity (orange) and increasing intensity (red). GDP growing faster than CO_2 emissions corresponds to falling CO_2-emission intensity,[4] whereas GDP growing slower than CO_2 emissions produces increasing emission

[3] Emission reduction: $g_{CO_2} < 0 < g_{GDP} \Rightarrow g_{\frac{CO_2}{GDP}} < 0 \Rightarrow CO_2\ level\ fell.$

[4] Emission increase: $0 < g_{CO_2} < g_{GDP} \Rightarrow g_{\frac{CO_2}{GDP}} < 0 \Rightarrow \frac{CO_2}{GDP}\ \ fell.$

intensity.[5]

Figure 2 also reveals that both developing and developed countries have gradually followed less carbon-intensive development paths over the past few decades overall. Developed countries have moved, on average, from an emission-intensifying pathway between 1950 and 1970 to a 2000-2018 emission-reducing pathway. This evolution between the different trajectories is clearly slower for developing countries. Some have succeeded in reducing their CO_2 intensity, although their emissions are still nonetheless steadily increasing. The situation is even more alarming in the others, as many have increased their intensity. A further important notable feature is that, regardless of the level of development, countries that are rich in fossil fuels seem to perform consistently worse than non fossil fuel-rich countries. With a few minor exceptions, they have failed to attain the stage of countries where emission levels are falling. They instead are stuck in a pollution trap with at best increasing emission levels despite falling intensity, and at worst increasing intensity.

[5] Emission intensification: $g_{CO_2} > g_{GDP} > 0 \Rightarrow g_{\frac{CO_2}{GDP}} > 0 \Rightarrow \frac{CO_2}{GDP}\ rose.$

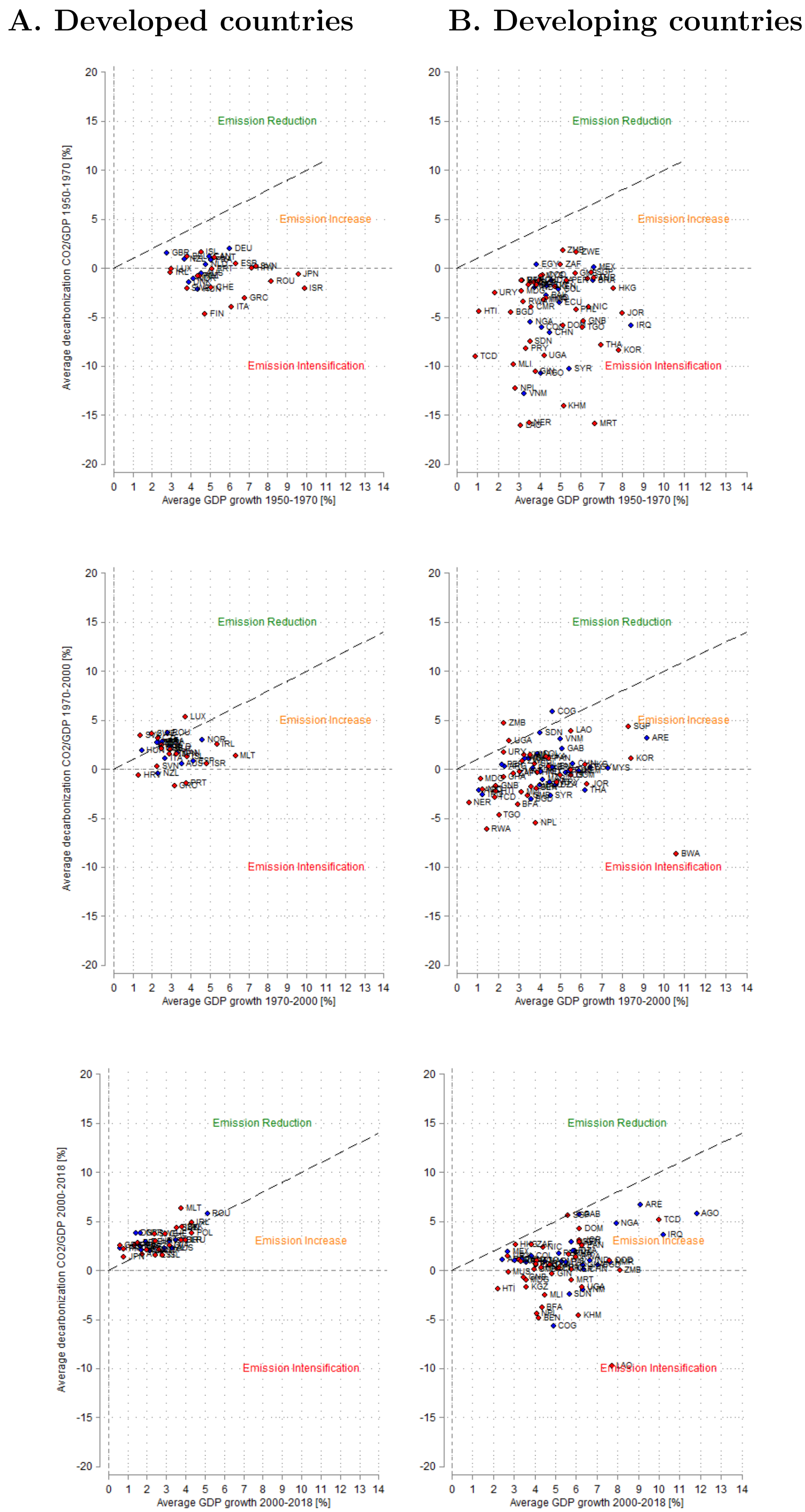

Figure 2: Stylized facts (Carbon trajectory)

This Figure plots each country's average decarbonization growth (CO_2 per GDP) and average economic growth in three periods: 1950-1970, 1970-2000 and 2000-2018. Panel A shows the results for developed countries and Panel B those for developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. Fossil fuel-rich countries are in blue and fossil fuel-poor countries are in red. Countries are fossil fuel-rich if they had at least one giant oil and gas discovery from 1950 to 2010. The list of countries and other country characteristics appear in Table A1.

3 Data and Empirical Strategy

In this section, we describe the data and empirical method we use to assess the carbon-curse hypothesis.

The over-reliance on energy endowments in natural resource-rich areas may not only yield the resource curse (Auty, 2007) but also environmental degradation (Masnadi et al., 2018), such as a sharp rise in carbon emissions leading to the carbon curse. Given that there is a close relationship between the resource and carbon curses, we consider the latter in the light of the abundant literature on the former.

