**Greenhouse Gas Emissions and the Stability of Equity Markets: International Evidence**

**Abstract**

This paper tests the effect of greenhouse gas emissions on the volatility of leading equity market indexes in international financial markets. Using panel regressions on nearly 30 years’ worth of data from stock exchanges in 50 countries, we suggest an innovative examination of whether financial markets of less polluting economic systems are associated with a lower degree of volatility. Our results confirm that there is such a relationship, with lower carbon and greenhouse gas emissions as well as agricultural nitrous oxide, nitrous oxide, and methane emissions, playing a central role in reducing volatility. This stabilizing effect holds for different measures of volatility: historical volatility, GARCH[1,1], and two measures of realized volatility based on squared and absolute returns. The results hold under different regression specifications and control variables. The emissions-volatility relationship is more valid in recent years, possibly due to the rapidly-growing interest, attention, and concern regarding climate change from policymakers, market participants, and financial agents. The empirical evidence documented here should prove of interest to policymakers, firms, investors, and all those seeking ways to ensure the stability of financial markets and foster a sustainable economic system. The information documented here supports the view that green finance is a key prerequisite for the future stability of equity markets and the enhancement of economic growth, as well as the argument that carbon risk is already priced into financial markets.

*Keywords*: Climate, stability, volatility, emissions, American depository receipts, carbon risk, greenhouse gases

*JEL classifications*: G01, G12, G15.

1. **Introduction**

One of the major concerns in recent years among individuals, firms, and policy makers is the escalation of climate change, which poses a major global challenge to the sustainability of businesses and economies. Anecdotal evidence suggests that climate issues have been gaining a high level of recognition and attention in recent years from CEOs, firms, policymakers, and investors when considering the environment aspects of their investment, portfolio, and other decisions. In an attempt to lessen the detrimental effects of climate change, steps are gradually being considered around the globe to lower a main determinant of climate change: pollutant emissions into the earth’s atmosphere. Recently, a group of 291 institutional investors managing a total USD 66 trillion in assets launched the Net Zero Asset Managers initiative (NZAM) aiming for net zero greenhouse gas (GHG) emissions by 2050.[[1]](#footnote-1) In parallel, financial markets now offer an increasing variety of green investment opportunities and responsible management of funds, including green bonds, ETFs, and mutual funds, as well as other socially-responsible investments.

GHG emissions and other forms of air pollution are not only a threat to the wellbeing of companies and societies, but also to the health of people. According to the World Health Organization (WHO), air pollution is responsible each year for about 6.7 million fatalities around the globe. This remarkable figure implies that emissions harm a part of the labor force that is vital to maintaining economic activity and that emissions are far from being costless. The COVID-19 pandemic has been a milestone in our understanding of the importance of human health to the labor force and economic activity and, interestingly, demonstrated the environmental aspect of global economic activity. Restrictions, closures, and other government interventions shut-down economies around the globe, leading to a sudden drop in CO2 emissions. Le Quéré et al. (2020) show that due to government policies, global emissions decreased by 17% at the outbreak of the pandemic (by April 2020), and at the peak, countries even reached a reduction of 26% on average. In fact, the pandemic, in a unique way, placed three issues on the table: economic activity, greenhouse gas emissions, and public health, highlighting the insight that a transition to a low-carbon economy is a desirable goal.

Industrial activity that emits GHGs and other pollutants is a double-edged sword. This activity is responsible not only for economic progress but also, to some degree, for regression due to the costs arising from environmental issues such as climate change. To put it differently, on the one hand, emissions are an integral part of today’s economic activity and growth, but on the other hand they, for example, harm the health and quality of the human capital necessary to maintain an economy. Palacious (2015) shows that human capital accounts for nearly 93% of the country’s aggregate wealth. In addition, it has been shown by previous studies that human capital is a risk factor for stock returns (e.g., Lustig and Van Nieuwuerburgh, 2008; Bansal et al., 2014). Emissions, therefore, may be reflected in the pricing of equity returns through their potentially detrimental effect on the labor force. Uncertainty about future human capital may be also reflected in greater volatility of equity returns or through the effects of climate change events.

Following the pandemic, and perhaps largely due to it, various agents have shown a rapidly growing interest in cleaner environments and green thinking, based on the understanding that the recovery and future of economic growth are dependent on achieving low-emission economies with lower levels of pollution, which are more resilient against climate change, to sustain societies. The reality, however, is completely at odds with this interest. Unfortunately, according to estimates published by the IMF,[[2]](#footnote-2) the total level of emissions has rebounded and soared significantly highly above pre-pandemic levels. Despite this disappointing picture, there is no doubt that the climate and pollution will continue to arouse great interest in the years to come. Ignorance or failure to embrace a timely adaptation to the new climate challenge would create greater uncertainty about our ability to achieve resilient societies, businesses, and economies.

Inspired by a flourishing strand in the finance literature, this paper attempts to test the impact of GHG emissions through the lens of capital markets. Using a central microstructure variable, market volatility, we empirically examine the relationship between GHG emissions and the volatility of leading global equity indices. We aim to unravel the extent to which emissions of different types may affect the sustainability and stability of financial markets. To the extent that pollution has a detrimental effect on the stability of financial markets, this study may offer an additional economic perspective on the urgency of addressing climate change. It might also accelerate the efforts of policymakers and other decision-makers to curb the detrimental financial, economic, and health effects of climate change.

There are essentially two contradicting views regarding carbon emissions and their risks, which motivate the examination of our study. According to the first view, investors are already pricing-in these risks, or at least demanding a risk premium for bearing or holding stocks associated with disproportionally high emissions (e.g., Oestreich & Tsiakas, 2015; Bolton & Kacperczyk, 2021; Bolton & Kacperczyk, 2021b; Hsu, Li, & Tsou, 2022). On the other hand, some are of the opinion that these risks are ignored, mispriced, or only weakly related to equity prices (e.g., Aswani, Raghunandan, & Rajgopal, 2022).[[3]](#footnote-3) The extent that emissions have (or do not have) an effect on equity volatility indicates whether financial markets are already considering emissions or simply ignoring them.

We have two major reasons for conducting the current research. First, it is not by accident that pollution and emissions are at the forefront of academic debate. Pollution is sometimes mistakenly considered a single-country problem but in fact, like a pandemic, it has the potential to cross borders and spread globally. Therefore, if volatility is indeed affected by emissions, and emissions are spreading all over the globe, then volatility should be transmitted and expanding as well. Revealing the ways in which emissions affect the stability of financial markets may lend support to the contention that national emissions are responsible not only for health and a sustainable economy but are also a sustainable catalyst for investments that strengthen economic growth. Second, volatility is a popular uncertainty measure and one of the central variables of interest for financial agents. As such, the finance literature has dedicated much attention to volatility in traditional asset pricing and portfolio theory (Markowitz, 1952; Sharpe, 1964; Lintner, 1965; Black & Scholes, 1973). To the extent that a greener and less polluting country enhances the stability of its financial markets, and given the potential benefits of low levels of volatility in attracting investment and enhancing accessibility to funding, among other advantages of a low-volatility financial environment, economies will profit by launching green-supportive initiatives that promote economic growth while preserving future environmental and climate sustainability.

To further investigate our main hypotheses, we use ADRs, which are shares of foreign companies traded on U.S. stock exchanges. Using ADRs is a unique design, which allows us to control for different market structures, currencies, and other country-specific factors, yet permits us to take advantage of the cross-sectional variation in emissions between countries, in addition to time-series variation. More simply, it enables us to isolate the impact of emissions in the home country on the volatility of securities prices while holding the market structure constant. This advantage has been a suitable design to address endogeneity issues in former studies (e.g., Blab, 2017; Blau, Brough & Thomas 2014; Eleswarapu & Venkataraman, 2006; Baig, Blau, and Sabah, 2021; Blau, Griffith, & Whitby, 2021; Aharon, Baig & Delisle, 2022a; Aharon, Baig & Delisle, 2022b).

To accomplish the goal of this research, we constructed a broad COMPUSTAT-based dataset containing leading equity indices encompassing 50 countries and nearly 30 years’ worth of data. For each leading index, we utilize four different volatility measures: historical standard deviation (HSD), GARCH [1,1], and 2 realized volatility proxies based on squared and absolute returns. Then, we retrieved data about each country’s emissions from the World Bank, including total GHG emissions, nitrous oxide emissions, methane emissions, CO2 emissions, agricultural methane emissions, and agricultural nitrous oxide emissions. Our main findings can be summarized as follows. First, we show that the impact of GHG emissions is not confined to conventionally-recognized aspects such as social and health issues but also to the wellbeing of financial markets. First, after for country-specific characteristics such as GDP per capita, population, and unemployment rate, we find that higher emission variables are associated with greater volatility in financial markets. The emission impact is economically significant: a one-standard-deviation increase in the level of GHG emissions leads to a XX-bps and XX-bps increase in index volatility, or respectively a YY% and YY% annualized increase. A similar picture arises from examining pollution through the lens of other emission variables such as total greenhouse gas emissions, nitrous oxide emissions, methane emissions, CO2 emissions, agricultural methane emissions, and agricultural nitrous oxide emissions.

Our paper joins previous studies in exploring external variables at the country-specific level and their effect on stability in equity markets (Blau, Brough & Thomas 2014; Blau 2017; Blau, Griffith & Whitby 2021; Aharon, Baig & Delisle, 2022a; Aharon, Baig & Delisle, 2022b). It strengthens the argument that embracing green environment standards will help to maintain resilient financial markets and sustainable economies.

The remainder of this study is structured as follows. In **Section 2**, we summarize the relevant literature and identify our research hypotheses; in **Section 3**, we describe the data and variables measurement; in **Section 4**, we outline our methodology; in **Section 5**, we discuss the empirical findings; and in **Section 6**, we summarize and present our conclusions.

1. **Literature Review and Hypothesis Development**

***2.1 Literature Review***

There is a growing body of literature concerning climate change, the environment and weather conditions, and their effects on different aspects of firms. These days, global and economic sustainability and green investment have become integral factors in finance and investment decisions made by firms.[[4]](#footnote-4)

Early studies in the finance literature already showed that environmental and climate variables may have the potential to affect the performance of global equity indexes. For instance, Hirshleifer & Shumway (2003) examined 26 national stock indices from 1982 to 1997 with respect to city cloud cover, showing a clear correlation to equity returns, whereas Cao & Wei (2005) examined the impact of temperature in different international stock indices, finding a negative correlation between temperature and returns across the whole range of temperatures. More recently, there is a rapidly-growing stream of literature dealing with aspects of pollution and their impact on corporate decision-making, strategy, and plans. For example, Tan et al. (2021) showed that air pollution tends to impact firms’ cash holdings by driving a pessimistic mood among managers, whereas Jiang et al. (2022) show that higher air pollution is associated with earnings management by firms. Wang et al. (2021) show that air pollution significantly enhances employee treatment. Firms headquartered in a city with severe air pollution tend to treat employees better. As can be seen from these examples, the literature has shown that air pollution and climate issues are deeply involved in different and divergent aspects of firms and individuals.

A developing strand in the literature deals with the specific impact of pollution and GHG emissions on firms’ fundamental metrics and decision-making. Earlier studies include Kim et al. (2015) who showed a positive relationship between carbon risk and the cost of equity capital. They find that the relationship is more evident in terms of magnitude in industries with lower GHG emission volumes. Their findings hint that companies from industries that have lower GHG emissions are urged and required to contain emissions at least as much as companies belonging to sectors with higher GHG emissions. Bose et al. (2021) show that GHG emissions even have the potential to drive corporate decisions on mergers and acquisitions, based on a sample encompassing 31 countries from the years 2006–2018. Specifically, they demonstrate that companies with higher emissions tend to acquire foreign companies in countries having lower standards of governance or environmental practice, thereby balancing their exposure to carbon risk through M&A transactions. They also find that the abnormal returns around M&A announcements are higher when high-emission companies acquire or merge with others in foreign countries that have low standards of environment regulations, as this enables these companies to outsource their carbon risk and lower the costs and risks associated with emissions.

Oestreich & Tsiakas (2015) explore the existence of a carbon premium through the European Union’s Emissions Trading Scheme and its impact on German firms. They find that dirty companies receiving free carbon emissions allowances outperformed the green or clean companies which were not eligible for allowances. They argue that their findings support the existence of a carbon premium associated with two driving factors: 1) expectations for improved cash flow because of the free allowances and 2) the exposure of dirty companies to “carbon risk,” which basically rewards them due to uncertainty about their future cash flows, as a result of uncertainty about the future price of emissions. Overall, they estimate the carbon premium as nearly 17% in annual terms.

More recently, Bui, Moses & Houqe (2021) performed a cross-country analysis including 34 countries, showing that companies with more intense GHG emissions tend to be attributed a higher implied cost of capital. Interestingly, they show that the disclosure of information regarding emissions may moderate this negative impact on the cost of capital.

Bolton & Kacperczyk (2021a) conducted a study on nearly 3,000 U.S. firms in the years 2005–2018 and showed that stocks of firms with higher emissions and changes in emissions earn higher returns. They show that these returns cannot be attributed to traditional risk factors or company-specific characteristics, and conclude that there is a risk premium for carbon risk. They conclude that this result supports the contention that investors now require compensation for their exposure to carbon risk. In a subsequent study, Bolton & Kacperczyk (2021b) explored the existence of rewards for over 14,400 firms from 77 countries. They confirm that a carbon premium does exist internationally by documenting higher stock returns for firms with higher carbon emission levels. In both studies, they show that the carbon premium is robust across all industries examined, and not limited to the traditional polluting industries such as the energy or utilities sectors. Surprisingly, they find that the carbon premium is not associated with emissions intensity, and explain that investors, as well as regulators, are mainly interested in the absolute level of emissions rather than the intensity of emissions.

