Global Assessment of Banks' Capacity to Support the Energy Transition

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Abstract

Substantial investments in renewable energy technology are needed to achieve sustainable development goals, reduce reliance on fossil fuels, and ensure access to clean and stable energy. However, securing funding for these initiatives is challenging, relying heavily on extensive financial support from banks. In response to this challenge, this article establishes a relationship between market-based default risk measures, such as Distance-to-Default (DD) and Distance-to-Capital (DC), and the proportion of renewable energy in a country's total energy supply. We collected data from a sample of 1,373 international banks across 27 countries from 2009 to 2022, using an ordinary linear fixed-effect model. After reviewing the literature, we categorized the study into two homogeneous sub-panels based on income group classification (developed or emerging countries). Overall, our results indicate that as countries accelerate their transition towards renewable energy sources, there is a correlated decrease in the likelihood of bank defaults. We observe a decline in bank vulnerability as nations with high CO_2 emissions embrace diversified energy matrices. Additionally, factors such as economic growth and bank size play pivotal roles in determining default risk. These trends remain consistent when examining developed countries. However, our findings also highlight a contrasting scenario in emerging economies, where the energy transition is associated with heightened risk for banks. To ensure the robustness of our findings, we conducted several tests, all of which validated our results. In conclusion, our study underscores the crucial role of a banking system in facilitating investments in renewable energy.

Keywords: Renewable Energy, Bank Risk, Developing Countries, Panel data
JEL codes: G10, G21, G28, Q01, Q43

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1 Introduction

The energy transition is a comprehensive change, motivated by factors beyond sustainability. With the increase in the concentration of greenhouse gases in the atmosphere reaching unprecedented levels, there is a global consensus on the need for a drastic reduction. Projections, such as the reference scenario for 2050, shed light on this urgency. If we follow our current trajectory without significant changes, energy-related CO2 emissions are expected to increase 6% - from 32 Gt in 2020 to 37 Gt in 2050 (Gielen et al., 2019). This direction contrasts sharply with the required 2.5% annual decline in energy-related CO2 emissions to align with global targets to mitigate climate change and its worst impacts (Jiang et al., 2023). For a sustainable path, the energy transition must prioritize the rapid deployment of renewable energy sources, improving energy efficiency in all sectors and advancing innovations in green technologies (Hassan et al., 2024).

Addressing this challenge necessitates substantial investments, which demand backing from financial institutions. To meet the sustainable development scenario, it's estimated that annual global investments in renewable energy will need to surge by 97 percent compared to current levels (Energy, 2018). Thus, banks are expected to play a key part in assisting a country's shift to renewable energy and strengthening its financial resilience to environmental risks (Mazzucato and Semieniuk, 2018). Nevertheless, high exposure of the banking sector to renewable energy could cause concern for their survival, which may hinder their active engagement in this sector (Safarzyńska and van den Bergh, 2017a). Unless this fear of default is addressed, the required financial participation of banks in renewable energy will hardly reach the required level.

This study evaluates panel data of listed banks and the share of renewable energy (REN) in the total energy supply of 27 countries from 2009 to 2022. Our results show a significant positive relationship between REN and two measures of bank-specific credit risk (i.e., distance to default [DD] and distance to capital [DC]). Our results align with the literature, showing that increasing REN significantly reduces banks' default risk. However, this study further tests the risks banks face in emerging and developing countries, finding that while the risk of default is decreasing for banks in developed countries, it is increasing for those in emerging countries. These results remain consistent with a large number of robustness tests, including using alternative measurements of renewable investment, using alternative proxies of bank-specific credit risk, breaking down the sample between more and less polluting countries, controlling for bank, country, and year fixed effects, excluding the global crisis during Covid-19, and using alternative estimation techniques (i.e., GMM regression, propensity score matching).

Our work is closely related to the research by Choudhury et al. (2021) and Nadeem et al. (2017) that considered an analysis of bank risk worldwide using the DD and DC measures. However, our paper is different from theirs in four important aspects. First, we expand the sample to capture the nuances of global economic factors associated with REN in managing risk. Second, our findings explored the role of emerging countries in REN and bank risk, highlighting that merely increasing investment in renewable sources in underdeveloped countries does not provide robust evidence of risk reduction. Third, we rely on different proxies and more robust measures to capture investment in renewables (i.e., the share of low carbon in the total primary energy supply and public investment) and to capture country-level fluctuations regarding gross domestic product (GDP) and population growth. Fourth, in contrast to them, we assessed Pearson's correlation to select the best World Bank indicator among the countries.