The impact of natural-resource rent on economic outcomes is difficult to establish. This is in part because a country's level of fossil-fuel dependence may reflect past economic performance, policy choices, and political institutions (Brunnschweiler and Bulte, 2008; Van der Ploeg and Poelhekke, 2010). In addition, past exploration, and therefore the observed pattern of geological resource wealth, also depends on institutional factors (Arezki et al., 2019; Cust and Harding, 2020). Recent work has thus considered the impact of giant oil and gas discoveries, instead of fossil-fuel resource wealth (as measured by reserves, production, or other measures). For example, Lei and Michaels (2014) examine the effect of giant oil and gas discoveries on armed conflicts, Arezki et al. (2017) on savings, investment and the current account, Cust and Mihalyi (2017) on short-term growth, Bahar and Santos (2018) on export concentration, Harding et al. (2020) on the real exchange rate and labor reallocation, Abdelwahed (2020) on domestic taxation, Okada and Samreth (2021) on government expenditure, Perez-Sebastian et al. (2021) on trade policy, and Vézina (2021) on arms imports.

The core underlying identifying assumption is that giant oil and gas discoveries are both economically significant as well as being comparatively rare and hard to predict. These discoveries are plausibly exogenous once we control for country-year fixed effects and previous discoveries (Harding et al., 2020). They therefore provide an ideal testing ground for the analysis of the causal relationship between changes in 'known' fossil-fuel resource rents and various economic and social outcomes. We here use this information on oil and gas field discoveries to establish the relationship between fossil fuels and CO_2 emissions.

3.1 Data

We evaluate the carbon-curse hypothesis using 1950-2018 data from 104 countries covering the full spectrum of fossil fuel-rich to fossil fuel-poor, developed and developing.[6] Also, we consider the countries that began the sample with negligible resource production before any giant discovery of oil and gas sources. Specifically, countries are included in the main sample if annual oil and gas production in 1950 was less than 10 barrels of oil energy equivalent per capita.[7] This assumption is relaxed in the robustness checks. The list of countries and other characteristics appear in Table A1 in the appendix.

Table 1 presents the descriptive statistics of the countries in our sample. We harmonize CO_2-emission intensities across countries by calculating CO_2 emissions 1) per unit of real GDP and 2) per capita. The anthropogenic CO_2 emissions in these countries represent 95% of the world's CO_2 emissions according to the Global Carbon Project (GCP).[8] Real GDP and population data come from the Maddison Historical Statistics (Bolt and van Zanden, 2020).[9] We use Maddison rather than Penn World Tables as the latter has substantially more missing data over our analysis period for many developing countries with discoveries.

[6] The panel dataset covers 36 developed and 68 developing countries. There are 43 countries that discovered at least one giant oil and gas field over the 1950-2018 period. Also, some restrictions and exclusions based on: 1) the use of different production thresholds, 2) use of two sources for the GDP variable, and 3) the time between discovery and production led us from a sample of 117 countries to 104 overall (see Table A1, more precisely, Sup., GDP, Late disco columns, respectively).

[7] Azerbaijan, Bahrain, Iran, Saudi Arabia, the United States and Venezuela produced more than 10 barrels per capita in 1950 and thus are excluded from our main sample (see Table A1).

[8] CO_2 emissions are based on 'production' or 'territorial' emissions (e.g. emissions from the burning of fossil fuels or cement production within a country's borders). They do not cover emissions from traded goods (consumption-based emissions).

[9] This measures GDP in International Geary-Khamis Dollars.

We nonetheless use the data from the Penn World Tables (PWT) as a robustness check. Table A3 in the appendix shows the descriptive statistics from the PWT database.

Table 1: Summary statistics

This table lists the descriptive statistics of the key variables. The dependent variables are annual CO_2 emissions per unit of GDP (CO_2/GDP) and per capita (CO_2/Capita) for each country. *Discovery Dummy* takes on a value of one once a country discovers a giant field. *Discovery Volume* is the annual cumulative volume in barrels of oil and gas per capita. *Discovery NPV* refers to the annual cumulative real net present value per GDP (BOE/US) and the annual cumulative real net present value per capita ($BOE/capita$).

	Mean	Median	SD	Min	Max	N
CO2/GDP (kg/US $)	0.32	0.24	0.31	0.00	2.46	6817
CO2/Capita (kg/capita)	3947.78	1604.12	5745.13	0.84	94130.13	6817
Discovery Dummy	0.32	0.00	0.46	0.00	1.00	6817
Discovery Volume (BOE/capita)	722.76	0.00	10324.15	0.00	332965.75	6817
Discovery NPV (BOE/US $)	0.13	0.00	0.77	0.00	19.29	6817
Discovery NPV (BOE/*capita*)	2080.78	0.00	20256.53	0.00	540125.25	6817

Our main regressors of interest are the indicators of the discovery of (at least one) giant oil and gas field in a given country in a given year. We use the data from Horn and Myron (2011) extended by Cust et al. (2021), which has information on all (1060) giant oilfields discovered either onshore and offshore from 1868 to 2018. The dataset includes information on the date of discovery, the estimated ultimately-recoverable amount of oil and gas (total volume in barrels), the nominal oil and gas prices at the date of discovery, and the net present value (in real 2011 US Dollars). We consider three different indicators of the impact of giant oil and gas discoveries on CO_2 intensity: a dummy variable taking on a value of one from the first discovery year to 2018, the annual cumulative volume of oil and gas in barrels per capita, and the annual cumulative real net present value in Dollars per unit of GDP (BOE/US $) and per capita (BOE/capita).[10]

We focus on the 1950-2018 period. Although the data for some countries go back further in time (the Maddison Project database provides GDP and population data since Roman

[10] Using a similar method to Arezki et al. (2017), Cust et al. (2021) first calculate the sum of the discounted gross revenues from the estimated ultimate recovery reserves at the time of the discovery and normalize the resulting value of GDP measured at the discovery date.

times), geographical coverage and data quality are more reliable since the 1950s.[11] The same observation applies to the data on giant oil and gas discoveries, with the majority of these discoveries taking place after 1950 (86.5% of them). Moreover, to assess the effect of discoveries on 2018 CO_2 emissions, we restrict the analysis to discoveries that occurred at least seven years earlier (due to a five to seven year lag between the announcement of a giant discovery and the start of production (Arezki et al., 2017; Horn and Myron, 2011)). This leads us to exclude countries whose first discoveries are only from 2010 onwards.[12] Last, all the variables are in a natural logarithm in order to run the estimations, except the discovery dummy.

3.2 Empirical Strategy

We appeal to the quasi-experimental nature of discoveries, and compare countries with (the treatment group) and without (the control group) giant oil and gas discoveries.[13] We estimate a two-way fixed-effect model (TWFE) as follows:

$$Y_{it} = \delta\, d_{it} + \alpha_i + \alpha_i * \gamma t + \epsilon_{it} \qquad (1)$$

where Y_{it} is the dependent variable (CO_2/GDP or $CO_2/Capita$) in country i at year t, δ the Average Treatment Effect (ATE), d_{it} a discovery dummy taking on a value of one from the first discovery year onward, α_i the country-fixed effect, and $\alpha_i * \gamma t$ the country-trend fixed effect. This allows us to estimate the same treatment effect as in the difference-in-differences model, although this estimator can easily be extended to allow for heterogeneous trends

[11] Country definitions may differ over time: we use those in the Maddison Project.