Pástor et al. (2021) present a theoretical model by which green assets have low expected returns because investors enjoy holding them and because green assets hedge climate risk. In a subsequent study, Pástor et al. (2022) claim to find that there is no empirical evidence for a carbon risk premium. Instead, they identify a “greenium” attributed to green stocks. Specifically, they find that green stocks typically outperform brown stocks when climate concerns increase (this is what they refer to as a “greenium”). In other words, the documented outperformance is only due to sudden changes or shocks to environment perceptions, which means that the outperformance is likely to be a one-time phenomenon, rather than a permanent one, due to “unexpectedly strong increases in environmental concerns, not high expected returns.” Their results agree with those of Choi, Gao, & Jiang (2020), who show that stocks of carbon-intensive companies underperform those of companies with low carbon emissions during abnormally warm weather, reflecting increasing concerns about climate change.

Hsu, Li, & Tsou (2022) show that a long-short portfolio constructed from long positions in stocks with high emission intensity and short positions in stocks with low toxic emission intensity within the industry generates a significant positive alpha, which supports the existence of a carbon or pollution risk premium: investors demand a reward for being exposed to more polluting companies. More specifically, under their model, higher-polluting companies are more exposed to policy regime shift risk, which can harm their profitability and stock price, and therefore these concerns justify the return premium. They also show that these excess returns cannot be explained by traditional risk factors. In economic terms, they show that a one-standard-deviation increase in emission intensity increases the expected stock returns by between 6.8% and 9.9% per year.

Aswani, Raghunandan, & Rajgopal (2022), also examine whether carbon emissions are associated with stock returns for 2,729 U.S. stocks during the years 2005–2019. They find that the so-called carbon risk or premium demanded for exposure to polluting companies is subsumed when controlling for size, industry, and vendor-estimated versus firm-disclosed emissions. Therefore, they conclude that investors and academics should be cautious in inferring the existence of a carbon premium.

Papers more closely related to our work, although rather sparse, deal with the impact of carbon gas and other GHG emissions on stock volatility. To the best of our knowledge, there are only two closely-related studies focusing on, or giving attention to, the possible impact on price stability. Bolton & Kacperczyk (2021c) find that voluntary disclosure has a mitigating effect on the price volatility of stocks of emitting companies. Specifically, they find that companies experience a reduction in the volatility of their stock returns. This is consistent with the view that disclosure reduces uncertainty. Hassan (2022) explores the impact of carbon price fluctuation on the extent and persistence of risk in the NASDAQ clean energy stock market. Using GARCH and E-GARCH models, Hassan finds that carbon price has a significant positive impact on the volatility of clean energy stocks.

From this viewpoint, we present our first attempt to examine the impact of emissions levels in a national setting, including the use of divergent proxies for emissions. We also extend our examination to the unique setting of ADRs from different countries. This allows us to test the impact of emission levels on equity volatility from the perspectives of both whole countries and individual companies. Our work contributes to the existing literature dealing with the impact of climate change on financial markets by examining volatility: an important variable for investors, CEOs, firms, and policymakers at the country level.

***2.2 Hypothesis Development***

There are several possible channels through which emissions may result in greater volatility in equity indexes. However, the key cause of the volatility may be uncertainty, which is itself a combination of several forces.

At the national level, a given country may have a higher or lower proportion of companies with high GHG emissions. In this context, the main mechanism determining volatility is uncertainty about the future. Uncertainty could be the changing preferences of consumers for greener products, but may also include the risk of regulatory changes and uncertainty about the outcome of the regulations themselves. Examples include global carbon taxes, trade restrictions, and various indemnities or compensation costs that a given company or the country as a whole might have to pay.

In a similar way, Pastor and Varonesi (2012) describe uncertainty about government policy as creating not only ambiguity about the action or intervention of the government but also uncertainty about the outcome of the policy itself. In addition, this uncertainty can be exacerbated if it is unclear whether the policy change is a single step or just the first of several steps in a bigger plan. According to this line of thinking, there should be a positive association between emissions and the volatility of equity returns. In fact, recently published papers show that this type of uncertainty about climate regulation is a significant risk and a major focus of institutional investors (Krueger, Sautner, & Starks, 2020, Stroebel and Wurgler, 2021; Ilhan, Sautner, & Vilkov 2021). Ilhan, Sautner, & Vilkov (2021) state that climate policy uncertainty is an obstacle for investors in their efforts to quantify the impact of future climate regulation. They support this claim through an examination of the downside tail risk for high-emission firms, in the options market. Remarkably, they show that cost of using options to hedge against downside tail risk is greater for firms with high carbon intensity, especially at times of increased focus on climate change. Conversely, this cost decreased after the election of President Trump, when climate regulation was fairly predictable and uncertainty about it decreased. In addition, according to a survey carried out by Krueger et al. (2021), institutional investors believe that climate change and other climate risks have financial implications for their portfolios. Interestingly, and supporting our main conjecture about the relationship with volatility, they argue that climate change risks pose severe difficulties for market participants, as climate change risks are difficult to value or hedge.

A subsequent survey by Stroebel and Wurgler (2021) of academics, professionals, and public sector regulators and economists, shows that the latter identify regulatory risk as the top climate risk to firms and investors for the next five years, and the realization of climate risk as the top such risk for the next 30 years. In fact, Lemoine (2021) argues that uncertainty is the fundamental issue governing climate change risk. Climate risks include different sources of ambiguity about future growth in productivity and consumption and uncertainty about future greenhouse gas emissions and the degree to which emissions will generate warming, as well as uncertainty regarding the channels through which warming will impact consumption and the environment. Uncertainty even underlies the model used to measure this social and economic impact.

From a micro, firm-level perspective, carbon-intensive firms may be highly impacted by both foreign and domestic rules and policy regulations such as carbon taxes or a cap-and-trade system. Such policies may have a financial effect on firms, as they may have to invest in innovative technologies and practices to reduce their emissions. A failure to meet emission targets may be costly and could considerably impact their stability and fundamentals.

Since the country is the aggregate value of its constituent firms, and each equity index is the reflection of this value, from the macro perspective, countries with more GHG emissions, are also more exposed to uncertainty about their total future national income from these constituent companies. National income may also be affected as a consequence of exposure to international agreements, green regulations, or sanctions from other countries. Due to these two factors, we expect that uncertainty about the firms’ value will be reflected in the volatility of the stock indices.

In a nutshell, the main message we attempt to deliver can be summarized as follows. First, based on the above studies, emissions and climate changes are leading causes of uncertainty of various types. Second, the level of national emissions is closely related to the emissions of its firms, which means that the more emitting firms are, the more emitting the country is. Third, since high-emission firms and countries are more exposed to carbon risk, and uncertainty is the key channel through which this risk is felt, they will experience higher volatility relative to countries/firms with lower emissions. Formally, this analysis tests the following two hypotheses:

Hypothesis (H1):

 *Ceteris paribus, countries with higher emissions will experience higher levels of volatility. This could be due to higher uncertainty about the aggregate future national income due to unexpected international or internal policy changes, their high dependency on old technologies, or higher costs of transitioning to low-carbon activity. According to H1, there is a positive relationship between emissions and volatility.*

Second, we also posit the following hypothesis regarding our firm-level ADR:

Hypothesis (H2)

*Ceteris paribus, firms from more emitting countries are more exposed to various forms of regulation, allowances, legislation,* *cap-and-trade systems, and other green policies affecting their business models. Such firms may face financial risk if they are not able to meet emissions reduction targets. Hence, they are subject to higher uncertainty regarding their cash flows. According to H2, we posit that ADRs from higher-polluting countries will be associated with greater volatility.*

1. **Data**

**Describe here all variables and sources for Index**

**Describe here all variables and sources for ADR and how we manually matched.**

**Describe here all general descriptive statistics for INDICES, countries, etc, maybe correlations.**

**Describe here all general descriptive statistics for ADRs, etc, maybe correlations.**

1. **Methodology**

We examine the role of emissions on the volatility of returns of the leading equity index for each country using panel regressions Eq. (1) below:

$VLT\_{c,t}^{i}=β\_{o}+β\_{1}LN(EMISSIONS\_{c,t})+β\_{2}LN(PRICE\_{c,t})+β\_{3}LN(TURNOVER\_{c,t})+β\_{4}LN(GDP\_{c,t})+ β\_{5}LN(UNEMPLOYMENT\_{c,t})+β\_{6}LN(POPULATION\_{c,t})+δ\_{t}+ε$*i.* (1)

Where, the left-hand side (LHS) variable,$VLT\_{c,t}^{i}$ is the ith volatility measure, for country c at a given point in time t. Specifically, we constructed 4 different volatility measures.

 $β\_{o}$ is the constant

The main independent variable is $LN(EMISSIONS\_{c,t})$ which is the natural log of each of the six EMISSIONS measures from the World Bank database: the total greenhouse gas emissions (kt of CO2 equivalent), nitrous oxide emissions (thousand metric tons of CO2 equivalent), methane emissions (kt of CO2 equivalent), CO2 emissions (kt), agricultural methane emissions (thousand metric tons of CO2 equivalent), and agricultural nitrous oxide emissions (thousand metric tons of CO2 equivalent). If the relationship between emissions and volatility holds, we expect that the beta coefficient of the emissions variable will be significantly positive, implying that the more polluting the country is, the greater the volatility of its leading equity index. We do not involve all our emissions variables in one regression specification to remove multicollinearity-related issues which could bias the inferences we draw from this analysis.

Other control variables are inserted to control for possible other effects related to country size, population, the degree of liquidity in the relevant financial market, and other macroeconomic variables such as GDP and unemployment. The regression specifications include year-fixed effects and robust standard errors clustered at the country-level to control for potential time trends as well as serial and cross-dependence issues.

To capture and isolate the effect of emissions level on volatility, and to mitigate against the potential drawback that we outlined in the introduction section, we add a second step at the firm-level by examining the volatility-emissions relationship through a sample of ADRs. Specifically, we run the following level-log the following fixed effects ordinary least squared (OLS) multivariate regression, Eq. (2), on our panel of ADR-year observations:

$VLT\_{i,c,t}^{1,2}=β\_{o}+β\_{1}LN(EMISSIONS\_{c,t})+β\_{2}SPREAD\_{i,t}+β\_{3}TURNOVER\_{i,t}+β\_{4}LN\left(PRICE\_{i,t}\right) + β\_{5}LN\left(SIZE\_{i,t}\right)+β\_{6}NASDAQ\_{i}+β\_{7}LN(GDP\_{c,t})+β\_{8}LN(UNEMPLOYMENT\_{c,t})+β\_{9}LN(POPULATION\_{c,t})+δ\_{t}+ε$*i.*

(2)

Our main independent variable is again $LN(EMISSIONS\_{c,t}$) which is the natural log of each of the six emission measures from the World Bank database described in the data section. We use robust t-stats corresponding to standard errors clustered at the firm level.

Following Blau (2017), and Blau, Griffith & Whitby (2021), the control variables include *Spread*, *Turnover*, natural log of *Price*, natural log of *Market Cap (Size),* *NASDAQ* dummy, natural log of *GDP*, natural log of *Unemployment* and *Population Growth.* Similarly, for our estimations at the country-level described in Eq. (1), we include year-fixed effects and robust standard errors clustered at the ADR-level to control for potential time trends as well as serial and cross-dependence issues.

1. **Empirical Results**

**Describe here results for Index**

**Describe here results for ADR**

1. **Summary and Conclusions**

In this paper, we test how country-level GHG emissions are associated with the volatility of their leading equity indices. We examine whether equity market returns mirror the instability and incorporate concerns about the sustainability of economies in response to GHG emissions and climate change. Our main findings support the view that investors do account for carbon risk and its economic consequences. Using a broad dataset of 50 leading equity indices from developed and developing countries, and 30 years’ worth of data, we show that there is a positive relationship between GHG emissions and the volatility of equity indices. In other words, CO2 and other greenhouse gas emissions are also detrimental in terms of the stability of financial markets. The emission impact is economically significant: a one-standard-deviation increase in the level of GHG emissions leads to a XX-bps and XX-bps increase in index volatility. To further verify this relationship, and to control for the possible impact of market structure on volatility, we extend our examinations to a unique firm-level dataset. Drawing on previous studies (Chung, 2006; Eleswarapu & Venkataraman, 2006; Blau, Brough & Thomas, 2014; Blau, 2017) we examine 716 ADRs, which are shares of foreign firms traded on U.S. exchanges, comprising 38 countries. The main results are essentially similar, hinting that ADRs from higher-emissions countries are associated with greater instability. The effect is also found to be economically significant: a one-standard-deviation increase in the level of GHG emissions leads to a XX-bps increase in ADRs volatility. The detrimental effect of GHG emissions is not subsumed by different control variables and holds for different model specifications.

 Based on these findings, our paper presents an additional and valuable angle showing the microstructure cost of pollution and environmental degradation. It may provide an additional incentive for policymakers and other decision-makers, at both the firm and country levels, to accommodate green environmental action and try their best to transition to low-carbon businesses and societies. In addition, since developed financial markets are the platform on which individuals and firms engage in asset allocation, investments, and economic activity, it is important to reveal possible factors that are responsible for shaping the microstructure of financial markets. In this era of climate change and other environment concerns, it seems that emissions also play a part in explaining the volatility on the level of nationwide indices and individual firms.

Our paper may reveal a possible channel through which policy makers can better promote economic growth, as it is already recognized that a low level of volatility in trading is an important ingredient and a prerequisite for advancing financial markets, firms, investment, and eventually economic growth (e.g., Campbell et al., 2001 and Alfaro et al. 2004). For policymakers, a volatile stock market can be a major challenge, given that the fragility of the financial market might provoke uncertainty, and may have a detrimental impact on growth expectations. Hence, volatility is a pivotal factor to be considered in decisions on the formulation of economic policies related to capital markets.