Our findings contribute to both REN and risk management literature. This study contributes to calls for sectorial-focused studies by investigating REN's growth role in banking's risk of default. It further provides an excursion to prior literature that heavily focused on renewable energy technologies in the non-financial sector. Our paper also contributes to the inconclusive debate over emerging countries and firm risk. Finally, although investment in renewable energy in emerging countries is linked with lower technology costs, evidence concerning how REN affects a bank's outcome is limited.

The rest of the paper is organized as follows. Section 2 reviews the literature and outlines the research hypotheses to be examined. Section 3 delves into the methodology, covering the measurement of variables, model estimation, and data analysis procedures. In Section 4, several robustness tests are outlined. Section 5 concludes the study by discussing the results and their implications for policy.

2 Theoretical rationale and hypothesis development

2.1 Renewable Energy Investments

Policy developments, increased environmental awareness, and the urgent need to address climate change have significantly transformed the history of investment in renewable energy in recent decades. The global increase in investments in renewable energy sources – such as solar, wind, hydro, and biomass – reflects a collective movement towards sustainable development and reducing carbon emissions. The role of government policies and incentives in defining investments in renewable energy and the implications for the risk environment of the banking sector becomes fundamental.

Commitment to renewable energy has historically been spurred by recognition of the finite nature of fossil fuels and the environmental consequences of their consumption. The oil crises of the 1970s served as a warning, leading to initial explorations of alternative energy sources. However, it was only at the end of the 20th century and the beginning of the 21st century that significant political changes and technological advances began a more pronounced transition to renewable energy. Countries worldwide have begun implementing policies designed to promote the adoption of renewable energy, ranging from subsidies and tax incentives to mandates for the use of renewable energy (Cui et al., 2018).

The impact of government rules and benefits is vital in guiding investments in renewable energy and adjusting the risk versus reward scenario. Government-backed strategies such as feed-in tariffs, renewable energy portfolio standards and tax incentives amplify the appeal of investing in green energy initiatives, ensuring stable profits and decreasing financial risks. By offsetting the higher initial costs and mitigating the perceived risks of renewable energy projects, these policies encourage banks and other financial institutions to allocate capital to these ventures (Gatzert and Kosub, 2016).

Political stability, technological advances, market demand for renewable energy and the global economic climate are some of the many factors that influence the risk environment for banks when considering investments in renewable energy. Particularly political and regulatory risks are very worrying, as political changes can have enormous effects on the viability of renewable energy projects. The introduction of supportive policies can mitigate these risks, while political uncertainty can exacerbate them, making risk management a critical analysis for banks involved in renewable energy financing (Hulshof and Mulder, 2020).

Aligning financial returns with positive environmental impacts provides a unique opportunity for banks to engage in sustainable financing through this shift to renewable energy. The literature highlights cases where green loans have not only reduced credit risk but also improved banks' environmental and financial performance, as seen in the case of China's Green Credit Policy (Cui et al., 2018).

However, the inherent risks associated with renewable energy investments, such as technological risks, market competition and dependence on subsidies, require a cautious approach, emphasizing the need for comprehensive risk assessment and innovative financing models (Safarzyńska and van den Bergh, 2017a).

2.2 Banks' role

Renewable energy projects require a substantial initial investment. Banks and other financial institutions are crucial in bridging this funding gap through a variety of financial instruments and models. For example, green bonds and loans have emerged as essential tools, allowing investors to get involved in environmentally sustainable projects. The positive correlation between green loans and reduced credit risk highlights the dual benefit of such instruments in promoting environmental sustainability and financial performance. Cui et al. (2018) examined China's Green Credit Policy, concluding that green loans carry lower credit risk than non-green loans, thereby improving banks' environmental and financial performance. This positive correlation between green loans and the reduction in non-performing loan ratios suggests that institutional pressures can effectively mitigate financial risks while promoting environmental sustainability.

However, renewable energy sources' volatile nature and dependence on fluctuating market prices present significant risks. Energy markets are inherently unstable due to variable demand, regulatory changes, and fluctuations in fuel prices, directly impacting the profitability and risk profile of renewable energy investments. Gatzert and Kosub (2016) investigate the political and regulatory uncertainties that exacerbate these risks, requiring innovative risk management and transfer solutions to promote sustainable growth. They highlight how political and regulatory risks present major barriers to investments in renewable energy in Europe, a sentiment shared by Abba et al. (2022) in the context of developing countries, particularly in Sub-Saharan Africa. These studies illustrate that regardless of economic development, uncertainty and variability in political and regulatory frameworks are universal challenges that require innovative risk management and financing solutions.