[12] See TableA1, more precisely column Late Discov.

[13] We follow Lei and Michaels (2014) and Arezki et al. (2017) in arguing that discoveries are plausibly exogenous due to the uncertainty surrounding exploration and future technology developments, once we control for country and year fixed effects and previous discoveries.

(Wooldridge, 2021).[14] The same treatment effect can therefore be estimated while explicitly allowing for violations of the common-trend assumption (Wooldridge, 2021). Last, ϵ_{it} is the error term.

We in addition use an event-study design to capture the effect over time of giant oil and gas discoveries in fossil fuel-rich countries. This approach is useful when the treatment effect over time is not a simple step function, and allows us to distinguish short- from long-run effects. Moreover, by focusing on the treated group only, we compare the outcome variable in the separate years following the discovery to some pre-discovery period.[15] Although each event-year coefficient is estimated with fewer observations than in the baseline difference-in-differences approach, event studies can also be used to look for pre-existing trends that could produce spurious difference-in-differences results.[16] The specification model is given by:

$$Y_{it} = \sum_{n=-10}^{30} \delta \, yd_{it} + \alpha_i + \alpha_i * \gamma_t + \epsilon_{it} \tag{2}$$

where yd_{it} is a dummy indicator for being before, during and after the discovery date, and δ the associated vector of coefficients. This dynamic approach traces out the temporal pattern of the treatment effect, rather than just the post-event average.

4 Results

This section presents the main TWFE results and a number of robustness checks in which we test different fossil fuel wealth thresholds. All of these, estimate the impact of giant fossil-

[14] The inclusion of both individual fixed effects and individual time trends accounts for individual-specific heterogeneity that changes at a constant rate over time. Individual time trends better take into account pre-trends and individual characteristics (Jacobson et al., 2005).

[15] By focusing only on the treated group, the sample is different from that in the baseline specification in Eq. (1).

[16] The inclusion of individual country fixed effects and time trends in the TWFE estimates also aims to tackle this issue

fuel discoveries on CO_2 emission intensities (CO_2 emissions per GDP and per capita). All of the tables use similar measures of the impact of giant fossil-fuel discoveries: the discovery date (Discovery Dummy), the cumulative volume in barrels per capita (Discovery Volume) and the cumulative NPV in Dollars per unit of GDP and per capita (Discovery NPV).

Our main findings appear in Table 2. The estimated coefficients in the first two columns show that giant discoveries have a significant impact on both CO_2 emissions per unit of GDP and per capita. All else equal, countries that discovered giant oil and gas fields emit roughly 30% more pollution post-discovery than countries without discoveries. These results are significant at the 1% level, and provide support for the carbon-curse hypothesis: fossil fuel-rich countries emit more carbon emissions per unit of GDP and per capita than fossil fuel-poor countries. One plausible explanation is that these discoveries trigger dependence (i.e. a lock-in effect) on domestic fossil-fuel resources. There are a number of underlying mechanisms. First, giant fossil-fuel discoveries re-orient countries' energy use towards fossil resources. Second, they allow the development of energy-intensive sectors such as heavy industry (Chiroleu-Assouline et al., 2020). Third, they lead to an increase in the domestic household consumption of fossil fuels due to greater subsidies on fossil-fuel consumption (Mahdavi et al., 2022). Fourth, as fossil resources are a political and economic windfall for domestic and export markets, fossil fuel-rich countries are more reluctant to adopt environmental policies and less carbon-intensive energy sources.

In columns (3) to (6), we split our sample into developed and developing countries. The estimated coefficients are significant for both, although those in developing countries are more significant and slightly larger. From the estimates, post-discovery CO_2 emissions per unit of GDP and per capita in developing countries rose by respectively 46% and 36% compared to developing countries without discoveries. The analogous figure for post-discovery CO_2 emissions per unit of GDP in developed countries is 21%, and is significant at the 5% level. This carbon-curse difference between developed and developing countries may reflect their different regulatory frameworks of environmental and energy policies. Developed countries often adopt more and stricter environmental and energy policies due to their economic resources and larger historical carbon footprints. Moreover, although some policies are applied in both regions, there is greater monitoring and implementation capacity in developed countries. Policies in developed countries may then mitigate lock-in effects more than in developing countries.

Rows 2 and 3 of Table 2 replicate these regressions for the cumulative volume in barrels per capita and the cumulative NPV in Dollars per unit of GDP and per capita. The results are clearly in line with those above in both the full sample and the country sub-samples, confirming also the carbon-curse hypothesis. A doubling of giant oil and gas discoveries' cumulative volume in barrels per capita is associated with a roughly 10% increase in CO_2 emissions per unit of GDP and per capita. However, a 1% increase in cumulative NPV in dollars per unit of GDP and per capita respectively results in a 1.14% increase in CO_2 emissions per unit of GDP and a 0.08% increase in CO_2 emissions per capita. These results are significant at the 1% level.

In columns (3)-(6), the estimated results for developed and developing countries confirm larger and statistically more-significant impacts in developing countries. We find for the latter that doubling giant oil and gas discoveries' cumulative volume in barrels per capita is associated with a 13.3% and 11.4% rise in CO_2 emissions per unit of GDP and per capita, respectively. These effects are significant at the 1% level. In developed countries, a similar increase in cumulative volume in barrels per capita produces around 5% higher CO_2 emissions intensity, with the effect being significant at the 10% level at least. Regarding the cumulative NPV in Dollars per unit of GDP and per capita, in developing countries a 1% increase in the indicator leads to higher CO_2 emissions of 1.23% in terms of GDP and 0.09% in terms of capita; these figures are respectively 0.49% and 0.05% in developed countries. The results in both country groups are significant at the 5% level at least. With three distinct explanatory variables and different sub-samples, all of our Table results clearly support the carbon curse phenomenon.

Table 2: TWFE: The impact of giant discoveries on CO_2 emissions

This table measures the impact on CO_2-emission intensity of giant discoveries, as compared to countries without discoveries, using a $TWFE$ specification. We present the effect for the overall sample and then for developed and developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. The dependent variable is either the logarithm of yearly CO_2 emissions per unit of GDP (CO_2/GDP) or per capita (CO_2/Capita) in each country. *Dummy Discovery* is a dummy variable taking the value of 1 once a country discovers a giant field. *Volume Discovery* is the logarithm of the yearly cumulative volume in barrels of oil and gas per capita, and *NPV Discovery* is the logarithm of the yearly cumulative real net present value in Dollars of GDP or per capita. We exclude countries producing more than 10 barrels per capita before 1950 from our sample. All regressions include country and country-trend fixed effects. Standard errors are clustered at the country level. t-statistics appear in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$.