In addition, our results may supply new insights for both academics and practitioners dealing with the stability of asset prices and may also be of interest to environmental and economic regulators and other financial agents endeavoring to preserve and promote the stability of both firms and financial markets.

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**Table 1: Summary Statistics - INDEX**

**Panel A** presents the descriptivestatistics for the INDEX volatility measures: the Historical Standard deviation (VLT1), the Conditional GARCH[1,1] Volatility (VLT2), the Realized Volatility (VLT3) based on squared returns, and finally the Realized Volatility (VLT4) based on the absolute value of returns. **Panel B** reports the statistics for the Pollution/Emissions Variables. Namely, Total greenhouse gas emissions (kt of CO2 equivalent), Nitrous oxide emissions (thousand metric tons of CO2 equivalent), Methane emissions (kt of CO2 equivalent), CO2 emissions (kt), Agricultural methane emissions (thousand metric tons of CO2 equivalent), and Agricultural nitrous oxide emissions (thousand metric tons of CO2 equivalent). Finally, **Panel C** reports the statistics of the macroeconomic, population and governance variables at the country level using information retrieved from the World Bank Database. The size sample for each variable is 957 observations.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   | **MEAN** | **MEDIAN** | **SD** | **P25** | **P75** |
|  **VARIABLE** | **[1]** | **[2]** | **[3]** | **[4]** | **[5]** |
| ***Panel A: Index Volatility Measures*** |
| **Historical Volatility** (**VLT1)** | 0.056534 | 0.049839 | 0.029699 | 0.035736 | 0.069793 |
| **GARCH Volatility** (**VLT2)** | 0.062576 | 0.057357 | 0.0253 | 0.045427 | 0.073786 |
| **Realized Volatility - R2** (**VLT3)** | 0.051789 | 0.03141 | 0.062491 | 0.0165 | 0.06018 |
| **Absolute Realized Volatility - |R|** (**VLT4)** | 0.557466 | 0.5043 | 0.274313 | 0.36285 | 0.68478 |
| ***Panel B: Pollution- Emissions Variables*** |
| **totalgreen~c** | 633,564.7 | 138,250.0 | 1,613,716.0 | 65,490.0 | 503,550.0 |
| **no2ghg** | 4,070.4 | 810.0 | 10,388.6 | 410.0 | 3,110.0 |
| **methanee~len** | 82,524.0 | 23,460.0 | 181,329.9 | 7,970.0 | 64,850.0 |
| **co2emissi~kt** | 503,459.7 | 99,540.0 | 1,346,206.0 | 44,770.0 | 355,180.0 |
| **agricultur~u** | 36,746.1 | 9,850.0 | 72,887.7 | 3,200.0 | 36,750.0 |
| **agrno2ghg** | 25,251.2 | 7,010.0 | 53,731.2 | 2,640.0 | 22,620.0 |
| ***Panel C: Country Characteristics*** |
| **prccm** | 9492.923 | 2511.62 | 28245.44 | 1032.76 | 6911.76 |
| **unemployme~r** | 7.001202 | 5.72 | 4.308818 | 4.03 | 8.94 |
| **stockstrad~s** | 59.8658 | 4.30E+01 | 6.27E+01 | 2.20E+01 | 7.86E+01 |
| **population~h** | 0.864007 | 0.675805 | 0.969753 | 0.254527 | 1.346583 |
| **GDP** | 1147.25 | 291.383 | 2547.934 | 120.823 | 900.045 |
|  |  |  |  |  |  |

**Table 1: Summary Statistics -ADR**

**Panel A** presents the descriptivestatistics for the ADR volatility measures: the Historical Standard deviation (VLT1), the Conditional GARCH[1,1] Volatility (VLT2), the Realized Volatility (VLT3) based on squared returns, and finally the Realized Volatility (VLT4) based on the absolute value of returns. **Panel B** reports the statistics for the Pollution/Emissions Variables. Namely, Total greenhouse gas emissions (kt of CO2 equivalent), Nitrous oxide emissions (thousand metric tons of CO2 equivalent), Methane emissions (kt of CO2 equivalent), CO2 emissions (kt), Agricultural methane emissions (thousand metric tons of CO2 equivalent), and Agricultural nitrous oxide emissions (thousand metric tons of CO2 equivalent).

Finally, **Panel C** reports the ADR statistics: **Spread** is the daily bid-ask spread computed as the difference between ask and bid prices of ADRs scaled by their mid-point. **Turnover** is the trading volume scaled by the shares outstanding. **Illiquidity** represents the Amihud (2002) illiquidity measure computed by scaling the absolute return by the dollar volume scaled up by a million. **Market Cap** is the ADR market capitalization calculated by multiplying price and shares outstanding, it is presented in billions. **Price** is the closing ADR price. **Nasdaq** is a dichotomous variable that takes on a value of 1 for ADRs listed on NASDAQ, zero otherwise. The size sample for each variable is 4692 observations.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|   | **MEAN** | **MEDIAN** | **SD** | **P25** | **P75** |
|  **VARIABLE** | **[1]** | **[2]** | **[3]** | **[4]** | **[5]** |
| ***Panel A: Index Volatility Measures*** |
| **yearlyvola~t** | 0.029500 | 0.024932 | 0.016401 | 0.017917 | 0.036823 |
| **yearlygarc~t** | 0.030196 | 0.025537 | 0.015996 | 0.018799 | 0.037278 |
| **fmvolatili~t** | 0.026505 | 0.021683 | 0.015972 | 0.015482 | 0.033384 |
| **yearlyrang~t** | 0.033151 | 0.026661 | 0.021301 | 0.016679 | 0.044700 |
| **yearlyspre~t** | 0.008613 | 0.003338 | 0.015327 | 0.001236 | 0.009401 |
| **yearlyturn~t** | 0.014904 | 0.007999 | 0.022594 | 0.004233 | 0.015944 |
| ***Panel B: Pollution- Emissions Variables*** |
| **totalgreen~c** | 2,895,326.0 | 655,180.0 | 4,375,061.0 | 369,050.0 | 1,336,090.0 |
| **no2ghg** | 14,081.6 | 3,690.0 | 19,556.7 | 2,520.0 | 9,650.0 |
| **methanee~len** | 317,929.2 | 77,780.0 | 433,193.6 | 30,500.0 | 431,070.0 |
| **co2emissi~kt** | 2,377,856.0 | 466,650.0 | 3,674,671.0 | 259,060.0 | 1,225,070.0 |
| **agricultur~u** | 118,316.1 | 34,660.0 | 143,556.2 | 15,380.0 | 319,730.0 |
| **agrno2ghg** | 101,673.0 | 28,955.0 | 136,304.3 | 8,610.0 | 161,680.0 |
| ***Panel C: ADR Characteristics*** |
| **size** | 1.390457 | 0.2960996 | 3.200763 | 0.0626297 | 1.263877 |
| **price\_t** | 24.92232 | 17.13 | 24.73323 | 7.2725 | 34.965 |
| **nasdaq** | 0.2766411 | 0 | 0.4473851 | 0 | 1 |
| **unemployme~r** | 6.599376 | 5.04 | 4.354483 | 4.1 | 8.04 |
| **population~h** | 0.7676002 | 0.666073 | 0.5389511 | 0.467672 | 1.078845 |
| **gdp** | 3216.809 | 1844.54 | 3712.025 | 580.07 | 4579.75 |

**Table 2: INDEX -Summary Statistics by Country**

This table presents the summary statistics of our sample by ADR home countries. For variable definitions please refer to Table 1.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **COUNTRY** | **[1]** | **[2]** | **[3]** | **[4]** | **[5]** | **[6]** | **[7]** | **[8]** | **[9]** | **[10]** | **[11]** | **[12]** | **[13]** | **[14]** | **[15]** |
| Australia | 0.035 | 0.041 | 0.017 | 0.359 | 3935.1 | 6.6 | 61.4 | 1.4 | 799.4 | 568895.3 | 2864.0 | 136739.0 | 347398.3 | 94665.7 | 72082.7 |
| Austria | 0.057 | 0.063 | 0.050 | 0.565 | 2035.5 | 4.8 | 63.8 | 0.5 | 310.2 | 80452.0 | 701.3 | 8975.0 | 65733.3 | 5308.3 | 2712.7 |
| Belgium | 0.044 | 0.046 | 0.029 | 0.432 | 2527.3 | 8.0 | 31.3 | 0.5 | 353.9 | 129229.2 | 681.3 | 11025.4 | 109520.8 | 7012.5 | 3451.3 |
| Brazil | 0.064 | 0.074 | 0.059 | 0.653 | 51331.4 | 9.8 | 60.2 | 1.0 | 1584.4 | 970168.3 | 7911.7 | 404791.7 | 397120.6 | 323784.4 | 148907.8 |
| Bulgaria | 0.079 | 0.087 | 0.121 | 0.804 | 707.5 | 9.5 | 13.0 | -0.7 | 41.2 | 60952.2 | 302.2 | 8595.6 | 48007.8 | 2156.7 | 2914.4 |
| China | 0.072 | 0.083 | 0.090 | 0.741 | 2976.5 | 4.2 | 179.0 | 0.5 | 7768.2 | 10400000.0 | 48391.5 | 1071747.0 | 8674668.0 | 341709.2 | 344518.5 |
| Croatia | 0.076 | 0.083 | 0.088 | 0.652 | 1766.7 | 11.8 | 4.7 | -0.5 | 44.8 | 26610.6 | 192.9 | 3588.8 | 19633.5 | 1581.2 | 1566.5 |
| Czech Republic | 0.064 | 0.066 | 0.060 | 0.611 | 799.9 | 6.1 | 52.4 | 0.1 | 110.9 | 141435.6 | 738.8 | 15266.3 | 120108.1 | 3735.6 | 3307.5 |
| Denmark | 0.051 | 0.052 | 0.035 | 0.506 | 180.6 | 6.5 | 50.1 | 0.3 | 173.9 | 75523.3 | 581.3 | 9782.0 | 58770.7 | 6732.0 | 4920.0 |
| Finland | 0.083 | 0.087 | 0.099 | 0.844 | 4904.5 | 11.9 | 49.2 | 0.3 | 133.5 | 73206.0 | 655.3 | 7625.3 | 59162.7 | 2872.0 | 3824.0 |
| France | 0.051 | 0.054 | 0.037 | 0.528 | 3623.4 | 9.9 | 80.4 | 0.5 | 1985.8 | 489395.0 | 3620.4 | 69247.3 | 357844.2 | 45737.7 | 34293.1 |
| Germany | 0.051 | 0.055 | 0.038 | 0.498 | 588.2 | 7.4 | 112.3 | 0.1 | 2977.8 | 921217.0 | 5894.4 | 66374.1 | 799494.1 | 36188.5 | 29304.8 |
| Ghana | 0.030 | 0.047 | 0.016 | 0.238 | 3299.8 | 7.6 | 3.4 | 2.5 | 16.3 | 19972.5 | 220.0 | 7305.0 | 8005.0 | 4362.5 | 3950.0 |
| Greece | 0.077 | 0.090 | 0.087 | 0.770 | 1853.0 | 15.8 | 43.4 | 0.0 | 240.2 | 105940.5 | 632.1 | 10479.5 | 85069.0 | 4457.9 | 3795.3 |
| Hungary | 0.057 | 0.066 | 0.048 | 0.571 | 22747.2 | 7.3 | 63.9 | -0.2 | 128.7 | 64150.0 | 421.1 | 7822.2 | 49037.8 | 2527.2 | 4635.0 |
| India | 0.044 | 0.055 | 0.024 | 0.417 | 11437.6 | 3.9 | 54.8 | 1.2 | 2259.4 | 3028408.0 | 20145.0 | 640610.0 | 2119412.0 | 492090.0 | 215082.5 |
| Ireland | 0.049 | 0.056 | 0.039 | 0.516 | 5200.4 | 8.2 | 20.3 | 1.3 | 213.2 | 67469.1 | 313.2 | 15957.3 | 40799.6 | 14665.0 | 9063.6 |
| Israel | 0.050 | 0.054 | 0.036 | 0.507 | 911.2 | 8.7 | 34.5 | 2.1 | 208.5 | 79580.8 | 451.6 | 8695.6 | 61841.6 | 506.8 | 885.6 |
| Jamaica | 0.044 | 0.048 | 0.034 | 0.418 | 165702.4 | 10.7 | 4.4 | 0.6 | 12.7 | 10137.3 | 68.2 | 915.5 | 8542.7 | 441.8 | 328.2 |
| Japan | 0.058 | 0.060 | 0.045 | 0.566 | 15956.4 | 3.8 | 85.9 | 0.1 | 4801.2 | 1257730.0 | 8631.0 | 32774.3 | 1169220.0 | 16623.0 | 8487.0 |
| Jordan | 0.041 | 0.063 | 0.027 | 0.388 | 4976.8 | 13.4 | 24.6 | 4.5 | 31.3 | 31338.2 | 158.2 | 5340.9 | 22951.8 | 534.5 | 583.6 |
| Kenya | 0.060 | 0.061 | 0.051 | 0.551 | 3880.1 | 8.6 | 5.9 | 2.6 | 46.8 | 54295.0 | 510.0 | 26192.5 | 12902.5 | 22772.5 | 13370.0 |
| Korea, Rep. | 0.066 | 0.071 | 0.069 | 0.653 | 1297.5 | 3.3 | 162.2 | 0.7 | 911.6 | 541107.7 | 2677.7 | 24231.0 | 480242.3 | 9463.3 | 5070.0 |
| Luxembourg | 0.058 | 0.064 | 0.050 | 0.559 | 1422.7 | 4.6 | 0.8 | 1.8 | 49.5 | 11063.8 | 127.1 | 573.3 | 10082.4 | 418.1 | 210.0 |
| Malaysia | 0.051 | 0.056 | 0.050 | 0.512 | 1172.1 | 3.3 | 28.5 | 2.0 | 188.1 | 206536.7 | 1117.0 | 28754.4 | 163258.5 | 4779.6 | 8492.2 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **country** | **yearly~y** | **yea~hvol** | **annsqr~r** | **annabs~r** | **prccm** | **unempl~r** | **stocks~s** | **popula~h** | **gdp** | **totalg~c** | **no2ghg** | **meth~len** | **co2em~kt** | **agricu~u** | **agrno2~g** |
|  | **[1]** | **[2]** | **[3]** | **[4]** | **[5]** | **[6]** | **[7]** | **[8]** | **[9]** | **[10]** | **[11]** | **[12]** | **[13]** | **[14]** | **[15]** |