Additionally, the challenges of renewable energy projects – from technological reliability to issues of maintenance and network integration – pose additional risks that can interfere with the financial health of the banks involved. These operational risks are intrinsically linked to the financial performance of renewable energy projects, affecting loan repayment rates and, by extension, credit risk for banks. Such challenges highlight the need for comprehensive risk assessments and mitigation strategies to safeguard financial stability (Safarzyńska and van den Bergh, 2017a).

Diversity and innovation are necessary to face these challenges through different renewable energy financing models. Public-private partnerships, for example, have been fundamental in mobilizing public funds to attract private investment, thus sharing the risk and increasing the viability of renewable projects. Furthermore, the role of government policies, such as feed-in tariffs and tax incentives, in stabilizing the renewable energy market cannot be overstated. Taghizadeh-Hesary and Yoshino (2020) argue for leveraging public financial institutions and financial instruments, such as indirect taxes and green credit guarantee schemes, to increase the attractiveness of investment in renewable energy projects. Mazzucato and Semieniuk (2018) discuss how public financial actors in developed countries are more willing to invest in higher-risk renewable energy technologies, contributing to the directionality of innovation in the sector. This willingness to embrace risk for the sake of innovation contrasts with the situation in many developing countries, where investments often focus on more established renewable technologies due to greater sensitivity to risk and limited financial resources for speculative ventures.

The banking sector's involvement in renewable energy financing is not only aimed at mitigating risks but also taking advantage of the opportunities that the global shift towards sustainability presents. Innovative financing solutions, effective risk management strategies, and a stable policy environment are needed. Banks can play a transformative role in this transition if equipped with the right tools and strategies, aligning financial objectives with environmental sustainability.

2.3 Renewable Energy and Banking Risks

The relationship between renewable energy investments and banking risks has received significant attention in academic and financial circles, especially considering the global push towards sustainable development. Empirical analyses exploring this relationship have produced diverse results, reflecting the complex interaction of economic, environmental, and regulatory factors that influence the risk profile of the banking sector.

The methodologies used in these studies ranged from quantitative analyses of loan performance and risk metrics to qualitative assessments of policy impacts on banking stability. For example, the Analytical Hierarchy Process was used by Zhou and Yang

(2020) to classify investment risks in distributed wind energy, highlighting the importance of stable electricity pricing policies in mitigating risks. These methodologies reveal the complex nature of assessing banking risks related to renewable energy, encompassing not only financial metrics but also political and regulatory environments.

The variation in results between different countries and regions can be largely attributed to economic, environmental and regulatory peculiarities. Both developed and developing countries face significant policy and regulatory risks, which impact the financing of renewable energy projects. For example, in BRICS countries, Zeng et al. (2017) identified specific challenges, including financing constraints and investment shortages for small and medium-sized enterprises, which are less prevalent in developed economies. Developed countries, as highlighted by Safarzyńska and van den Bergh (2017a), face financial stability risks arising from rapid investments in renewable energy, reflecting the complex integration of renewable energy into existing financial and energy systems. This contrast highlights the significant impact of regional peculiarities on the relationship between investments in renewable energy and banking risks.

Existing studies, although extremely valuable, are limited by their regional focus, given the different market characteristics, technological trends, and regulatory policies of each region. This study aims to contribute to those studies by carrying out an analysis of the returns and possible risks associated with investing in green energy and to make a more comprehensive analysis, across developed and emerging countries, of the impacts of renewable energy investments on the banking sector across different economic contexts.

2.4 Hypothesis

We postulate our first hypothesis in line with the resource dependence theory and acknowledge energy source differences in decision-making.

> H_1: Expansion in the share of renewable energy in the total energy supply of a country decreases the likelihood of banks facing defaults.

The underlying assumption that supports Hypothesis 1 (H_1) is the positive relationship between renewable energy and firm profitability. According to the model proposed by Safarzyńska and van den Bergh (2017b), an increase in profitability tends to increase the likelihood of a company honoring a bank loan, thus reducing the risk of default for the bank. On the other hand, if the company chooses to purchase renewable energy from external sources instead of producing it internally, its improved profitability can increase the likelihood of paying off energy-related expenses, thus benefiting the supplying power plants. Consequently, these plants will be in a more favorable position to honor their obligations to the bank, helping reduce the risk of default. In any case, promoting renewable energy financing has the potential to help banks mitigate their risk of default.