	All		Developed		Developing	
	(1) CO_2/GDP	(2) CO_2/Capita	(3) CO_2/GDP	(4) CO_2/Capita	(5) CO_2/GDP	(6) CO_2/Capita
Discovery Dummy	0.377***	0.316***	0.212**	0.239	0.464***	0.356**
	(3.906)	(3.098)	(2.110)	(1.601)	(3.428)	(2.649)
Discovery Volume	0.102***	0.091***	0.046**	0.049*	0.133***	0.114***
	(3.578)	(3.173)	(2.408)	(1.804)	(3.407)	(2.925)
Discovery NPV	1.141***	0.079***	0.488***	0.049**	1.231***	0.090**
	(4.071)	(2.960)	(33.865)	(2.439)	(4.123)	(2.561)
Observations	6817	6817	2275	2275	4542	4542

Figure 3 shows the dynamic impact of discoveries from 10 years prior to 30 years following the countries' first giant discovery in an event-study design. Panels A and B plot CO_2 intensity per unit of GDP and per capita: these produce similar results. Up to 10 years before the first discovery, CO_2-emission intensities are not statistically significant. This suggests that the proposed specification helps minimize biases related to potential pre-trends. Following the first giant discovery, there are three phases of CO_2 intensity per unit of GDP or per capita: (i) 3 years after the first giant discovery, pollution increases rapidly and becomes significant; (ii) around 5-7 years, pollution peaks; and (iii) pollution then remains significant and substantial for at least 30 years post-discovery. All else constant, during the most-polluting phase (5 to 25 years after the first discovery), fossil fuel-rich countries emit 35% more pollution annually than pre-discovery. Figure 3 then suggests that giant discoveries push countries towards a more carbon-intensive development path. The CO_2-intensity peak is at 5-7 years after the first giant discovery, and corresponds to the start of full-scale production.[17] However, the first signs of significantly-higher pollution paths can already be seen 3 years post-discovery. Finally, just three years after a giant discovery, fossil-fuel rich countries are heading towards a highly polluted path.

A. CO_2 **emissions per GDP** **B.** CO_2 **emissions per capita**

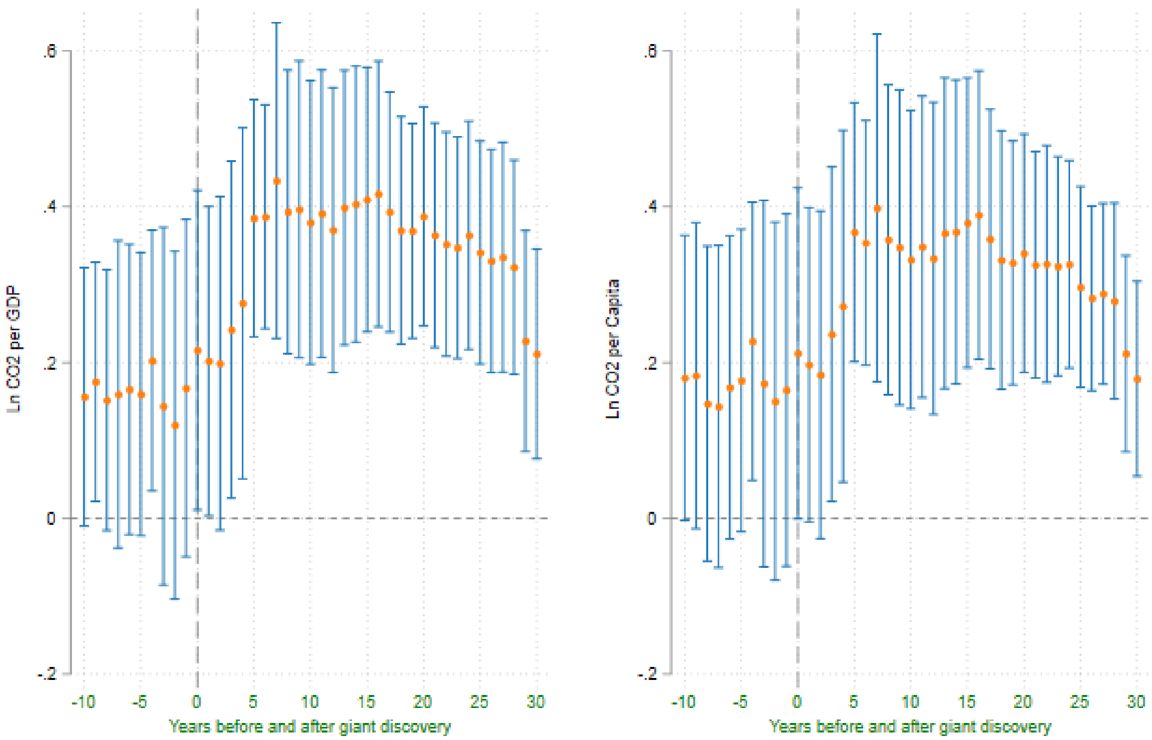

Figure 3: The impact of the first giant discovery on countries' CO_2 emissions
Using an event-study design, this figure shows the dynamic impact of countries making giant discoveries on CO_2 emissions over an event window of 10 years before to 30 years after the first discovery. Panel A and B present the results using the logarithm of the carbon-intensity measures, expressed in terms of CO_2 emissions per unit of GDP (tonnes per unit of GDP) and CO_2 emissions per capita (tonnes per capita), respectively.

The Appendix presents a number of robustness checks that have the advantage of providing additional intuitions regarding the carbon curse.

[17] Arezki et al. (2017) use data from Global Energy Systems (Uppsala University), including 358 discoveries of giant oil fields in 47 countries, and find an average delay between discovery and the start of production of 5.4 years, split between 6.4 and 4.6 years for offshore and onshore discoveries, respectively. However, alternative data from Norwegian giant oil fields suggests that it takes, on average, 10.3 years to go from drilling to production (Höök and Aleklett, 2008).

We first examine whether our findings continue to hold if we change the fossil fuel-rich threshold. However, increasing this threshold to additional giant discoveries, rather than the first giant discovery (as in our main specifications), reduces the exogenous nature of the discoveries. Table A2 shows the number of countries and their discoveries over various periods. The results indicate that countries often have additional discoveries only a few years after their first (with the gap between a giant oil discovery and the start of production being 6 to 10 years). Within the 6 years following their first giant discovery, 47%, 21%, and 14% of countries have at least 2, at least 3, and 4 or more giant discoveries, respectively. The results are very similar, although slightly larger, within 10 years of the first discovery. As shown in Figure 3, this suggests that the carbon curse is triggered by the first giant discovery: once the first giant fossil field is found countries start to pollute more, which is accompanied by more-aggressive exploration. By focusing on the 6-10 year window after the first giant discovery, we partially tackle the endogeneity of successive discoveries. In the robustness checks, we examine whether our findings hold if we define fossil fuel-rich countries with thresholds of at least 2, at least 3, and 4 or more giant discoveries within the 6-10 year window after the first giant discovery: Tables A4, A5 and A6, respectively, for discoveries within 6 years of the first, and Tables A7, A8 and A9 for discoveries within 10 years of the first. The results for both the 6- and 10-year window indicate that tighter restrictions on the thresholds of discoveries produce larger effect sizes. These results also confirm that giant discoveries have larger effects on country CO_2 intensities in developing countries.