**Table 2: INDEX- Summary Statistics by Country – *Continued***

This table presents the summary statistics of our sample by ADR home countries. For variable definitions please refer to Table 1.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **COUNTRY** | **[1]** | **[2]** | **[3]** | **[4]** | **[5]** | **[6]** | **[7]** | **[8]** | **[9]** | **[10]** | **[11]** | **[12]** | **[13]** | **[14]** | **[15]** |
| Malta | 0.034 | 0.041 | 0.020 | 0.352 | 3700.3 | 6.0 | 2.7 | 1.3 | 9.0 | 2699.0 | 14.0 | 221.5 | 2286.5 | 69.5 | 30.5 |
| Mexico | 0.060 | 0.066 | 0.057 | 0.614 | 21625.7 | 4.0 | 28.8 | 1.4 | 851.6 | 573120.7 | 3660.7 | 116994.1 | 406606.2 | 55539.3 | 33486.2 |
| Morocco | 0.031 | 0.036 | 0.013 | 0.307 | 10335.2 | 9.2 | 6.7 | 1.4 | 102.0 | 77582.9 | 422.9 | 11244.3 | 57541.4 | 7057.1 | 7078.6 |
| Netherlands | 0.058 | 0.069 | 0.064 | 0.537 | 461.7 | 5.2 | 81.8 | 0.5 | 598.4 | 203610.0 | 866.4 | 22547.6 | 162360.8 | 12662.8 | 7546.0 |
| New Zealand | 0.029 | 0.031 | 0.013 | 0.306 | 5280.4 | 4.8 | 12.2 | 1.4 | 158.5 | 82564.0 | 379.3 | 33431.3 | 32806.0 | 28150.7 | 14522.7 |
| Nigeria | 0.057 | 0.064 | 0.041 | 0.542 | 29331.7 | 6.5 | 7.3 | 2.6 | 444.5 | 285685.0 | 6115.0 | 127600.0 | 108700.0 | 46231.7 | 28678.3 |
| Norway | 0.055 | 0.059 | 0.043 | 0.520 | 334.2 | 4.0 | 69.1 | 0.8 | 312.3 | 48759.3 | 338.9 | 5417.4 | 37076.7 | 2654.1 | 2625.9 |
| Pakistan | 0.086 | 0.084 | 0.106 | 0.804 | 5438.7 | 3.9 | 156.3 | 2.5 | 107.3 | 257049.4 | 1908.8 | 101956.5 | 110810.0 | 82349.4 | 37496.5 |
| Peru | 0.074 | 0.084 | 0.091 | 0.746 | 9220.2 | 5.0 | 10.1 | 1.1 | 108.4 | 73855.8 | 432.1 | 27732.1 | 36827.4 | 16400.5 | 7395.3 |
| Philippines | 0.067 | 0.076 | 0.068 | 0.670 | 2881.1 | 5.4 | 23.2 | 1.9 | 143.0 | 147014.7 | 874.7 | 57527.7 | 76247.7 | 45699.4 | 9517.1 |
| Poland | 0.065 | 0.072 | 0.062 | 0.622 | 35307.3 | 11.3 | 39.9 | -0.1 | 365.1 | 368550.4 | 2104.4 | 32985.6 | 307941.6 | 15402.4 | 17113.6 |
| Portugal | 0.056 | 0.059 | 0.046 | 0.562 | 8217.1 | 8.3 | 64.1 | 0.2 | 189.4 | 73892.2 | 581.7 | 12260.0 | 56633.9 | 4678.3 | 2367.8 |
| Romania | 0.081 | 0.089 | 0.108 | 0.767 | 4913.4 | 6.4 | 12.6 | -0.7 | 136.8 | 115558.5 | 641.0 | 18493.0 | 86216.0 | 9373.5 | 6753.5 |
| Russian Federation | 0.076 | 0.092 | 0.083 | 0.746 | 1276.0 | 5.8 | 39.2 | 0.1 | 1719.9 | 2329122.0 | 6841.8 | 619700.9 | 1627928.0 | 53330.9 | 42405.5 |
| Saudi Arabia | 0.050 | 0.059 | 0.034 | 0.466 | 7532.2 | 5.7 | 59.9 | 2.3 | 697.5 | 694847.1 | 3211.4 | 106362.9 | 523695.7 | 2761.4 | 3457.1 |
| Singapore | 0.054 | 0.063 | 0.046 | 0.509 | 2417.4 | 4.0 | 49.6 | 2.2 | 171.7 | 52964.6 | 209.6 | 2497.9 | 40185.4 | 0.0 | 36.1 |
| Slovak Republic | 0.050 | 0.056 | 0.036 | 0.453 | 243.3 | 15.0 | 2.3 | 0.0 | 70.3 | 44053.1 | 193.8 | 4731.9 | 36311.9 | 1388.1 | 1270.0 |
| Slovenia | 0.066 | 0.079 | 0.082 | 0.699 | 3939.8 | 6.1 | 16.7 | 0.2 | 32.9 | 18915.0 | 154.2 | 2113.3 | 15720.0 | 1147.5 | 611.7 |
| Spain | 0.056 | 0.060 | 0.043 | 0.545 | 8226.6 | 17.1 | 104.4 | 0.6 | 1011.1 | 341865.7 | 2725.7 | 37884.7 | 271600.3 | 23687.0 | 16077.7 |
| Sweden | 0.065 | 0.066 | 0.057 | 0.640 | 148.6 | 6.8 | 64.5 | 0.4 | 267.2 | 71237.9 | 863.6 | 8077.9 | 56372.1 | 4205.0 | 4017.9 |
| Switzerland | 0.040 | 0.044 | 0.024 | 0.407 | 6271.0 | 3.8 | 73.5 | 0.8 | 471.6 | 52262.7 | 504.3 | 5666.0 | 43011.0 | 4222.7 | 1814.7 |
| Thailand | 0.072 | 0.080 | 0.083 | 0.707 | 945.5 | 1.4 | 73.4 | 0.7 | 250.9 | 300315.3 | 1902.3 | 68637.7 | 198761.3 | 53023.7 | 15855.0 |
| Turkey | 0.071 | 0.076 | 0.072 | 0.734 | 87755.5 | 10.2 | 165.9 | 1.5 | 798.8 | 413190.7 | 1738.6 | 44130.7 | 334160.0 | 18429.3 | 24176.4 |
| United Kingdom | 0.039 | 0.043 | 0.021 | 0.386 | 4928.9 | 6.9 | 63.9 | 0.5 | 2014.5 | 664667.2 | 3708.4 | 90911.2 | 518626.8 | 30898.4 | 25146.0 |
| United States | 0.037 | 0.041 | 0.021 | 0.385 | 1250.7 | 5.9 | 140.6 | 1.0 | 12413.4 | 6323144.0 | 52047.9 | 638071.7 | 5293109.0 | 199462.1 | 173502.4 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **country** | **yearly~y** | **yea~hvol** | **annsqr~r** | **annabs~r** | **prccm** | **unempl~r** | **stocks~s** | **popula~h** | **gdp** | **totalg~c** | **no2ghg** | **meth~len** | **co2em~kt** | **agricu~u** | **agrno2~g** |
|  | **[1]** | **[2]** | **[3]** | **[4]** | **[5]** | **[6]** | **[7]** | **[8]** | **[9]** | **[10]** | **[11]** | **[12]** | **[13]** | **[14]** | **[15]** |

**Table 2: ADR -Summary Statistics by Country**

This table presents the summary statistics of our sample by ADR home countries. For variable definitions please refer to Table 1.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **COUNTRY** | **[1]** | **[2]** | **[3]** | **[4]** | **[5]** | **[6]** | **[7]** | **[8]** | **[9]** | **[10]** | **[11]** | **[12]** | **[13]** | **[14]** | **[15]** | **[16]** | **[17]** | **[18]** |
| **Argentina** | 20 | 0.032 | 0.032 | 0.029 | 0.043 | 0.010 | 0.009 | 0.96 | 17.47 | 9.63 | 1.04 | 396.8 | 346856.6 | 1073.4 | 124674.9 | 163658.8 | 84889.1 | 41998.5 |
| **Australia** | 24 | 0.035 | 0.039 | 0.033 | 0.036 | 0.016 | 0.012 | 0.57 | 26.39 | 5.41 | 1.45 | 996.6 | 594974.7 | 3073.5 | 134698.4 | 376219.9 | 89977.9 | 69191.9 |
| **Austria** | 1 | 0.017 | 0.017 | 0.017 | 0.011 | 0.011 | 0.007 | 0.04 | 39.11 | 5.20 | 0.52 | 303.3 | 87926.7 | 721.7 | 8700.0 | 73535.0 | 5056.7 | 2538.3 |
| **Belgium** | 3 | 0.021 | 0.021 | 0.018 | 0.018 | 0.003 | 0.013 | 0.80 | 55.75 | 7.81 | 0.71 | 458.4 | 120555.3 | 705.3 | 9432.9 | 102884.1 | 6448.8 | 3381.8 |
| **Brazil** | 21 | 0.028 | 0.028 | 0.023 | 0.033 | 0.004 | 0.016 | 3.57 | 19.29 | 9.61 | 0.93 | 1829.6 | 1007453.0 | 8505.3 | 414182.9 | 419335.7 | 329020.0 | 154060.5 |
| **Chile** | 25 | 0.021 | 0.021 | 0.020 | 0.026 | 0.010 | 0.011 | 0.33 | 27.97 | 8.49 | 1.10 | 183.3 | 87817.1 | 798.8 | 11647.0 | 67636.0 | 6452.6 | 5505.1 |
| **China** | 204 | 0.038 | 0.040 | 0.035 | 0.048 | 0.007 | 0.026 | 0.91 | 20.66 | 4.19 | 0.54 | 8675.6 | 10800000.0 | 49612.7 | 1091289.0 | 9024385.0 | 339144.7 | 345309.2 |
| **Colombia** | 1 | 0.028 | 0.027 | 0.024 | 0.036 | 0.007 | 0.126 | 0.06 | 33.84 | 10.40 | 1.04 | 295.6 | 161154.0 | 778.0 | 69876.0 | 66262.0 | 43980.0 | 18934.0 |
| **Denmark** | 4 | 0.035 | 0.036 | 0.034 | 0.048 | 0.033 | 0.005 | 0.17 | 23.78 | 4.92 | 0.28 | 215.8 | 71998.2 | 601.8 | 9920.0 | 55270.0 | 6476.4 | 4377.3 |
| **Finland** | 3 | 0.020 | 0.020 | 0.018 | 0.018 | 0.006 | 0.005 | 0.42 | 17.02 | 10.42 | 0.26 | 169.8 | 81093.3 | 760.0 | 6443.3 | 67610.0 | 2546.7 | 3836.7 |
| **France** | 39 | 0.032 | 0.032 | 0.028 | 0.031 | 0.011 | 0.013 | 1.50 | 24.20 | 8.72 | 0.63 | 2315.0 | 487382.6 | 3615.9 | 68639.1 | 359468.0 | 44523.8 | 33576.7 |
| **Germany** | 27 | 0.028 | 0.028 | 0.024 | 0.025 | 0.010 | 0.014 | 1.37 | 37.81 | 8.09 | -0.01 | 3133.2 | 900424.9 | 5891.1 | 61562.6 | 785484.3 | 34645.7 | 28810.7 |
| **Greece** | 5 | 0.028 | 0.029 | 0.025 | 0.030 | 0.009 | 0.011 | 0.18 | 13.81 | 10.42 | 0.23 | 262.2 | 118974.7 | 705.6 | 10953.8 | 97510.9 | 4637.2 | 3974.4 |
| **Hungary** | 2 | 0.026 | 0.027 | 0.023 | 0.031 | 0.007 | 0.003 | 0.30 | 18.61 | 7.52 | -0.21 | 117.3 | 68340.0 | 405.0 | 8210.0 | 52748.0 | 2593.0 | 4504.0 |
| **India** | 15 | 0.024 | 0.025 | 0.022 | 0.027 | 0.003 | 0.013 | 2.25 | 23.37 | 3.41 | 1.27 | 1878.5 | 2743258.0 | 18079.6 | 628366.4 | 1860967.0 | 486245.0 | 206238.8 |
| **Indonesia** | 2 | 0.023 | 0.023 | 0.021 | 0.019 | 0.004 | 0.005 | 1.27 | 30.48 | 5.95 | 1.31 | 615.2 | 778387.0 | 5468.0 | 280661.7 | 415960.7 | 86997.7 | 71551.0 |
| **Ireland** | 19 | 0.031 | 0.031 | 0.028 | 0.040 | 0.008 | 0.009 | 1.46 | 23.65 | 7.72 | 1.56 | 232.2 | 68817.4 | 327.5 | 15905.2 | 42299.2 | 14633.3 | 9025.7 |
| **Israel** | 23 | 0.032 | 0.036 | 0.031 | 0.037 | 0.017 | 0.017 | 1.71 | 16.83 | 7.37 | 1.89 | 266.1 | 84434.9 | 473.6 | 8454.9 | 64769.6 | 539.6 | 916.8 |
| **Italy** | 14 | 0.023 | 0.023 | 0.020 | 0.024 | 0.010 | 0.006 | 0.60 | 24.67 | 8.46 | 0.46 | 1915.8 | 514174.6 | 3086.0 | 48769.8 | 434416.5 | 21414.4 | 12587.1 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| no\_adr | year~y\_t | year~h\_t | fmvola~t | year~e\_t | year~d\_t | year~r\_t | size | price\_t | unempl~r | popula~h | gdp | totalg~c | no2ghg | meth~len | co2em~kt | agricu~u | agrno2~g |
| **[1]** | **[2]** | **[3]** | **[4]** | **[5]** | **[6]** | **[7]** | **[8]** | **[9]** | **[10]** | **[11]** | **[12]** | **[13]** | **[14]** | **[15]** | **[16]** | **[17]** | **[18]** |