However, scholars also asserted that the governments of many developing countries have taken measures to commit and ensure a reduction of carbon emissions, emphasizing the transformation to renewable energy as a key strategy (Zeng et al., 2017; Amendolagine et al., 2019; Wang et al., 2022). Nonetheless, despite these efforts, the financial constraints prevailing in many of these countries are sometimes an almost impossible challenge. In this case, private sector engagement is a necessity rather than an option, as this sector can facilitate and aid in renewable energy investment with strong benefits for the country and non-government businesses. But, as Unep (2007, 2004) highlights, developing countries use public and concessional resources to attain the aid of the private sector, even though this does not fully address the different challenges or risks that the private sector experiences. On the other hand, Cicea et al. (2014) points out that the use of these instruments to engage the private sector has the dual benefit of being more sustainable and minimizing the instability that this could bring to the industry; while augmenting the competitiveness of the renewable energy market. Therefore, we postulate a second hypothesis (H_2) to fill this literature gap:

> H_2: The relationship between the share of renewable energy in a country's total energy supply and bank-specific credit risk will be more pronounced in developed countries than in emerging countries.

3 Data and methodology

3.1 Data

We collected renewable energy data from the International Energy Agency (IEA) for 2009–2022. We started in 2009 when IEA started its coverage. Following this, we collected information on bank financial characteristics from Eikon Thomson Reuters. We used Bloomberg to capture the countries' risk-free rate to calculate the bank-specific credit risk (i.e., the processes mentioned in section 3.2; DD and DC). Data on world governance indicators, gross domestic product, and population were obtained from the World Bank website. Merging all data yielded a final sample of 1,373 bank-year observations across 27 countries. The list with the number of banks by country used in our analysis is demonstrated in Table 1.

<Insert Table 1 around here.>

3.2 Variable definitions

3.2.1 Dependent variables

We capture bank-specific credit risk using different distance to risk-based models. The literature identifies two categories of default risk indicators: accounting-based and market-based. Accounting-based measures include Z-score, nonperforming assets ratio, profitability ratio, and leverage ratio, while market-based measures include the Kealhofer Merton Vasicek (KMV) DD, equity returns, equity volatility, and market capitalization to total debt. Merton (1974) first introduced DD in his seminal work, referring to the distance between the bank's given position and default position where default is a position in which the bank's asset value goes under the liability value threshold (Milne, 2014). Later studies extended the same model by introducing DC (Ji et al., 2019). DC shows the capital buffer drilled before reaching the default (Harada and Ito, 2011).

Although accounting-based measures have been extensively studied regarding financial stability and their relationship with market competition, there is limited literature on market-based measures like DD (Khan and Ahmad, 2022). Market-based measures offer advantages over accounting-based measures by incorporating forward-looking information from the stock market, reflecting market perceptions of a bank's performance (Denzler et al., 2006; Nadeem et al., 2017; Kabir and Worthington, 2017). This paper adopts the DD and DC measures to calculate bank-specific credit risk.

Theoretically, DD refers to a position where a firm's market value of assets A_t is less than its value of liability L_t (Dar and Qadir, 2019). Eq. (1) presents the DD_t at time t ($t \epsilon [0, T]$):

$$DD_t = -\frac{ln(L_t) - [ln(A_t) + (\mu - 0.5\sigma_A^2) \cdot (T - t)]}{\sigma_A \sqrt{T - t}} \quad (1)$$

where parameter μ is the expected drift in the asset A_t, modelled by the risk-free return, and σ_A is the asset volatility.

The DC is an alternative credit risk measure rooted in the credit risk structural model. It uses the prompt corrective action (PCA) and Basel framework's capital adequacy ratio (CAR) to fine-tune DD, where CAR$_t$ is at least 8%. DC_t is presented in Eq. (2):

$$DC_t = \left[ln\left(\frac{A_t}{\frac{1}{1-CAR_t} Lt} \right) + (\mu - 0.5\sigma_A^2)T \right] \left(\sigma_A \sqrt{T} \right)^{-1} \quad (2)$$

3.2.2 Explanatory variables

Data on the share of renewable energy in a country's total primary energy supply (REN) were sourced from the official International Energy Agency website. Although we acknowledge the possible heterogeneous effect of bank's default risk on the disaggregated renewable energy sources (such as solar and wind), our study focuses on the total renewable energy as a share of the total energy supply due to data limitation for the countries and the time period considered in this study. Data on the Share of Renewable Energy in the Total Primary Energy Supply (LCREN) and Public Investment Trends in Renewables (PIREN) were sourced from this same Agency.