Second, to ensure that sample selection does not lie behind the results, we consider different criteria for excluding the countries that were already fossil fuel-rich before 1950. In Table 2, we exclude those producing more than 10 barrels per capita before 1950. In Tables A10 to A12, we lower this exclusion threshold to no restrictions, 1 barrel per capita and 5 barrels per capita, respectively. The results are qualitatively unchanged, so that they are not sensitive to pre-1950 production levels.

Last, we construct the variables using GDP and population data from the Penn World Tables (PWT). The results in Table A13 are robust, but slightly smaller in size.

5 Conclusion

Fossil fuel-rich countries pollute more than their fossil fuel-poor counterparts, a phenomenon that is dubbed the carbon curse. Our results add to the nascent literature on this topic in two ways. We provide the first plausibly-causal evidence by measuring the impacts of unexpected increases in fossil-fuel resource wealth. This avoids confounding variables (such as the perceived importance of the green agenda) that may drive both fossil-fuel dependence and pollution. Second, the effects we capture are more-precisely estimated, which allows us to infer new insights into the channels behind the carbon curse.

We show that the discovery of giant oil and gas fields leads to large increases in country emissions. Following giant discoveries, the emission intensities per unit of GDP and per capita rise by over 30% as compared to fossil fuel-poor countries. We further find that doubling giant fossil-fuel discoveries in terms of volume in barrels and net present value in Dollars per capita results in roughly 10% higher CO_2 intensity per capita, with this effect being more pronounced in developing countries. Last, the carbon curse is triggered as soon as the first giant oil and gas discoveries are found.

To mitigate climate change, countries need to rapidly decarbonize their economies. So far, countries rich in petroleum wealth have lagged behind their fossil fuel-poor peers in doing so. Our findings forewarn that the countries that made their most-recent petroleum discoveries in the past decade may pose problems for the attainment of global climate goals.

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Appendix

Table A1: List of Countries

This table lists the countries analyzed and their characteristics. *Discov. No.* is the number of giant oil and gas discoveries during the overall period (1950-2018), *Dev.* whether the country is developed "+" or developing "-" according to the $M49$ standard of the Statistics Division of the United Nations Secretariat, and *Sup.* whether the country produced more than 1, 5 or 10 barrels per capita before 1950. *Late discov.* identifies countries that have their first discovery after 2010, *GDP* identifies countries that have their first giant oil and gas discoveries while their GDP is missing (*"ex. PWT"* and *"ex. Madd/PWT"* refer to Penn World Tables data and both Maddison Project and Penn World Tables data, respectively).

Country	Dev.	Discov. No.	Sup.	Late Discov.	GDP
Algeria	-	10			Ex. PWT
Angola	-	12			Ex. PWT
Argentina	-	4	1		
Australia	+	21			
Austria	+	0	1		
Azerbaijan	-	7	10		Ex. Madd/PWT
Bahrain	-	1	10		
Bangladesh	-	1			
Belarus	+	0			
Belgium	+	0			
Benin	-	0			
Botswana	-	0			
Brazil	-	19			
Burkina Faso	-	0			
Cambodia	-	0			
Cameroon	-	0			
Canada	+	14	1		
Chad	-	0			
Chile	-	0			
China	-	28			
Colombia	-	6	1		
Congo	-	6			
Croatia	+	0			
Cyprus	+	1		Yes	
Czech Rep.	+	0			
Dem. Rep. Congo	-	0			
Denmark	+	1			
Dominican Rep.	-	0			
Ecuador	-	1			
Egypt	-	14			
Estonia	+	0			
Ethiopia	-	1		Yes	
Finland	+	0			
France	+	2			
Gabon	-	2			
Gambia	-	0			
Germany	+	1			
Ghana	-	3			
Greece	+	0			
Guinea	-	0			
Guinea-Bissau	-	0			
Haiti	-	0			
Honduras	-	0			
Hong Kong	-	0			

Country	Dev.	Discov. No.	Sup.	Late Discov.	GDP
Hungary	+	1			Ex. PWT
Iceland	+	0			
India	-	9			
Iran	-	34	10		
Iraq	-	21	5		Ex. PWT
Ireland	+	0			
Israel	+	2			
Italy	+	2			
Japan	+	0			
Jordan	-	0			
Kazakhstan	-	10			Ex. Madd/PWT
Kenya	-	0			
Kyrgyzstan	-	0			
Laos	-	0			
Latvia	+	0			
Lithuania	+	0			
Luxembourg	+	0			
Madagascar	-	0			
Malaysia	-	6			
Mali	-	0			
Malta	+	0			
Mauritania	-	0			
Mauritius	-	0			
Mexico	-	11	1		
Moldova	+	0			
Morocco	-	1			
Myanmar	-	5			
Nepal	-	0			
Netherlands	+	3			
New Zealand	+	1			
Nicaragua	-	0			
Niger	-	0			
Nigeria	-	20			
Norway	+	18			
Oman	-	7			Ex. Madd/PWT
Pakistan	-	5			
Panama	-	0			
Paraguay	-	0			
Peru	-	3	1		
Philippines	-	1			
Poland	+	0			
Portugal	+	0			
Romania	+	1	1		
Russia	+	45	1		Ex. Madd/PWT
Rwanda	-	0			
Saudi Arabia	-	29	10		Ex. PWT
Senegal	-	3		Yes	
Singapore	-	0			
Slovakia	+	0			
Slovenia	+	0			
South Africa	-	0			
South Korea	-	0			
Spain	+	1			
Sri Lanka	-	0			
Sudan	-	2			
Sweden	+	0			
Switzerland	+	0			
Syria	-	1			Ex. PWT
Tajikistan	-	1			Ex. Madd/PWT
Tanzania	-	5		Yes	

Country	Dev.	Discov. No.	Sup.	Late Discov.	GDP
Togo	-	0			
Tunisia	-	3			
Turkey	-	0			
Turkmenistan	-	12	5		Ex. Madd/PWT
Uganda	-	0			
Ukraine	+	5			Ex. Madd/PWT
UEA	-	12			Ex. PWT
United Kingdom	+	13			
United States	+	34	10		
Uruguay	-	0			
Uzbekistan	-	10	1		Ex. Madd/PWT
Venezuela	-	11	10		
Vietnam	-	4			Ex. PWT
Yemen	-	2			Ex. PWT
Zambia	-	0			
Zimbabwe	-	0			

Table A2: The Distribution of Discoveries

This table displays the distribution of countries based on the number of giant oil and gas discoveries in the 6 to 10 years following the first discovery, covering the period 1950-2018. The column labeled *No* refers to the number of countries that have not made any giant discovery and are considered fossil fuel-poor. The columns labeled *At least one* to *At least four* refer to the number of countries that have made one or more giant discoveries and are classified as fossil fuel-rich (in parentheses, the percentage of fossil-fuel rich countries that meet the thresholds). The table is divided between the overall sample, developed and developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat.