**Table 2: ADR- Summary Statistics by Country – *Continued***

This table presents the summary statistics of our sample by ADR home countries. For variable definitions please refer to Table 1.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **COUNTRY** | **[1]** | **[2]** | **[3]** | **[4]** | **[5]** | **[6]** | **[7]** | **[8]** | **[9]** | **[10]** | **[11]** | **[12]** | **[13]** | **[14]** | **[15]** | **[16]** | **[17]** | **[18]** |
| **Japan** | 36 | 0.022 | 0.022 | 0.019 | 0.018 | 0.005 | 0.009 | 1.29 | 32.55 | 4.25 | 0.00 | 5009.9 | 1272687.0 | 8813.0 | 30904.0 | 1191598.0 | 15646.8 | 8163.7 |
| **Luxembourg** | 3 | 0.032 | 0.032 | 0.028 | 0.031 | 0.009 | 0.006 | 0.40 | 20.51 | 4.29 | 1.49 | 40.8 | 12059.4 | 129.4 | 578.1 | 11070.6 | 403.1 | 215.6 |
| **Mexico** | 31 | 0.025 | 0.025 | 0.022 | 0.032 | 0.010 | 0.007 | 2.11 | 26.50 | 4.12 | 1.36 | 1036.0 | 626008.5 | 4021.3 | 124386.5 | 448231.7 | 56185.2 | 33659.8 |
| **New Zealand** | 3 | 0.020 | 0.020 | 0.017 | 0.019 | 0.008 | 0.004 | 0.52 | 18.15 | 4.83 | 1.36 | 106.2 | 82707.5 | 368.3 | 33710.8 | 32790.0 | 28147.5 | 14794.2 |
| **Norway** | 5 | 0.022 | 0.022 | 0.018 | 0.021 | 0.006 | 0.012 | 1.68 | 26.27 | 3.80 | 0.84 | 360.8 | 48615.7 | 345.1 | 5187.1 | 37523.7 | 2586.9 | 2621.4 |
| **Peru** | 4 | 0.029 | 0.029 | 0.027 | 0.040 | 0.009 | 0.007 | 1.42 | 16.42 | 3.75 | 1.18 | 164.2 | 87283.9 | 532.8 | 30357.5 | 46587.5 | 17380.6 | 7908.3 |
| **Philippines** | 1 | 0.018 | 0.018 | 0.016 | 0.020 | 0.001 | 0.004 | 1.89 | 44.04 | 3.33 | 1.67 | 229.0 | 173351.2 | 1030.0 | 61733.5 | 95182.4 | 48295.9 | 10115.3 |
| **Portugal** | 2 | 0.015 | 0.015 | 0.014 | 0.013 | 0.007 | 0.004 | 0.26 | 31.46 | 6.38 | 0.32 | 181.5 | 80261.4 | 610.0 | 12721.4 | 62652.9 | 4604.3 | 2428.6 |
| **Russia** | 7 | 0.035 | 0.035 | 0.031 | 0.043 | 0.003 | 0.012 | 2.36 | 15.85 | 5.91 | 0.10 | 1665.9 | 2323289.0 | 6832.9 | 619862.4 | 1621874.0 | 53323.5 | 42516.2 |
| **Singapore** | 3 | 0.033 | 0.033 | 0.029 | 0.036 | 0.004 | 0.035 | 0.33 | 10.18 | 4.79 | 2.03 | 177.4 | 54080.9 | 226.4 | 2677.3 | 40040.0 | 0.0 | 58.2 |
| **South Africa** | 13 | 0.031 | 0.031 | 0.029 | 0.037 | 0.007 | 0.018 | 1.63 | 24.21 | 25.33 | 1.39 | 333.1 | 512575.4 | 2863.3 | 75675.0 | 406666.7 | 16791.0 | 14741.5 |
| **South Korea** | 14 | 0.027 | 0.026 | 0.023 | 0.026 | 0.008 | 0.011 | 1.55 | 30.82 | 3.30 | 0.49 | 1202.8 | 623138.8 | 3137.3 | 23734.0 | 551577.8 | 9215.5 | 4807.6 |
| **Spain** | 13 | 0.022 | 0.023 | 0.018 | 0.023 | 0.006 | 0.010 | 1.47 | 21.09 | 15.28 | 0.96 | 1246.3 | 371164.4 | 2953.6 | 39103.0 | 297530.7 | 24365.6 | 16198.6 |
| **Sweden** | 11 | 0.032 | 0.030 | 0.029 | 0.038 | 0.036 | 0.007 | 0.09 | 27.39 | 5.20 | 0.34 | 293.1 | 68565.0 | 911.7 | 7206.1 | 54478.9 | 3866.7 | 3844.4 |
| **Switzerland** | 11 | 0.021 | 0.021 | 0.017 | 0.018 | 0.004 | 0.014 | 2.15 | 28.37 | 4.14 | 0.85 | 501.5 | 52716.5 | 521.6 | 5486.0 | 43442.8 | 4065.1 | 1729.2 |
| **The Netherlands** | 15 | 0.025 | 0.025 | 0.020 | 0.022 | 0.007 | 0.010 | 1.82 | 23.77 | 4.63 | 0.37 | 736.2 | 198889.7 | 934.7 | 19090.0 | 165378.9 | 11718.4 | 6965.7 |
| **Turkey** | 1 | 0.025 | 0.025 | 0.022 | 0.023 | 0.002 | 0.011 | 0.79 | 14.39 | 10.27 | 1.46 | 703.0 | 384969.5 | 1650.0 | 42651.1 | 309172.8 | 17710.6 | 23493.3 |
| **United Kingdom** | 89 | 0.027 | 0.028 | 0.024 | 0.027 | 0.011 | 0.013 | 1.89 | 29.92 | 5.72 | 0.63 | 2468.8 | 638114.3 | 3659.4 | 79656.4 | 512263.2 | 28557.2 | 23632.9 |
| **Venezuela** | 2 | 0.048 | 0.049 | 0.047 | 0.050 | 0.048 | 0.002 | 0.377 | 9.263 | 16.170 | 1.825 | 92.9 | 337780.0 | 1050.0 | 180830.0 | 140750.0 | 25430.0 | 10890.0 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| no\_adr | year~y\_t | year~h\_t | fmvola~t | year~e\_t | year~d\_t | year~r\_t | size | price\_t | unempl~r | popula~h | gdp | totalg~c | no2ghg | meth~len | co2em~kt | agricu~u | agrno2~g |
| **[1]** | **[2]** | **[3]** | **[4]** | **[5]** | **[6]** | **[7]** | **[8]** | **[9]** | **[10]** | **[11]** | **[12]** | **[13]** | **[14]** | **[15]** | **[16]** | **[17]** | **[18]** |

**Table 3: INDEX- Correlations**

This table provides Pearson correlation between variables. For variable definitions please refer to Table 1.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | [11] | [12] | [13] | [14] | [15] |
| **yearlyvola~y** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **yearlygarc~l** | 0.8710 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **annsqretvar** | 0.9259 | 0.8182 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| **annabsretvar** | 0.9455 | 0.8531 | 0.9052 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| **lntotghg** | 0.0064 | -0.0022 | -0.0093 | 0.0253 | 1 |  |  |  |  |  |  |  |  |  |  |
| **lnno2ghg** | -0.0039 | -0.0193 | -0.0225 | 0.0157 | 0.9805 | 1 |  |  |  |  |  |  |  |  |  |
| **lnmethghg** | 0.0338 | 0.0353 | 0.0210 | 0.0539 | 0.9269 | 0.9095 | 1 |  |  |  |  |  |  |  |  |
| **lnco2ghg** | 0.0001 | -0.0102 | -0.0156 | 0.0191 | 0.9905 | 0.9698 | 0.8754 | 1 |  |  |  |  |  |  |  |
| **lnagmethghg** | 0.0439 | 0.0286 | 0.0313 | 0.0660 | 0.719 | 0.7471 | 0.8339 | 0.6698 | 1 |  |  |  |  |  |  |
| **lnagrno2ghg** | 0.0328 | 0.0201 | 0.0216 | 0.0552 | 0.8393 | 0.8507 | 0.9294 | 0.7903 | 0.9492 | 1 |  |  |  |  |  |
| **lnprice** | -0.1262 | -0.111 | -0.1128 | -0.0988 | 0.1112 | 0.1279 | 0.1348 | 0.0856 | 0.1366 | 0.1474 | 1 |  |  |  |  |
| **lnstockstu~r** | 0.1190 | 0.0776 | 0.09 | 0.1392 | 0.6114 | 0.5961 | 0.5230 | 0.6228 | 0.3522 | 0.4590 | 0.0155 | 1 |  |  |  |
| **lnunemploy~t** | 0.0046 | 0.0264 | -0.0226 | 0.0043 | -0.108 | -0.1069 | -0.099 | -0.0996 | -0.0491 | -0.0138 | 0.0951 | -0.1391 | 1 |  |  |
| **lngdp** | -0.1393 | -0.1772 | -0.1374 | -0.1171 | 0.8828 | 0.8989 | 0.7416 | 0.8973 | 0.585 | 0.6863 | 0.1275 | 0.6173 | -0.092 | 1 |  |
| **population~w** | -0.0764 | -0.0854 | -0.0579 | -0.0788 | -0.1244 | -0.1286 | -0.0259 | -0.1714 | -0.1836 | -0.1484 | 0.0604 | -0.1086 | -0.1886 | -0.1721 | 1 |

**Table 3: ADR- Correlations**

This table provides Pearson correlation between variables. For variable definitions please refer to Table 1.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|   | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | [11] | [12] | [13] | [14] | [15] | [16] | [17] |
| **yearlyvola~t** | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **yearlygarc~t** | 0.9252 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **fmvolatili~t** | 0.9765 | 0.9229 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **yearlyrang~t** | 0.8770 | 0.8586 | 0.8746 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |  |
| **lntotghg** | 0.2396 | 0.275 | 0.2427 | 0.2835 | 1 |  |  |  |  |  |  |  |  |  |  |  |  |
| **lnno2ghg** | 0.2124 | 0.2443 | 0.2129 | 0.2473 | 0.9868 | 1 |  |  |  |  |  |  |  |  |  |  |  |
| **lnmethghg** | 0.2717 | 0.3076 | 0.2752 | 0.3526 | 0.9131 | 0.8856 | 1 |  |  |  |  |  |  |  |  |  |  |
| **lnco2ghg** | 0.2288 | 0.2639 | 0.2322 | 0.263 | 0.9933 | 0.9841 | 0.8676 | 1 |  |  |  |  |  |  |  |  |  |
| **lnagmethghg** | 0.2155 | 0.2397 | 0.2122 | 0.2865 | 0.8183 | 0.8063 | 0.9347 | 0.7635 | 1 |  |  |  |  |  |  |  |  |
| **lnagrno2ghg** | 0.2561 | 0.2898 | 0.2571 | 0.3334 | 0.8698 | 0.8527 | 0.9744 | 0.8219 | 0.974 | 1 |  |  |  |  |  |  |  |
| **yearlyturn~t** | 0.3187 | 0.3067 | 0.2823 | 0.3234 | 0.2225 | 0.2188 | 0.2168 | 0.22 | 0.1653 | 0.2048 | 1 |  |  |  |  |  |  |
| **yearlyspre~t** | 0.4896 | 0.4865 | 0.5495 | 0.4694 | -0.0791 | -0.0902 | -0.0529 | -0.0786 | -0.0695 | -0.0562 | -0.0999 | 1 |  |  |  |  |  |
| **lnprice** | -0.5513 | -0.5906 | -0.5925 | -0.5911 | -0.1294 | -0.1098 | -0.1669 | -0.1184 | -0.1179 | -0.1498 | -0.0417 | -0.4026 | 1 |  |  |  |  |
| **lnsize** | -0.4152 | -0.4597 | -0.4867 | -0.3584 | 0.0012 | 0.013 | 0.0133 | -0.0088 | 0.0636 | 0.0194 | -0.0416 | -0.6164 | 0.5424 | 1 |  |  |  |
| **lnunemploy~t** | -0.0538 | -0.0754 | -0.0613 | -0.0607 | -0.3561 | -0.3455 | -0.2161 | -0.3814 | -0.1732 | -0.172 | -0.0544 | 0.0205 | -0.0009 | 0.0315 | 1 |  |  |
| **lngdp** | 0.1469 | 0.1781 | 0.1372 | 0.1435 | 0.8759 | 0.8942 | 0.7012 | 0.8925 | 0.6426 | 0.6773 | 0.1729 | -0.118 | -0.0664 | 0.0541 | -0.3929 | 1 |  |
| **population~w** | 0.004 | 0.0143 | 0.0174 | 0.0745 | -0.3937 | -0.4165 | -0.1643 | -0.4308 | -0.1989 | -0.1768 | -0.0474 | 0.0775 | -0.0624 | -0.0491 | 0.1512 | -0.5538 | 1 |