In this paper, we use five variables related to bank performance from Eikon Thomson Reuters to estimate the relationship between bank default and the proportion of renewable energy in a country's supply. These are the return on equity (ROE or bank profitability) (Trad et al., 2017), the size of the bank (natural logarithm of total assets), the leverage of the company (debt ratio) (Capasso et al., 2020), the market value (i.e., the price-to-book ratio PB ratio) (Switzer et al., 2018), and revenue growth (Stiroh, 2006).

Regarding control variables used, Omri and Nguyen (2014) have studied the determinants of renewable energy consumption. They find GDP to affect renewable energy consumption but show heterogeneous results across the different income groups. In this paper, GDP growth serves as a measure of output. Population growth is included as a control variable as it has been proven to significantly affect energy use (Li and Lin, 2015; Amuakwa-Mensah and Näsström, 2022). Some variables in the data contain missing values making the panel unbalanced. Data on renewable energy and other macroeconomic variables are collected from the World Bank's World Development Indicator (WDI).

3.2.3 Regression Model

We use the following regression model to examine the effect of an increase in renewable energy proportion in a country's primary energy supply on bank-specific credit risk:

$$CR_{i,t} = \alpha + \varphi REN_{i,t} + \gamma' C_{i,t} + \varepsilon_{i,t} \tag{3}$$

where i represents the bank, and t represents the time (i.e., year). The dependent variable $CR_{i,t}$ is one of the bank-specific credit risk variables (DD_t and DC_t) defined in Eqs. (1) to (2). $REN_{i,t}$ represents the main independent variable of interest (i.e., REN). The vector $C_{i,t}$ represents a comprehensive set of k control variables; α is a constant, and

φ and γ are the estimated coefficients for the $REN_{i,t}$ and k control variables, respectively; $\varepsilon_{i,t}$ is the residual of the model. Since bank risk varies across different banks and over time, we included bank and year-fixed effects in all our regressions, except when mentioned otherwise.

As pooled OLS regression estimates the model assuming the underlaying relationship as static, its results could be invalid if the actual relationship among the variables is found to be dynamic. To test the nature of the relationship between REN and DD, we estimated the dynamic model (Eq. 4) using OLS regression after controlling the same bank-specific and country-specific variables.

$$CR_{i,t} = \alpha + \beta CR_{i,t-1} + \varphi REN_{i,t} + \gamma^{'} C_{i,t} + \varepsilon_{i,t} \tag{4}$$

Lagged estimator ($CR_{i,t-1}$) was added in the regression model to test the dynamic nature of the model (Nadeem et al., 2017).

4 Empirical Analysis

4.1 Descriptive statistics

We present the descriptive statistics in Table 2, followed by the Pearson correlation matrix for all the variables in our study in Table 3.

<Insert Tables 2 and 3 around here.>

In order to further limit the influence of outliers, we winsorize bank-control variables in the model at the 5th and 95th percentiles. That is, we replace any observation below the 5th percentile with the 5th percentile and any observation above the 95th percentile with the 95th percentile.

In addition, we used a formal test to ensure that the multicollinearity problem was adequately addressed. We calculated the variance inflation factor (VIF) for each independent variable in our models. The largest VIF values are 1.87 and 1.91, which confirms that there is no multicollinearity problem in our sample because it is far from 5 (Studenmund and Cassidy, 1997).

4.2 Baseline results

First, we tested the Breusch and Pagan Lagrangian multiplier test for random effects for both dependent variables used in the main model specification (DD and DC), and the null hypothesis that variances across entities are zero was rejected (DD: LM = 31229.49, $p < 0.001$; DC: LM = 8610.47, $p < 0.001$), so the random effect model can deal with heterogeneity better than pooled OLS. Then, we estimated the Hausman test to select the appropriate estimation method. Rejecting the null hypothesis ($p < 0.00$, for both dependent variables) results in the most appropriate method being fixed effects. We also use robust standard errors in our estimations in order to ensure that the covariance estimator handles heteroscedasticity of unknown form.

The results obtained from Eq. (4) appear in Table 4, which summarizes the empirical results for our main bank-specific credit risk measures, distance to default risk (DD), and distance to capital risk (DC).

<Insert Table 4 around here.>

In full estimation, we found a positive and statistically significant 1% level relation between DD and the share of renewable energy in the total energy supply of a country. The same result was found for DC and REN. In other words, countries that expand investments in renewable energy reduce banks' default risk by increasing DD and DC, thus confirming the H1 hypothesis proposed in this study and corroborating with previous literature (Choudhury et al., 2021).