	No	At least one	At least two	At least three	At least four
Overall (104)					
All	61	43(100%)	32(74.4%)	26(60.5%)	21(48.8%)
6 years	61	43(100%)	20(46.5%)	9(20.9%)	6(14%)
10 years	61	43(100%)	24(55.8%)	14(32.6%)	7(16.3%)
Developed (36)					
All	22	14(100%)	8(57.1%)	5(35.7%)	4(28.6%)
6 years	22	14(100%)	5(35.7%)	3(21.4%)	2(14.3%)
10 years	22	14(100%)	6(42.9%)	3(21.4%)	3(21.4%)
Developing (68)					
All	39	29(100%)	24(82.8%)	21(72.4%)	17(58.6%)
6 years	39	29(100%)	15(51.7%)	6(20.7%)	4(13.8%)
10 years	39	29(100%)	18(62.1%)	11(37.9%)	4(13.8%)

Table A3: Summary statistics (*PWT* database)

This table reports the descriptive statistics of the key variables using Penn World Table (PWT) data. The dependent variables are annual CO_2 emissions per unit of GDP (CO_2/GDP) and per capita (CO_2/Capita) for each country. *Discovery Dummy* is a dummy variable taking on a value of 1 once a country discovers a giant field. *Discovery Volume* is the annual cumulative volume of oil and gas per capita($BOE/capita$). *Discovery NPV* is the annual cumulative real net present value in Dollars per unit of GDP (BOE/US) and per capita ($BOE/capita$).

	Mean	Median	SD	Min	Max	N
CO2/GDP (kg/US $)	0.25	0.20	0.21	0.00	1.69	5858
CO2/Capita (kg/capita)	3845.19	1610.23	4948.08	1.37	41071.90	5858
Discovery Dummy	0.29	0.00	0.45	0.00	1	5858
Discovery Volume (BOE/capita)	81.85	0.00	418.87	0.00	5278.48	5858
Discovery NPV (BOE/*US* $)	0.04	0.00	0.17	0.00	2.87	5858
Discovery NPV (BOE/*capita*)	667.56	0.00	5049.34	0.00	63005.57	5858

Table A4: TWFE: The Discovery Impact on CO_2 Emissions (at least two discoveries up to 6 years after the first one)

This table measures the impact on CO_2-emission intensity of giant discoveries, as compared to countries without discoveries, using a $TWFE$ specification. We present the effect for the overall sample and then for developed and developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. The dependent variable is either the logarithm of yearly CO_2 emissions per unit of GDP (CO_2/GDP) or per capita (CO_2/Capita) in each country. *Dummy Discovery* is a dummy variable taking the value of 1 once a country discovers at least two giant discoveries within 6 years following the first one and 0 for countries without discoveries (excluding countries with only one discovery). *Volume Discovery* is the logarithm of the yearly cumulative volume in barrels of oil and gas per capita, and *NPV Discovery* is the logarithm of the yearly cumulative real net present value in Dollars of GDP or per capita. We exclude countries producing more than 10 barrels per capita before 1950 from our sample. All regressions include country and country-trend fixed effects. Standard errors are clustered at the country level. t-statistics appear in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$.

	All Sample		Developed		Developing	
	(1) CO_2/GDP	(2) CO_2/Capita	(3) CO_2/GDP	(4) CO_2/Capita	(5) CO_2/GDP	(6) CO_2/Capita
Discovery Dummy	0.383***	0.298**	0.198*	0.203	0.487***	0.351**
	(3.523)	(2.609)	(1.832)	(1.285)	(3.134)	(2.271)
Discovery Volume	0.103***	0.088***	0.044**	0.044	0.139***	0.115**
	(3.325)	(2.815)	(2.247)	(1.595)	(3.214)	(2.622)
Discovery NPV	1.304***	0.080***	0.491***	0.052**	1.473***	0.089**
	(3.986)	(2.746)	(29.146)	(2.447)	(4.912)	(2.344)
Observations	6403	6403	2137	2137	4266	4266

Table A5: TWFE: The Discovery Impact on CO_2 Emissions (at least three discoveries within 6 years after the first one)

This table measures the impact on CO_2-emission intensity of giant discoveries, as compared to countries without discoveries, using a $TWFE$ specification. We present the effect for the overall sample and then for developed and developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. The dependent variable is either the logarithm of yearly CO_2 emissions per unit of GDP (CO_2/GDP) or per capita (CO_2/Capita) in each country. *Dummy Discovery* is a dummy variable taking the value of 1 once a country discovers at least three giant discoveries within 6 years following the first one and 0 for countries without discoveries (excluding countries with only one or two discoveries). *Volume Discovery* is the logarithm of the yearly cumulative volume in barrels of oil and gas per capita, and *NPV Discovery* is the logarithm of the yearly cumulative real net present value in Dollars of GDP or per capita. We exclude countries producing more than 10 barrels per capita before 1950 from our sample. All regressions include country and country-trend fixed effects. Standard errors are clustered at the country level. t-statistics appear in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$.

	All Sample		Developed		Developing	
	(1) CO_2/GDP	(2) CO_2/Capita	(3) CO_2/GDP	(4) CO_2/Capita	(5) CO_2/GDP	(6) CO_2/Capita
Discovery Dummy	0.531***	0.406**	0.231*	0.249	0.771***	0.532**
	(3.492)	(2.562)	(1.877)	(1.442)	(3.262)	(2.153)
Discovery Volume	0.141***	0.118***	0.058***	0.061**	0.195***	0.156***
	(3.531)	(2.925)	(2.792)	(2.258)	(3.617)	(2.682)
Discovery NPV	1.409***	0.106**	0.492***	0.064***	1.627***	0.129**
	(4.142)	(2.618)	(28.560)	(4.288)	(5.506)	(2.168)
Observations	5446	5446	1930	1930	3516	3516

Table A6: TWFE: The Discovery Impact on CO_2 Emissions (at least four discoveries within 6 years after the first one)

This table measures the impact on CO_2-emission intensity of giant discoveries, as compared to countries without discoveries, using a $TWFE$ specification. We present the effect for the overall sample and then for developed and developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. The dependent variable is either the logarithm of yearly CO_2 emissions per unit of GDP (CO_2/GDP) or per capita (CO_2/Capita) in each country. *Dummy Discovery* is a dummy variable taking the value of 1 once a country discovers at least four giant discoveries within 6 years following the first one and 0 for countries without discoveries (excluding countries with only one, two or three discoveries). *Volume Discovery* is the logarithm of the yearly cumulative volume in barrels of oil and gas per capita, and *NPV Discovery* is the logarithm of the yearly cumulative real net present value in Dollars of GDP or per capita. We exclude countries producing more than 10 barrels per capita before 1950 from our sample. All regressions include country and country-trend fixed effects. Standard errors are clustered at the country level. t-statistics appear in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$.