**Table 4: Country Emissions and Volatility Regressions – VLT1**

This table provides the results of the following OLS regression:

$VLT\_{c,t}^{1}=β\_{o}+β\_{1}LN(EMISSIONS\_{c,t})+β\_{2}LN(PRICE\_{c,t})+β\_{3}TURNOVER\_{c,t}+β\_{4}LN(GDP\_{c,t})+β\_{5}LN(UNEMPLOYMENT\_{c,t})+β\_{6}LN(POPULATION\_{c,t})+δ\_{t}+ε$*i*

The LHS variable, $VLT\_{c,t}^{1}$, is the Historical Standard deviation (VLT1) of country i on time t. The main independent variable is$ LN(EMISSIONS\_{c,t})$ which is the natural log of each of the six EMISSIONS measures from World Bank Database: Total greenhouse gas emissions (kt of CO2 equivalent), Nitrous oxide emissions (thousand metric tons of CO2 equivalent), Methane emissions (kt of CO2 equivalent), CO2 emissions (kt), Agricultural methane emissions (thousand metric tons of CO2 equivalent), and Agricultural nitrous oxide emissions (thousand metric tons of CO2 equivalent). For remaining variable definitions, please refer to Table 1. Robust t-stats corresponding to standard errors clustered at the country level are reported in parenthesis. \*\*\*, \*\*, and \* reflect statistical significance at 0.01, 0.05, and 0.10 levels, respectively.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | [11] | [12] |
|  |   |   |   |   |   |   |   |   |   |   |  |  |
| **lntotghg** | 0.0099\*\*\* | 0.0087\*\*\* |  |  |  |  |  |  |  |  |  |  |
|  | (4.698) | (3.887) |  |  |  |  |  |  |  |  |  |  |
| **lnno2ghg** |  |  | 0.0114\*\*\* | 0.0098\*\*\* |  |  |  |  |  |  |  |  |
|  |  |  | (5.416) | (4.165) |  |  |  |  |  |  |  |  |
| **lnmethghg** |  |  |  |  | 0.0053\*\* | 0.0045\*\* |  |  |  |  |  |  |
|  |  |  |  |  | (2.674) | (2.425) |  |  |  |  |  |  |
| **lnco2ghg** |  |  |  |  |  |  | 0.0100\*\*\* | 0.0087\*\*\* |  |  |  |  |
|  |  |  |  |  |  |  | (4.920) | (3.843) |  |  |  |  |
| **lnagmethghg** |  |  |  |  |  |  |  |  | 0.0025\*\* | 0.0017 |  |  |
|  |  |  |  |  |  |  |  |  | (2.119) | (1.592) |  |  |
| **lnagrno2ghg** |  |  |  |  |  |  |  |  |  |  | 0.0035\*\* | 0.0026\* |
|  |  |  |  |  |  |  |  |  |  |  | (2.198) | (1.747) |
| **lnprice** | -0.0017\* | 0.0000 | -0.0018\* | -0.0002 | -0.0018\* | 0.0001 | -0.0014 | 0.0002 | -0.0019\* | 0.0001 | -0.0019\* | 0.0001 |
|  | (-1.732) | (0.001) | (-1.779) | (-0.171) | (-1.830) | (0.045) | (-1.417) | (0.200) | (-1.851) | (0.132) | (-1.817) | (0.083) |
| **lnstocksturnover** | 0.0058\*\*\* | 0.0025 | 0.0061\*\*\* | 0.0029\* | 0.0062\*\*\* | 0.0027 | 0.0057\*\*\* | 0.0024 | 0.0070\*\*\* | 0.0033\* | 0.0066\*\*\* | 0.0030\* |
|  | (2.924) | (1.361) | (3.306) | (1.720) | (2.952) | (1.402) | (3.123) | (1.442) | (3.674) | (1.982) | (3.400) | (1.757) |
| **lngdp** | -0.0144\*\*\* | -0.0111\*\*\* | -0.0160\*\*\* | -0.0124\*\*\* | -0.0103\*\*\* | -0.0071\*\*\* | -0.0147\*\*\* | -0.0112\*\*\* | -0.0085\*\*\* | -0.0052\*\*\* | -0.0091\*\*\* | -0.0058\*\*\* |
|  | (-6.380) | (-4.732) | (-7.627) | (-5.401) | (-4.336) | (-3.281) | (-6.840) | (-4.795) | (-4.896) | (-2.998) | (-4.495) | (-3.058) |
| **lnunemployment** | 0.0007 | -0.0002 | 0.0008 | -0.0001 | 0.0005 | -0.0005 | 0.0006 | -0.0003 | 0.0006 | -0.0005 | -0.0001 | -0.0010 |
|  | (0.271) | (-0.090) | (0.312) | (-0.039) | (0.169) | (-0.235) | (0.242) | (-0.129) | (0.233) | (-0.225) | (-0.034) | (-0.455) |
| **populationgrowth** | -0.0033\* | -0.0034\*\* | -0.0033\* | -0.0034\*\* | -0.0038\*\* | -0.0038\*\* | -0.0026 | -0.0028\* | -0.0023 | -0.0026 | -0.0027 | -0.0029\* |
|  | (-1.920) | (-2.278) | (-1.877) | (-2.238) | (-2.113) | (-2.428) | (-1.440) | (-1.767) | (-1.163) | (-1.529) | (-1.420) | (-1.739) |
| **Constant** | 0.3134\*\*\* | 0.2401\*\*\* | 0.3949\*\*\* | 0.3118\*\*\* | 0.2716\*\*\* | 0.1949\*\*\* | 0.3199\*\*\* | 0.2444\*\*\* | 0.2508\*\*\* | 0.1690\*\*\* | 0.2628\*\*\* | 0.1814\*\*\* |
|  | (8.261) | (5.758) | (9.042) | (6.342) | (6.214) | (4.509) | (8.315) | (5.632) | (6.627) | (4.292) | (6.269) | (4.371) |
| **Year Fixed Effects** | No  | Yes | No  | Yes | No  | Yes | No  | Yes | No  | Yes | No  | Yes |
| **Clustered SE** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Observations** | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 |
| **R-squared** | 0.162 | 0.436 | 0.170 | 0.440 | 0.143 | 0.422 | 0.157 | 0.431 | 0.128 | 0.406 | 0.131 | 0.411 |

**Table 5: Country Emissions and Volatility Regressions – VLT2**

This table provides the results of the following OLS regression:

$VLT\_{c,t}^{2}=β\_{o}+β\_{1}LN(EMISSIONS\_{c,t})+β\_{2}LN(PRICE\_{c,t})+β\_{3}TURNOVER\_{c,t}+β\_{4}LN(GDP\_{c,t})+β\_{5}LN(UNEMPLOYMENT\_{c,t})+β\_{6}LN(POPULATION\_{c,t})+δ\_{t}+ε$*i*

The LHS variable, $VLT\_{c,t}^{2}$, is the Conditional GARCH[1,1] Volatility of country i on time t. The main independent variable is$ LN(EMISSIONS\_{c,t})$ which is the natural log of each of the six EMISSIONS measures from World Bank Database: Total greenhouse gas emissions (kt of CO2 equivalent), Nitrous oxide emissions (thousand metric tons of CO2 equivalent), Methane emissions (kt of CO2 equivalent), CO2 emissions (kt), Agricultural methane emissions (thousand metric tons of CO2 equivalent), and Agricultural nitrous oxide emissions (thousand metric tons of CO2 equivalent). For remaining variable definitions, please refer to Table 1. Robust t-stats corresponding to standard errors clustered at the country level are reported in parenthesis. \*\*\*, \*\*, and \* reflect statistical significance at 0.01, 0.05, and 0.10 levels, respectively.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | [11] | [12] |
|  |   |   |   |   |   |   |   |   |   |   |  |  |
| **lntotghg** | 0.0105\*\*\* | 0.0100\*\*\* |  |  |  |  |  |  |  |  |  |  |
|  | (4.782) | (4.302) |  |  |  |  |  |  |  |  |  |  |
| **lnno2ghg** |  |  | 0.0114\*\*\* | 0.0108\*\*\* |  |  |  |  |  |  |  |  |
|  |  |  | (4.932) | (4.219) |  |  |  |  |  |  |  |  |
| **lnmethghg** |  |  |  |  | 0.0056\*\*\* | 0.0051\*\* |  |  |  |  |  |  |
|  |  |  |  |  | (2.882) | (2.639) |  |  |  |  |  |  |
| **lnco2ghg** |  |  |  |  |  |  | 0.0108\*\*\* | 0.0102\*\*\* |  |  |  |  |
|  |  |  |  |  |  |  | (4.832) | (4.240) |  |  |  |  |
| **lnagmethghg** |  |  |  |  |  |  |  |  | 0.0022\* | 0.0016 |  |  |
|  |  |  |  |  |  |  |  |  | (1.726) | (1.405) |  |  |
| **lnagrno2ghg** |  |  |  |  |  |  |  |  |  |  | 0.0033\* | 0.0027\* |
|  |  |  |  |  |  |  |  |  |  |  | (1.984) | (1.684) |
| **lnprice** | -0.0011 | -0.0003 | -0.0013 | -0.0005 | -0.0013 | -0.0002 | -0.0008 | -0.0000 | -0.0013 | -0.0000 | -0.0013 | -0.0001 |
|  | (-1.109) | (-0.228) | (-1.173) | (-0.376) | (-1.290) | (-0.171) | (-0.794) | (-0.007) | (-1.245) | (-0.031) | (-1.252) | (-0.093) |
| **lnstocksturnover** | 0.0042\*\* | 0.0024 | 0.0046\*\*\* | 0.0029\* | 0.0047\*\* | 0.0027 | 0.0041\*\* | 0.0024 | 0.0055\*\*\* | 0.0033\*\* | 0.0051\*\*\* | 0.0030\* |
|  | (2.311) | (1.375) | (2.743) | (1.812) | (2.365) | (1.416) | (2.485) | (1.465) | (3.223) | (2.141) | (2.904) | (1.864) |
| **lngdp** | -0.0144\*\*\* | -0.0125\*\*\* | -0.0155\*\*\* | -0.0136\*\*\* | -0.0100\*\*\* | -0.0080\*\*\* | -0.0148\*\*\* | -0.0129\*\*\* | -0.0077\*\*\* | -0.0055\*\*\* | -0.0084\*\*\* | -0.0063\*\*\* |
|  | (-6.694) | (-5.390) | (-7.467) | (-5.803) | (-4.695) | (-3.741) | (-6.909) | (-5.385) | (-4.719) | (-3.247) | (-4.614) | (-3.408) |
| **lnunemployment** | 0.0011 | 0.0002 | 0.0012 | 0.0003 | 0.0009 | -0.0002 | 0.0010 | 0.0001 | 0.0010 | -0.0002 | 0.0003 | -0.0007 |
|  | (0.494) | (0.103) | (0.536) | (0.144) | (0.361) | (-0.070) | (0.457) | (0.065) | (0.427) | (-0.069) | (0.154) | (-0.289) |
| **populationgrowth** | -0.0033\*\* | -0.0034\*\* | -0.0033\*\* | -0.0034\*\* | -0.0038\*\* | -0.0038\*\* | -0.0025\* | -0.0027\* | -0.0023 | -0.0025 | -0.0027 | -0.0027\* |
|  | (-2.327) | (-2.446) | (-2.172) | (-2.309) | (-2.437) | (-2.462) | (-1.782) | (-1.924) | (-1.441) | (-1.589) | (-1.663) | (-1.756) |
| **Constant** | 0.3112\*\*\* | 0.2712\*\*\* | 0.3878\*\*\* | 0.3450\*\*\* | 0.2670\*\*\* | 0.2193\*\*\* | 0.3194\*\*\* | 0.2793\*\*\* | 0.2387\*\*\* | 0.1859\*\*\* | 0.2519\*\*\* | 0.2002\*\*\* |
|  | (8.531) | (6.447) | (9.138) | (6.932) | (6.646) | (5.091) | (8.316) | (6.193) | (6.498) | (4.664) | (6.498) | (4.867) |
| **Year Fixed Effects** | No  | Yes | No  | Yes | No  | Yes | No  | Yes | No  | Yes | No  | Yes |
| **Clustered SE** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Observations** | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 |
| **R-squared** | 0.195 | 0.398 | 0.198 | 0.399 | 0.166 | 0.374 | 0.189 | 0.394 | 0.132 | 0.341 | 0.138 | 0.348 |

**Table 6: Country Emissions and Volatility Regressions – VLT3**

This table provides the results of the following OLS regression:

$VLT\_{c,t}^{3}=β\_{o}+β\_{1}LN(EMISSIONS\_{c,t})+β\_{2}LN(PRICE\_{c,t})+β\_{3}TURNOVER\_{c,t}+β\_{4}LN(GDP\_{c,t})+β\_{5}LN(UNEMPLOYMENT\_{c,t})+β\_{6}LN(POPULATION\_{c,t})+δ\_{t}+ε$*i*