Additionally, we split up the sample in developed and emerging countries to test the hypotheses H2 and present the estimated results in Table 5. For developed countries, we find the same results: the REN coefficient is positive and significant, which implies that ceteris-paribus, more investment in renewable energy, reduces the chances of default of that bank. On the other hand, this effect is negative and significant for emerging countries. This result is probably due to the fact that banks in emerging markets perceive higher risks associated with financing renewable energy projects, leading to a reluctance to extend credit or invest in this sector.

<Insert Table 5 around here.>

5 Robustness

We performed several tests to confirm the robustness of our baseline findings, such as: matching, alternative explanation variables, covid-19, CO_2 emission and the generalized method of moment (GMM).

We use Mahalanobis distance matching (MDM) and propensity score matching (PSM) to match banks from developed countries to banks of emerging countries on several covariates. In the end, we had a sample of 4,034 observations, 2,562 from developed countries, and 1472 from emerging countries. Figure 1 shows the balancing of the sample among the covariates: bank Size, leverage, profitability, market value, and revenue growth. Table 6 shows the results that reproduce our main findings and confirm our hypotheses H2, thus lending credibility to our results.

<Insert Figure 1 and Table 6 around here.>

To explain the impact of the Covid-19 pandemic on banks' credit risk, we estimate the main model, which includes periods before and after the mentioned pandemic. In our sample, the pre-pandemic period is between 2017-2019, and the post-pandemic period is

2020-2022. We follow the same estimation pattern of Eq. 4 with a full sample model as shown in Table 7. The coefficients of the REN are positive and significant at the 1% level, which corroborates the main findings.

<Insert Table 7 around here.>

For the analysis of countries with different levels of CO_2 emissions, our results indicate a significant and positive relationship between the financial stability of banks and the adoption of renewable energies in countries belonging to the fourth quantile. Government policies and regulations promoting environmental sustainability can drive the transition to renewable energy. These policies can include financial incentives for clean energy projects, such as subsidies, tax exemptions, and renewable energy targets. By supporting the adoption of renewable energy, these policies can contribute to the financial stability of banks by reducing the risk associated with energy investments.

<Insert Table 8 around here.>

We estimate our models using the two-step generalized method of moments (GMM) estimator based on Arellano and Bond (1991), allowing us to control for endogeneity using instruments. Specifically, we have used all the right-hand-side variables in the models, lagged up to four times, as instruments in the difference equations[1]. The results in Table 9 portray that the REN is positive and significant for both credit risk measures, DD and DC, thus confirming our main findings in Hypotheses H1.

<Insert Table 9 around here.>

Although renewable energies are generally considered more sustainable and environmentally friendly, the term "low carbon" can cover a broader range of energy sources that, although not renewable, have relatively low carbon emissions. As the relationship

[1]We need to define the number of lags because an extensive instrument collection overfits endogenous variables even as it weakens the Hansen test of the instruments' joint validity (Roodman, 2009).

between “share of low carbon” (LCREN) and DD was similar but less strong than the relationship initially observed with REN (see Table 10), this indicates that banks are responding more positively to renewable energies than to other low-carbon energy sources. A similar result can be seen for emerging and developed economies.

An increase in public investment in renewable energy (PIREN) could indicate a stronger commitment on the part of the government to the energy transition. This could lead banks globally to perceive that there is a favorable environment for growth and sustainability in the renewable energy sectors, which could increase confidence in the economy and, by extension, reduce banks' perceived risk of default. However, financial resources can be limited in emerging countries and allocated less efficiently. A significant increase in investments in renewable energies can lead to competition for these resources, thus reducing the availability of credit for other sectors of the economy. This can negatively affect the ability of companies and individuals to honor their financial commitments, increasing the risk of bank defaults.

<Insert Table 10 around here.>

5.1 Implications

Based on our results, renewable energy generation, globally and for the two income groups, is significantly related with most banking performance variables. We have summarised our results from Tables 4 to 9 in Table 11 for DD and Table **??** for DC to ease comparative discussion on the effects of banking performance indicators on renewable energy generation.