	All Sample		Developed		Developing	
	(1) CO_2/GDP	(2) CO_2/Capita	(3) CO_2/GDP	(4) CO_2/Capita	(5) CO_2/GDP	(6) CO_2/Capita
Discovery Dummy	0.534***	0.453***	0.247*	0.258	0.787***	0.624**
	(3.452)	(2.642)	(1.787)	(1.317)	(3.213)	(2.338)
Discovery Volume	0.139***	0.127***	0.061**	0.062**	0.197***	0.175**
	(3.183)	(2.805)	(2.718)	(2.103)	(3.171)	(2.644)
Discovery NPV	1.425***	0.125***	0.490***	0.069***	1.697***	0.156**
	(3.887)	(2.786)	(31.097)	(4.190)	(5.854)	(2.409)
Observations	5170	5170	1861	1861	3309	3309

Table A7: TWFE: The Discovery Impact on CO_2 Emissions (at least two discoveries within 10 years after the first one)

This table measures the impact on CO_2-emission intensity of giant discoveries, as compared to countries without discoveries, using a $TWFE$ specification. We present the effect for the overall sample and then for developed and developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. The dependent variable is either the logarithm of yearly CO_2 emissions per unit of GDP (CO_2/GDP) or per capita (CO_2/Capita) in each country. *Dummy Discovery* is a dummy variable taking the value of 1 once a country discovers at least two giant discoveries within 10 years following the first one and 0 for countries without discoveries (excluding countries with only one discovery). *Volume Discovery* is the logarithm of the yearly cumulative volume in barrels of oil and gas per capita, and *NPV Discovery* is the logarithm of the yearly cumulative real net present value in Dollars of GDP or per capita. We exclude countries producing more than 10 barrels per capita before 1950 from our sample. All regressions include country and country-trend fixed effects. Standard errors are clustered at the country level. t-statistics appear in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$.

	All Sample		Developed		Developing	
	(1) CO_2/GDP	(2) CO_2/Capita	(3) CO_2/GDP	(4) CO_2/Capita	(5) CO_2/GDP	(6) CO_2/Capita
Discovery Dummy	0.389***	0.333***	0.212**	0.236	0.489***	0.388***
	(3.861)	(3.165)	(2.076)	(1.556)	(3.403)	(2.762)
Discovery Volume	0.103***	0.091***	0.046**	0.047*	0.135***	0.116***
	(3.518)	(3.103)	(2.353)	(1.717)	(3.367)	(2.891)
Discovery NPV	1.305***	0.081***	0.491***	0.048**	1.471***	0.093**
	(4.059)	(2.947)	(29.007)	(2.329)	(4.995)	(2.570)
Observations	6472	6472	2137	2137	4335	4335

Table A8: TWFE: The Discovery Impact on CO_2 Emissions (at least three discoveries within 10 years after the first one)

This table measures the impact on CO_2-emission intensity of giant discoveries, as compared to countries without discoveries, using a $TWFE$ specification. We present the effect for the overall sample and then for developed and developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. The dependent variable is either the logarithm of yearly CO_2 emissions per unit of GDP (CO_2/GDP) or per capita (CO_2/Capita) in each country. *Dummy Discovery* is a dummy variable taking the value of 1 once a country discovers at least three giant discoveries within 10 years following the first one and 0 for countries without discoveries (excluding countries with only one or two discoveries). *Volume Discovery* is the logarithm of the yearly cumulative volume in barrels of oil and gas per capita, and *NPV Discovery* is the logarithm of the yearly cumulative real net present value in Dollars of GDP or per capita. We exclude countries producing more than 10 barrels per capita before 1950 from our sample. All regressions include country and country-trend fixed effects. Standard errors are clustered at the country level. t-statistics appear in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$.

	All Sample		Developed		Developing	
	(1) CO_2/GDP	(2) CO_2/Capita	(3) CO_2/GDP	(4) CO_2/Capita	(5) CO_2/GDP	(6) CO_2/Capita
Discovery Dummy	0.565***	0.530***	0.329***	0.408***	0.711***	0.607***
	(4.167)	(4.555)	(3.868)	(4.955)	(3.460)	(3.371)
Discovery Volume	0.151***	0.143***	0.071***	0.082***	0.201***	0.181***
	(4.042)	(4.218)	(4.301)	(4.448)	(4.220)	(4.110)
Discovery NPV	1.594***	0.128***	0.492***	0.072***	1.924***	0.156***
	(4.883)	(4.076)	(28.580)	(5.697)	(12.948)	(3.847)
Observations	5593	5593	1861	1861	3732	3732

Table A9: TWFE: The Discovery Impact on CO_2 Emissions (at least four discoveries within 10 years after the first one)

This table measures the impact on CO_2-emission intensity of giant discoveries, as compared to countries without discoveries, using a $TWFE$ specification. We present the effect for the overall sample and then for developed and developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. The dependent variable is either the logarithm of yearly CO_2 emissions per unit of GDP (CO_2/GDP) or per capita (CO_2/Capita) in each country. *Dummy Discovery* is a dummy variable taking the value of 1 once a country discovers at least four giant discoveries within 10 years following the first one and 0 for countries without discoveries (excluding countries with only one, two or three discoveries). *Volume Discovery* is the logarithm of the yearly cumulative volume in barrels of oil and gas per capita, and *NPV Discovery* is the logarithm of the yearly cumulative real net present value in Dollars of GDP or per capita. We exclude countries producing more than 10 barrels per capita before 1950 from our sample. All regressions include country and country-trend fixed effects. Standard errors are clustered at the country level. t-statistics appear in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$.

	All Sample		Developed		Developing	
	(1) CO_2/GDP	(2) CO_2/Capita	(3) CO_2/GDP	(4) CO_2/Capita	(5) CO_2/GDP	(6) CO_2/Capita
Discovery Dummy	0.667***	0.716***	0.329***	0.408***	1.244***	1.243***
	(3.887)	(4.391)	(3.868)	(4.955)	(3.510)	(3.683)
Discovery Volume	0.156***	0.160***	0.071***	0.082***	0.248***	0.245***
	(3.447)	(3.722)	(4.301)	(4.448)	(4.111)	(4.406)
Discovery NPV	1.579***	0.151***	0.492***	0.072***	1.992***	0.222***
	(4.237)	(3.633)	(28.580)	(5.697)	(12.031)	(4.682)
Observations	4834	4834	1861	1861	2973	2973

Table A10: TWFE: The Discovery Impact on CO_2 Emissions (no restriction on the level of barrel per capita)

This table measures the impact on CO_2-emission intensity of giant discoveries, as compared to countries without discoveries, using a $TWFE$ specification. We present the effect for the overall sample and then for developed and developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. The dependent variable is either the logarithm of yearly CO_2 emissions per unit of GDP (CO_2/GDP) or per capita (CO_2/Capita) in each country. *Dummy Discovery* is a dummy variable taking the value of 1 once a country discovers a giant field. *Volume Discovery* is the logarithm of the yearly cumulative volume in barrels of oil and gas per capita, and *NPV Discovery* is the logarithm of the yearly cumulative real net present value in Dollars of GDP or per capita. All regressions include country and country-trend fixed effects. Standard errors are clustered at the country level. t-statistics appear in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$.