The LHS variable, $VLT\_{c,t}^{3}$, is the annualized realized Volatility of country i on time t based on squared monthly returns. The main independent variable is$ LN(EMISSIONS\_{c,t})$ which is the natural log of each of the six EMISSIONS measures from World Bank Database: Total greenhouse gas emissions (kt of CO2 equivalent), Nitrous oxide emissions (thousand metric tons of CO2 equivalent), Methane emissions (kt of CO2 equivalent), CO2 emissions (kt), Agricultural methane emissions (thousand metric tons of CO2 equivalent), and Agricultural nitrous oxide emissions (thousand metric tons of CO2 equivalent). For remaining variable definitions, please refer to Table 1. Robust t-stats corresponding to standard errors clustered at the country level are reported in parenthesis. \*\*\*, \*\*, and \* reflect statistical significance at 0.01, 0.05, and 0.10 levels, respectively.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | [11] | [12] |
|  |   |   |   |   |   |   |   |   |   |   |  |  |
| **lntotghg** | 0.0180\*\*\* | 0.0176\*\*\* |  |  |  |  |  |  |  |  |  |  |
|  | (4.800) | (4.633) |  |  |  |  |  |  |  |  |  |  |
| **lnno2ghg** |  |  | 0.0197\*\*\* | 0.0189\*\*\* |  |  |  |  |  |  |  |  |
|  |  |  | (5.317) | (4.595) |  |  |  |  |  |  |  |  |
| **lnmethghg** |  |  |  |  | 0.0100\*\*\* | 0.0092\*\*\* |  |  |  |  |  |  |
|  |  |  |  |  | (3.065) | (3.084) |  |  |  |  |  |  |
| **lnco2ghg** |  |  |  |  |  |  | 0.0182\*\*\* | 0.0177\*\*\* |  |  |  |  |
|  |  |  |  |  |  |  | (4.879) | (4.499) |  |  |  |  |
| **lnagmethghg** |  |  |  |  |  |  |  |  | 0.0046\*\* | 0.0034\* |  |  |
|  |  |  |  |  |  |  |  |  | (2.318) | (1.790) |  |  |
| **lnagrno2ghg** |  |  |  |  |  |  |  |  |  |  | 0.0068\*\* | 0.0057\*\* |
|  |  |  |  |  |  |  |  |  |  |  | (2.572) | (2.171) |
| **lnprice** | -0.0030\* | -0.0007 | -0.0032\* | -0.0011 | -0.0033\* | -0.0006 | -0.0025 | -0.0003 | -0.0034\* | -0.0005 | -0.0034\* | -0.0006 |
|  | (-1.752) | (-0.394) | (-1.768) | (-0.538) | (-1.837) | (-0.334) | (-1.432) | (-0.146) | (-1.805) | (-0.232) | (-1.783) | (-0.300) |
| **lnstocksturnover** | 0.0101\*\*\* | 0.0038 | 0.0108\*\*\* | 0.0046\* | 0.0109\*\*\* | 0.0043 | 0.0100\*\*\* | 0.0037 | 0.0123\*\*\* | 0.0054\*\* | 0.0116\*\*\* | 0.0048\* |
|  | (3.276) | (1.354) | (3.797) | (1.865) | (3.212) | (1.405) | (3.537) | (1.431) | (4.128) | (2.210) | (3.749) | (1.868) |
| **lngdp** | -0.0268\*\*\* | -0.0224\*\*\* | -0.0289\*\*\* | -0.0242\*\*\* | -0.0195\*\*\* | -0.0145\*\*\* | -0.0272\*\*\* | -0.0228\*\*\* | -0.0161\*\*\* | -0.0105\*\*\* | -0.0175\*\*\* | -0.0121\*\*\* |
|  | (-6.637) | (-5.637) | (-7.546) | (-5.888) | (-5.033) | (-4.198) | (-6.819) | (-5.502) | (-5.633) | (-3.800) | (-5.280) | (-3.955) |
| **lnunemployment** | -0.0016 | -0.0027 | -0.0014 | -0.0025 | -0.0021 | -0.0034 | -0.0018 | -0.0029 | -0.0018 | -0.0033 | -0.0031 | -0.0044 |
|  | (-0.337) | (-0.681) | (-0.293) | (-0.625) | (-0.420) | (-0.831) | (-0.378) | (-0.725) | (-0.388) | (-0.836) | (-0.688) | (-1.133) |
| **populationgrowth** | -0.0060\* | -0.0066\*\* | -0.0060\* | -0.0066\*\* | -0.0070\* | -0.0074\*\* | -0.0048 | -0.0054\* | -0.0042 | -0.0050 | -0.0049 | -0.0055\* |
|  | (-1.802) | (-2.270) | (-1.755) | (-2.210) | (-1.977) | (-2.414) | (-1.382) | (-1.770) | (-1.111) | (-1.522) | (-1.350) | (-1.737) |
| **Constant** | 0.5406\*\*\* | 0.4360\*\*\* | 0.6750\*\*\* | 0.5644\*\*\* | 0.4685\*\*\* | 0.3474\*\*\* | 0.5518\*\*\* | 0.4466\*\*\* | 0.4289\*\*\* | 0.2946\*\*\* | 0.4541\*\*\* | 0.3230\*\*\* |
|  | (7.829) | (6.099) | (8.267) | (6.340) | (6.315) | (4.890) | (7.692) | (5.816) | (6.508) | (4.510) | (6.335) | (4.712) |
| **Year Fixed Effects** | No  | Yes | No  | Yes | No  | Yes | No  | Yes | No  | Yes | No  | Yes |
| **Clustered SE** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Observations** | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 |
| **R-squared** | 0.123 | 0.413 | 0.126 | 0.413 | 0.112 | 0.402 | 0.120 | 0.410 | 0.100 | 0.387 | 0.104 | 0.392 |

**Table 7: Country Emissions and Volatility Regressions – VLT4**

This table provides the results of the following OLS regression:

$VLT\_{c,t}^{3}=β\_{o}+β\_{1}LN(EMISSIONS\_{c,t})+β\_{2}LN(PRICE\_{c,t})+β\_{3}TURNOVER\_{c,t}+β\_{4}LN(GDP\_{c,t})+β\_{5}LN(UNEMPLOYMENT\_{c,t})+β\_{6}LN(POPULATION\_{c,t})+δ\_{t}+ε$*i*

The LHS variable, $VLT\_{c,t}^{3}$, is the annualized realized Volatility of country i on time t based on absolute monthly returns. The main independent variable is$ LN(EMISSIONS\_{c,t})$ which is the natural log of each of the six EMISSIONS measures from World Bank Database: Total greenhouse gas emissions (kt of CO2 equivalent), Nitrous oxide emissions (thousand metric tons of CO2 equivalent), Methane emissions (kt of CO2 equivalent), CO2 emissions (kt), Agricultural methane emissions (thousand metric tons of CO2 equivalent), and Agricultural nitrous oxide emissions (thousand metric tons of CO2 equivalent). For remaining variable definitions, please refer to Table 1. Robust t-stats corresponding to standard errors clustered at the country level are reported in parenthesis. \*\*\*, \*\*, and \* reflect statistical significance at 0.01, 0.05, and 0.10 levels, respectively.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Model** | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | [11] | [12] |
|  |   |   |   |   |   |   |   |   |   |   |  |  |
| **lntotghg** | 0.0904\*\*\* | 0.0790\*\*\* |  |  |  |  |  |  |  |  |  |  |
|  | (4.480) | (3.678) |  |  |  |  |  |  |  |  |  |  |
| **lnno2ghg** |  |  | 0.1038\*\*\* | 0.0905\*\*\* |  |  |  |  |  |  |  |  |
|  |  |  | (5.247) | (4.137) |  |  |  |  |  |  |  |  |
| **lnmethghg** |  |  |  |  | 0.0494\*\*\* | 0.0421\*\* |  |  |  |  |  |  |
|  |  |  |  |  | (2.709) | (2.475) |  |  |  |  |  |  |
| **lnco2ghg** |  |  |  |  |  |  | 0.0917\*\*\* | 0.0793\*\*\* |  |  |  |  |
|  |  |  |  |  |  |  | (4.654) | (3.604) |  |  |  |  |
| **lnagmethghg** |  |  |  |  |  |  |  |  | 0.0241\*\* | 0.0166\* |  |  |
|  |  |  |  |  |  |  |  |  | (2.336) | (1.810) |  |  |
| **lnagrno2ghg** |  |  |  |  |  |  |  |  |  |  | 0.0337\*\* | 0.0257\* |
|  |  |  |  |  |  |  |  |  |  |  | (2.373) | (1.911) |
| **lnprice** | -0.0107 | 0.0049 | -0.0121 | 0.0030 | -0.0124 | 0.0052 | -0.0083 | 0.0070 | -0.0129 | 0.0059 | -0.0129 | 0.0055 |
|  | (-1.150) | (0.468) | (-1.237) | (0.268) | (-1.290) | (0.486) | (-0.868) | (0.640) | (-1.320) | (0.555) | (-1.296) | (0.511) |
| **lnstocksturnover** | 0.0559\*\*\* | 0.0250 | 0.0589\*\*\* | 0.0285\* | 0.0601\*\*\* | 0.0270 | 0.0554\*\*\* | 0.0247 | 0.0671\*\*\* | 0.0324\*\* | 0.0634\*\*\* | 0.0296\* |
|  | (2.962) | (1.421) | (3.338) | (1.773) | (2.963) | (1.443) | (3.162) | (1.504) | (3.692) | (2.046) | (3.401) | (1.799) |
| **lngdp** | -0.1302\*\*\* | -0.0984\*\*\* | -0.1447\*\*\* | -0.1118\*\*\* | -0.0936\*\*\* | -0.0636\*\*\* | -0.1328\*\*\* | -0.1000\*\*\* | -0.0776\*\*\* | -0.0462\*\*\* | -0.0837\*\*\* | -0.0524\*\*\* |
|  | (-6.203) | (-4.462) | (-7.438) | (-5.270) | (-4.354) | (-3.202) | (-6.603) | (-4.475) | (-5.034) | (-2.958) | (-4.609) | (-3.028) |
| **lnunemployment** | 0.0065 | -0.0012 | 0.0077 | -0.0001 | 0.0042 | -0.0042 | 0.0057 | -0.0020 | 0.0057 | -0.0038 | -0.0010 | -0.0087 |
|  | (0.278) | (-0.055) | (0.323) | (-0.004) | (0.176) | (-0.191) | (0.247) | (-0.090) | (0.245) | (-0.171) | (-0.044) | (-0.400) |
| **populationgrowth** | -0.0305\* | -0.0311\*\* | -0.0305\* | -0.0312\*\* | -0.0354\*\* | -0.0347\*\* | -0.0242 | -0.0256\* | -0.0211 | -0.0232 | -0.0249 | -0.0258\* |
|  | (-1.892) | (-2.158) | (-1.860) | (-2.146) | (-2.122) | (-2.365) | (-1.422) | (-1.680) | (-1.144) | (-1.465) | (-1.423) | (-1.693) |
| **Constant** | 2.8219\*\*\* | 2.1169\*\*\* | 3.5707\*\*\* | 2.7925\*\*\* | 2.4559\*\*\* | 1.7260\*\*\* | 2.8843\*\*\* | 2.1608\*\*\* | 2.2757\*\*\* | 1.5001\*\*\* | 2.3854\*\*\* | 1.6118\*\*\* |
|  | (8.269) | (5.467) | (8.928) | (6.155) | (6.312) | (4.370) | (8.301) | (5.321) | (6.816) | (4.172) | (6.447) | (4.273) |
| **Year Fixed Effects** | No  | Yes | No  | Yes | No  | Yes | No  | Yes | No  | Yes | No  | Yes |
| **Clustered SE** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Observations** | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 | 957 |
| **R-squared** | 0.155 | 0.444 | 0.164 | 0.449 | 0.139 | 0.433 | 0.150 | 0.440 | 0.126 | 0.418 | 0.128 | 0.422 |

**Table 4: ADR- Volatility Regressions – VLT1 and VLT2**

This table provides the results from the variations in estimation of the following OLS regression equation on a pooled sample of ADR-day observations.

$VLT\_{i,c,t}^{1,2}=β\_{o}+β\_{1}LN(EMISSIONS\_{c,t})+β\_{2}SPREAD\_{i,t}+β\_{3}TURNOVER\_{i,t}+β\_{4}LN(PRICE\_{i,t})+β\_{5}LN(SIZE\_{i,t})+β\_{6}NASDAQ\_{i}+β\_{7}LN(GDP\_{c,t})+β\_{8}LN(UNEMPLOYMENT\_{c,t})+β\_{9}LN(POPULATION\_{c,t})+δ\_{t}+ε$*i*

The dependent variable is VLT1 and VLT2 which is the Historical Standard deviation (VLT1) and the Conditional GARCH[1,1] Volatility of ADR i from country c on time t . The main independent variable is $LN(EMISSIONS\_{c,t}$) which is the natural log of each of the six EMISSIONS measures from World Bank Database.: For remaining variable definitions, please refer to Table 1 and Table 4.