<Insert Table 11 around here.>

These results have significant implications for understanding the factors influencing bank default risk in different economic contexts. The relationship between REN and bank default risk varies between developed and emerging countries. While REN reduces the risk of default in developed countries, in emerging countries, it increases the risk. This suggests that transitioning to renewable energies may benefit banks in more mature economies, where economic and regulatory conditions may favor sustainable investments. Financial factors such as bank size, bank leverage, bank profitability, revenue growth, and GDP growth generally reduce bank default risk in all the contexts analyzed. This suggests that banking institutions' financial health, operating performance, and economic growth are key to determining default risk.

6 Discussion and Conclusion

Renewable energy forms a large part of the energy mix for power generation in many countries. Global efforts to combat climate change are forcing companies to prioritize the reduction of carbon emissions through adopting renewable energy sources, making financing renewable energy a vital necessity. Renewable energy targets have been set in more than 164 nations (Philip et al., 2022), but developing countries face substantial challenges in transitioning to renewable sources. These include financing, knowledge management, legal framework and implementation, as well as the need for political leadership and transparency.

This document focuses on economic understanding, highlighting the challenges faced by banks in developed and emerging countries in intensifying renewable energy participation in the energy matrix. Limited resources in developing countries often force these nations to persist with outdated financial methods and tools. As many developed countries increase their financial support efforts, a better understanding of the economic implications will empower policymakers and decision-makers. This understanding is key to maximizing the benefits of renewable energy deployment.

Developed countries have strengthened investor confidence by setting reliable and time-sensitive renewable energy targets. These targets chart the course of renewable energy development in today's energy sector and provide a roadmap for future financing tools.

Recognizing that policy implementation alone may not be enough, developing countries often take a multi-pronged approach to ensure a stable investment environment and help address non-economic barriers, such as social and environmental concerns.

One of the biggest challenges that new financial trends face in developing countries is the perception of risk due to the inaccurate and sometimes misleading knowledge that some developing countries have regarding the cost and generation of renewable energy and the decisions based on policymakers (Mazzucato and Semieniuk, 2018). This is due to a lack of government transparency and methodology and reliable data, resources, and assumptions used to make cost calculations. Developing countries find themselves at a crossroads regarding investments in the clean technology sector. Therefore, securing funding for projects from local or international sources can be a key step in creating and growing the renewable energy sector.

Creating a favorable investment environment is key to overcoming financing barriers and attracting investors, with most new investments coming from private sources. Policymakers and international financial institutions must employ appropriate policy and fiscal tools to stimulate private sector investment, while public funding remains a significant catalyst and must be increased. Ultimately, an analysis of financing mechanisms adapted to the specific circumstances of each country is needed, as there is no one-size-fits-all approach. Furthermore, it is essential to recognize that financial tools alone cannot drive a country's transition to renewable energy; a collaborative effort involving government, industry, the population, various sectors, business plans, technology, education, and resources is needed.

6.1 Conclusion

This research investigated the association between bank performance and the share of renewable energy in total primary energy supply, focusing on balance sheet financial performance indicators (i.e., return on assets, bank size, bank leverage, market value, and revenue growth) and economic indicators (i.e., GDP growth and population). We focused on a global panel dataset of 27 countries and considered the classification by income group of the countries. We applied the fixed-effect OLS technique to account for the potential serial correlation associated with our panel model.

We observed that switching to renewable sources reduces banks' risk of default. This result was interpreted through Safarzyńska and van den Bergh (2017a), which argued that when banks release money to the corporate sector to invest in renewable energy, this increases the profitability of the borrowing companies and the likelihood that they will repay the bank loans. Investing in renewable energy allows companies to align their business goals with stakeholder interests, which increases the company's social acceptance (Dowling and Pfeffer, 1975) and, in turn, allows it to obtain premium prices for its products, thereby increasing profitability (Miles and Covin, 2000).

By dividing the data set into two income categories (developed and emerging countries), we detected some differences between the categories in the role that renewable energy generation plays in the banking sector's default risk. The results for developed panels largely followed the same pattern, while the results for emerging countries stood out in this study. According to our results, the increase in renewable generation significantly and positively affects bank default risk in developing countries. The share of renewable energy generation in developing countries is increased by a high return on assets, an increase in bank size, and financial stability.

We compared our results with Amuakwa-Mensah and Näsström (2022), who investigated how the banking sector's health – measured through indicators such as return on assets, bank size, and financial stability – facilitates or hinders renewable energy consumption. The authors claimed that a robust banking sector significantly strengthens the capacity to consume renewable energy, channeling the necessary financial resources towards sustainable projects. This statement reinforces the critical role of financial institutions in the transition to a more sustainable energy mix. Their article concluded that improved banking sector performance is associated with increased renewable energy consumption globally. However, visible differences between income groups suggest the need for specific policy guidance based on a country's income class to stimulate growth in renewable energy consumption.