	All Sample		Developed		Developing	
	(1) CO_2/GDP	(2) CO_2/Capita	(3) CO_2/GDP	(4) CO_2/Capita	(5) CO_2/GDP	(6) CO_2/Capita
Discovery Dummy	0.368***	0.325***	0.212**	0.239	0.446***	0.367***
	(3.917)	(3.255)	(2.111)	(1.602)	(3.443)	(2.836)
Discovery Volume	0.096***	0.092***	0.047**	0.050*	0.120***	0.111***
	(3.702)	(3.534)	(2.474)	(1.870)	(3.449)	(3.299)
Discovery NPV	1.061***	0.080***	0.488***	0.050**	1.129***	0.089***
	(4.113)	(3.280)	(33.891)	(2.490)	(4.127)	(2.888)
Observations	7091	7091	2344	2344	4747	4747

Table A11: TWFE: The Discovery Impact on CO_2 Emissions (restriction at 1 barrel per capita)

This table measures the impact on CO_2-emission intensity of giant discoveries, as compared to countries without discoveries, using a $TWFE$ specification. We present the effect for the overall sample and then for developed and developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. The dependent variable is either the logarithm of yearly CO_2 emissions per unit of GDP (CO_2/GDP) or per capita (CO_2/Capita) in each country. *Dummy Discovery* is a dummy variable taking the value of 1 once a country discovers a giant field. *Volume Discovery* is the logarithm of the yearly cumulative volume in barrels of oil and gas per capita, and *NPV Discovery* is the logarithm of the yearly cumulative real net present value in Dollars of GDP or per capita. We exclude countries producing more than 1 barrel per capita before 1950 from our sample. All regressions include country and country-trend fixed effects. Standard errors are clustered at the country level. t-statistics appear in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$.

	All Sample		Developed		Developing	
	(1) CO_2/GDP	(2) CO_2/Capita	(3) CO_2/GDP	(4) CO_2/Capita	(5) CO_2/GDP	(6) CO_2/Capita
Discovery Dummy	0.422***	0.381***	0.282***	0.353***	0.501***	0.397***
	(4.120)	(3.752)	(3.579)	(3.373)	(3.297)	(2.684)
Discovery Volume	0.108***	0.100***	0.055***	0.062**	0.140***	0.122***
	(3.595)	(3.370)	(3.047)	(2.509)	(3.326)	(2.937)
Discovery NPV	1.309***	0.084***	0.491***	0.056***	1.478***	0.095**
	(4.013)	(2.958)	(29.024)	(2.930)	(4.957)	(2.493)
Observations	6265	6265	2068	2068	4197	4197

Table A12: TWFE: The Discovery Impact on CO_2 Emissions (restriction at 5 barrel per capita)

This table measures the impact on CO_2-emission intensity of giant discoveries, as compared to countries without discoveries, using a $TWFE$ specification. We present the effect for the overall sample and then for developed and developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. The dependent variable is either the logarithm of yearly CO_2 emissions per unit of GDP (CO_2/GDP) or per capita (CO_2/Capita) in each country. *Dummy Discovery* is a dummy variable taking the value of 1 once a country discovers a giant field. *Volume Discovery* is the logarithm of the yearly cumulative volume in barrels of oil and gas per capita, and *NPV Discovery* is the logarithm of the yearly cumulative real net present value in Dollars of GDP or per capita. We exclude countries producing more than 5 barrels per capita before 1950 from our sample. All regressions include country and country-trend fixed effects. Standard errors are clustered at the country level. t-statistics appear in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$.

	All Sample		Developed		Developing	
	(1) CO_2/GDP	(2) CO_2/Capita	(3) CO_2/GDP	(4) CO_2/Capita	(5) CO_2/GDP	(6) CO_2/Capita
Discovery Dummy	0.377***	0.316***	0.212**	0.239	0.464***	0.356**
	(3.906)	(3.098)	(2.110)	(1.601)	(3.428)	(2.648)
Discovery Volume	0.101***	0.089***	0.046**	0.049*	0.132***	0.112***
	(3.530)	(3.105)	(2.408)	(1.804)	(3.349)	(2.842)
Discovery NPV	1.300***	0.078***	0.488***	0.049**	1.468***	0.089**
	(4.042)	(2.915)	(33.865)	(2.439)	(4.972)	(2.514)
Observations	6748	6748	2275	2275	4473	4473

Table A13: TWFE: The Discovery Impact on CO_2 Emissions (PWT data)

This table measures the impact on CO_2-emission intensity of giant discoveries, as compared to countries without discoveries, using a $TWFE$ specification. We present the effect for the overall sample and then for developed and developing countries, classified according to the $M49$ standard of the Statistics Division of the United Nations Secretariat. The dependent variable is either the logarithm of yearly CO_2 emissions per unit of GDP (CO_2/GDP) or per capita (CO_2/Capita) in each country. *Dummy Discovery* is a dummy variable taking the value of 1 once a country discovers a giant field. *Volume Discovery* is the logarithm of the yearly cumulative volume in barrels of oil and gas per capita, and *NPV Discovery* is the logarithm of the yearly cumulative real net present value in Dollars of GDP or per capita. We exclude countries producing more than 10 barrels per capita before 1950 from our sample. We use Penn World Table source for the GDP and Population data. All regressions include country and country-trend fixed effects. Standard errors are clustered at the country level. t-statistics appear in parentheses. $***p < 0.01, **p < 0.05, *p < 0.1$.

	All Sample		Developed		Developing	
	(1) CO_2/GDP	(2) CO_2/Capita	(3) CO_2/GDP	(4) CO_2/Capita	(5) CO_2/GDP	(6) CO_2/Capita
Discovery Dummy	0.170***	0.200**	0.150**	0.244*	0.183**	0.171
	(2.883)	(2.348)	(2.446)	(1.969)	(2.054)	(1.481)
Discovery Volume	0.038**	0.049**	0.028**	0.047*	0.047*	0.051*
	(2.576)	(2.520)	(2.046)	(1.881)	(1.856)	(1.720)
Discovery NPV	0.304	0.042**	0.215***	0.048**	0.356	0.039
	(1.186)	(2.327)	(8.333)	(2.499)	(0.864)	(1.485)
Observations	5858	5858	2020	2020	3838	3838