|  |  |  |
| --- | --- | --- |
|  | **VLT1** | **VLT2** |
| **Model** | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | [11] | [12] |
|  |   |   |   |   |   |   |   |   |   |   |  |  |
| **lntotghg** | 0.0022\*\*\* |  |  |  |  |  | 0.0023\*\*\* |  |  |  |  |  |
|  | (6.598) |  |  |  |  |  | (5.389) |  |  |  |  |  |
| **lnno2ghg** |  | 0.0019\*\*\* |  |  |  |  |  | 0.0019\*\*\* |  |  |  |  |
|  |  | (4.947) |  |  |  |  |  | (3.972) |  |  |  |  |
| **lnmethghg** |  |  | 0.0018\*\*\* |  |  |  |  |  | 0.0018\*\*\* |  |  |  |
|  |  |  | (7.915) |  |  |  |  |  | (6.642) |  |  |  |
| **lnco2ghg** |  |  |  | 0.0020\*\*\* |  |  |  |  |  | 0.0021\*\*\* |  |  |
|  |  |  |  | (5.816) |  |  |  |  |  | (4.784) |  |  |
| **lnagmethghg** |  |  |  |  | 0.0013\*\*\* |  |  |  |  |  | 0.0013\*\*\* |  |
|  |  |  |  |  | (6.595) |  |  |  |  |  | (5.453) |  |
| **lnagrno2ghg** |  |  |  |  |  | 0.0015\*\*\* |  |  |  |  |  | 0.0017\*\*\* |
|  |  |  |  |  |  | (7.593) |  |  |  |  |  | (6.266) |
| **yearlyspread\_t** | 0.3820\*\*\* | 0.3807\*\*\* | 0.3756\*\*\* | 0.3835\*\*\* | 0.3724\*\*\* | 0.3755\*\*\* | 0.3204\*\*\* | 0.3190\*\*\* | 0.3138\*\*\* | 0.3219\*\*\* | 0.3104\*\*\* | 0.3136\*\*\* |
|  | (11.802) | (11.859) | (11.902) | (11.823) | (11.919) | (11.962) | (9.717) | (9.768) | (9.836) | (9.722) | (9.855) | (9.895) |
| **yearlyturnover\_t** | 0.2115\*\*\* | 0.2142\*\*\* | 0.2112\*\*\* | 0.2127\*\*\* | 0.2169\*\*\* | 0.2129\*\*\* | 0.1866\*\*\* | 0.1896\*\*\* | 0.1861\*\*\* | 0.1878\*\*\* | 0.1920\*\*\* | 0.1876\*\*\* |
|  | (11.364) | (11.435) | (11.313) | (11.424) | (11.509) | (11.406) | (10.596) | (10.681) | (10.523) | (10.670) | (10.743) | (10.587) |
| **lnprice** | -0.0051\*\*\* | -0.0052\*\*\* | -0.0050\*\*\* | -0.0052\*\*\* | -0.0051\*\*\* | -0.0051\*\*\* | -0.0053\*\*\* | -0.0054\*\*\* | -0.0052\*\*\* | -0.0054\*\*\* | -0.0053\*\*\* | -0.0052\*\*\* |
|  | (-15.382) | (-15.589) | (-15.314) | (-15.556) | (-15.628) | (-15.604) | (-14.834) | (-15.176) | (-14.726) | (-15.068) | (-15.248) | (-15.131) |
| **lnsize** | 0.0003\* | 0.0003\* | 0.0002 | 0.0004\*\* | 0.0002 | 0.0003 | -0.0001 | -0.0001 | -0.0002 | -0.0001 | -0.0003 | -0.0002 |
|  | (1.898) | (1.897) | (1.409) | (2.059) | (1.246) | (1.472) | (-0.677) | (-0.625) | (-1.173) | (-0.494) | (-1.311) | (-1.122) |
| **nasdaq** | 0.0046\*\*\* | 0.0048\*\*\* | 0.0048\*\*\* | 0.0045\*\*\* | 0.0051\*\*\* | 0.0049\*\*\* | 0.0061\*\*\* | 0.0062\*\*\* | 0.0063\*\*\* | 0.0060\*\*\* | 0.0066\*\*\* | 0.0064\*\*\* |
|  | (7.479) | (7.721) | (7.817) | (7.345) | (8.203) | (7.961) | (7.887) | (8.199) | (8.284) | (7.732) | (8.729) | (8.484) |
| **lngdp** | -0.0010\*\* | -0.0006 | -0.0005 | -0.0009\* | 0.0002 | -0.0002 | -0.0009\* | -0.0004 | -0.0003 | -0.0007 | 0.0004 | -0.0001 |
|  | (-2.376) | (-1.287) | (-1.424) | (-1.927) | (0.540) | (-0.786) | (-1.754) | (-0.688) | (-0.880) | (-1.352) | (1.113) | (-0.380) |
| **lnunemployment** | 0.0002 | 0.0001 | -0.0004 | 0.0004 | -0.0003 | -0.0005 | -0.0001 | -0.0002 | -0.0007 | 0.0001 | -0.0006 | -0.0009 |
|  | (0.347) | (0.111) | (-0.644) | (0.624) | (-0.502) | (-0.915) | (-0.115) | (-0.339) | (-1.121) | (0.166) | (-0.969) | (-1.421) |
| **populationgrowthannualsppopgrow** | -0.0001 | 0.0001 | -0.0010\* | 0.0002 | -0.0002 | -0.0007 | 0.0005 | 0.0008 | -0.0004 | 0.0009 | 0.0004 | -0.0001 |
|  | (-0.203) | (0.180) | (-1.846) | (0.331) | (-0.467) | (-1.361) | (0.859) | (1.193) | (-0.644) | (1.335) | (0.628) | (-0.242) |
| **Constant** | 0.0280\*\*\* | 0.0301\*\* | 0.0246\*\*\* | 0.0260\*\* | 0.0137 | 0.0229\*\* | 0.0327\*\*\* | 0.0340\*\*\* | 0.0301\*\*\* | 0.0306\*\*\* | 0.0187\*\* | 0.0293\*\*\* |
|  | (2.786) | (2.534) | (2.736) | (2.465) | (1.497) | (2.476) | (3.149) | (2.677) | (3.330) | (2.785) | (2.050) | (3.149) |
| **Year Fixed Effects** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Clustered SE** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Observations** | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 |
| **R-squared** | 0.630 | 0.625 | 0.632 | 0.628 | 0.628 | 0.631 | 0.628 | 0.622 | 0.631 | 0.625 | 0.627 | 0.630 |

**Table 4: ADR- Volatility Regressions – VLT3 and VLT4**

This table provides the results from the variations in estimation of the following OLS regression equation on a pooled sample of ADR-day observations.

$VLT\_{i,c,t}^{1,2}=β\_{o}+β\_{1}LN(EMISSIONS\_{c,t})+β\_{2}SPREAD\_{i,t}+β\_{3}TURNOVER\_{i,t}+β\_{4}LN(PRICE\_{i,t})+β\_{5}LN(SIZE\_{i,t})+β\_{6}NASDAQ\_{i}+β\_{7}LN(GDP\_{c,t})+β\_{8}LN(UNEMPLOYMENT\_{c,t})+β\_{9}LN(POPULATION\_{c,t})+δ\_{t}+ε$*i*

The dependent variable is VLT3 and VLT4 which is the realized volatility based on squared returns (VLT3) and the absolute returns (VLT3) of ADR i from country c on time t. The main independent variable is $LN(EMISSIONS\_{c,t}$) which is the natural log of each of the six EMISSIONS measures from World Bank Database. For remaining variable definitions, please refer to Table 1 and Table 4.

|  |  |  |
| --- | --- | --- |
|  | **VLT3** | **VLT4** |
| **Model** | [1] | [2] | [3] | [4] | [5] | [6] | [7] | [8] | [9] | [10] | [11] | [12] |
|  |   |   |   |   |   |   |   |   |   |   |  |  |
| **lntotghg** | 0.0027\*\*\* |  |  |  |  |  | 0.0053\*\*\* |  |  |  |  |  |
|  | (7.880) |  |  |  |  |  | (10.620) |  |  |  |  |  |
| **lnno2ghg** |  | 0.0024\*\*\* |  |  |  |  |  | 0.0050\*\*\* |  |  |  |  |
|  |  | (6.311) |  |  |  |  |  | (9.304) |  |  |  |  |
| **lnmethghg** |  |  | 0.0020\*\*\* |  |  |  |  |  | 0.0041\*\*\* |  |  |  |
|  |  |  | (8.895) |  |  |  |  |  | (12.741) |  |  |  |
| **lnco2ghg** |  |  |  | 0.0025\*\*\* |  |  |  |  |  | 0.0049\*\*\* |  |  |
|  |  |  |  | (7.188) |  |  |  |  |  | (9.642) |  |  |
| **lnagmethghg** |  |  |  |  | 0.0014\*\*\* |  |  |  |  |  | 0.0030\*\*\* |  |
|  |  |  |  |  | (7.281) |  |  |  |  |  | (10.495) |  |
| **lnagrno2ghg** |  |  |  |  |  | 0.0017\*\*\* |  |  |  |  |  | 0.0037\*\*\* |
|  |  |  |  |  |  | (8.457) |  |  |  |  |  | (12.499) |
| **yearlyspread\_t** | 0.3926\*\*\* | 0.3911\*\*\* | 0.3850\*\*\* | 0.3945\*\*\* | 0.3815\*\*\* | 0.3850\*\*\* | 0.5443\*\*\* | 0.5419\*\*\* | 0.5290\*\*\* | 0.5478\*\*\* | 0.5212\*\*\* | 0.5288\*\*\* |
|  | (11.888) | (11.946) | (12.046) | (11.905) | (12.093) | (12.130) | (17.883) | (17.402) | (16.673) | (17.980) | (15.726) | (16.258) |
| **yearlyturnover\_t** | 0.1793\*\*\* | 0.1820\*\*\* | 0.1799\*\*\* | 0.1803\*\*\* | 0.1862\*\*\* | 0.1818\*\*\* | 0.2648\*\*\* | 0.2690\*\*\* | 0.2644\*\*\* | 0.2672\*\*\* | 0.2775\*\*\* | 0.2681\*\*\* |
|  | (10.712) | (10.801) | (10.655) | (10.794) | (10.901) | (10.760) | (13.194) | (13.297) | (12.976) | (13.295) | (13.104) | (13.083) |
| **lnprice** | -0.0051\*\*\* | -0.0052\*\*\* | -0.0050\*\*\* | -0.0051\*\*\* | -0.0051\*\*\* | -0.0050\*\*\* | -0.0081\*\*\* | -0.0083\*\*\* | -0.0078\*\*\* | -0.0082\*\*\* | -0.0080\*\*\* | -0.0079\*\*\* |
|  | (-15.418) | (-15.674) | (-15.330) | (-15.625) | (-15.724) | (-15.664) | (-18.463) | (-18.977) | (-18.433) | (-18.772) | (-18.975) | (-18.902) |
| **lnsize** | -0.0000 | -0.0000 | -0.0001 | -0.0000 | -0.0002 | -0.0001 | 0.0017\*\*\* | 0.0017\*\*\* | 0.0014\*\*\* | 0.0017\*\*\* | 0.0014\*\*\* | 0.0015\*\*\* |
|  | (-0.272) | (-0.205) | (-0.859) | (-0.026) | (-1.014) | (-0.779) | (6.927) | (6.820) | (6.140) | (7.113) | (5.694) | (6.201) |
| **nasdaq** | 0.0052\*\*\* | 0.0054\*\*\* | 0.0054\*\*\* | 0.0051\*\*\* | 0.0057\*\*\* | 0.0055\*\*\* | 0.0089\*\*\* | 0.0093\*\*\* | 0.0093\*\*\* | 0.0087\*\*\* | 0.0100\*\*\* | 0.0096\*\*\* |
|  | (8.458) | (8.748) | (8.840) | (8.272) | (9.261) | (9.003) | (10.110) | (10.440) | (11.004) | (9.720) | (11.630) | (11.257) |
| **lngdp** | -0.0017\*\*\* | -0.0013\*\*\* | -0.0008\*\* | -0.0016\*\*\* | -0.0001 | -0.0006\* | -0.0046\*\*\* | -0.0042\*\*\* | -0.0031\*\*\* | -0.0044\*\*\* | -0.0018\*\*\* | -0.0027\*\*\* |
|  | (-3.861) | (-2.802) | (-2.528) | (-3.497) | (-0.371) | (-1.795) | (-7.418) | (-6.498) | (-6.924) | (-6.659) | (-4.007) | (-6.197) |
| **lnunemployment** | -0.0000 | -0.0002 | -0.0007 | 0.0002 | -0.0006 | -0.0009 | -0.0004 | -0.0007 | -0.0017\*\* | 0.0000 | -0.0016\*\* | -0.0021\*\*\* |
|  | (-0.079) | (-0.354) | (-1.134) | (0.262) | (-0.948) | (-1.375) | (-0.481) | (-0.912) | (-2.349) | (0.033) | (-2.035) | (-2.795) |
| **populationgrowthannualsppopgrow** | -0.0002 | -0.0000 | -0.0011\*\* | 0.0001 | -0.0003 | -0.0008 | 0.0010 | 0.0013\* | -0.0011 | 0.0017\*\* | 0.0007 | -0.0004 |
|  | (-0.402) | (-0.010) | (-2.089) | (0.212) | (-0.537) | (-1.524) | (1.389) | (1.776) | (-1.564) | (2.251) | (0.988) | (-0.645) |
| **Constant** | 0.0453\*\*\* | 0.0509\*\*\* | 0.0379\*\*\* | 0.0445\*\*\* | 0.0256\*\*\* | 0.0357\*\*\* | 0.0697\*\*\* | 0.0872\*\*\* | 0.0602\*\*\* | 0.0660\*\*\* | 0.0360\*\*\* | 0.0571\*\*\* |
|  | (4.623) | (4.381) | (4.254) | (4.372) | (2.811) | (3.878) | (5.105) | (5.585) | (5.010) | (4.612) | (2.909) | (4.688) |
| **Year Fixed Effects** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Clustered SE** | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| **Observations** | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 | 4,692 |
| **R-squared** | 0.640 | 0.634 | 0.641 | 0.638 | 0.636 | 0.640 | 0.684 | 0.674 | 0.691 | 0.678 | 0.681 | 0.688 |

1. <https://www.netzeroassetmanagers.org/>;

 <https://www.netzeroassetmanagers.org/media/2021/12/NZAM-Commitment.pdf> [↑](#footnote-ref-1)
2. International Monetary Fund. 2022.Climate Change Indicators Dashboard. <https://climatedata.imf.org/pages/access-data>. Accessed on [2022-12-03].<https://climatedata.imf.org/pages/re-indicators> [↑](#footnote-ref-2)
3. <https://www.unpri.org/pri-blog/financial-markets-are-mispricing-climate-risk/5135.article> [↑](#footnote-ref-3)
4. Giglio et al. (2021) present a detailed review about literature exploring the relationships between climate change and financial markets. [↑](#footnote-ref-4)