Our research results revealed a significant reduction in bank default risk associated with the increase in the share of renewable energy in developed countries, attributed to positive impacts such as the increase in the size of banks and the reduction of CO_2 emissions. On the contrary, the aforementioned study observed an inverse relationship in emerging countries, highlighting the increased risk of default for banks, which represents a complex challenge for financing renewable energy in these regions.

The variation between developed and emerging nations revealed in both studies illustrates how the economic advancement and regulatory frameworks of the respective countries shape the influence of renewable energy investments in the banking sector. In nations with well-established financial systems, collaboration between renewable energy investments and banking sector stability promotes a welcoming environment for innovative and sustainable investments. This beneficial cycle increases environmental sustainability and reinforces financial health, initiating a constructive spiral of investment in renewable energy. On the other hand, the scenario in emerging countries tells a different story. Despite the critical need for renewable energy to achieve sustainable development objectives, the high risk of bank default reflects these regions' profound financial and economic difficulties. Elements such as underdeveloped financial markets, greater political and economic uncertainties, and less advantageous regulatory environments contribute to this increased risk, necessitating specific measures to cultivate a more favorable atmosphere for financing renewable energy projects.

The effect of renewable energy generation on banking risk across income groups pointed to an important direction for targeted policies based on countries' income class, with the aim of stimulating growth in renewable energy generation. While we were cautious about interpreting our results for the global sample, our results supported the argument that the banking sector plays an important role in renewable energy generation. As more data becomes available in the future, the research could be extended to re-examine the effect of banking performance on the various types of renewable energy, such as solar, wind, hydro, and biomass, focusing on various countries, especially non-OECD countries. This is because the different sources require varying investment sizes and have different associated risk levels.

References

Abba, Z., Balta-Ozkan, N., and Hart, P. (2022). A holistic risk management framework for renewable energy investments. *Renewable and Sustainable Energy Reviews*, 160:112305.

Amendolagine, V., Presbitero, A. F., Rabellotti, R., and Sanfilippo, M. (2019). Local sourcing in developing countries: The role of foreign direct investments and global value chains. *World Development*, 113:73–88.

Amuakwa-Mensah, F. and Näsström, E. (2022). Role of banking sector performance in renewable energy consumption. *Applied Energy*, 306:118023.

Arellano, M. and Bond, S. (1991). Some tests of specification for panel data: Monte carlo evidence and an application to employment equations. *The review of economic studies*, 58(2):277–297.

Capasso, G., Gianfrate, G., and Spinelli, M. (2020). Climate change and credit risk. *Journal of Cleaner Production*, 266:121634.

Choudhury, T., Kamran, M., Djajadikerta, H. G., and Sarker, T. (2021). Can banks sustain the growth in renewable energy supply? an international evidence. *The European Journal of Development Research*, pages 1–31.

Cicea, C., Marinescu, C., Popa, I., and Dobrin, C. (2014). Environmental efficiency of investments in renewable energy: Comparative analysis at macroeconomic level. *Renewable and Sustainable Energy Reviews*, 30:555–564.

Cui, Y., Geobey, S., Weber, O., and Lin, H. (2018). The impact of green lending on credit risk in china. *Sustainability*, 10(6):2008.

Dar, A. A. and Qadir, S. (2019). Distance to default and probability of default: an experimental study. *Journal of Global Entrepreneurship Research*, 9(1):1–12.

Denzler, S. M., Dacorogna, M. M., Müller, U. A., and McNeil, A. J. (2006). From default probabilities to credit spreads: Credit risk models do explain market prices. *Finance Research Letters*, 3(2):79–95.

Dowling, J. and Pfeffer, J. (1975). Organizational legitimacy: Social values and organizational behavior. *Pacific sociological review*, 18(1):122–136.

Energy, I. G. (2018). Co2 status report 2017. international energy agency. 2017c.

Gatzert, N. and Kosub, T. (2016). Risks and risk management of renewable energy projects: The case of onshore and offshore wind parks. *Renewable and Sustainable Energy Reviews*, 60:982–998.

Gielen, D., Gorini, R., Wagner, N., Leme, R., Gutierrez, L., Prakash, G., Asmelash, E., Janeiro, L., Gallina, G., Vale, G., et al. (2019). Global energy transformation: a roadmap to 2050.

Harada, K. and Ito, T. (2011). Did mergers help japanese mega-banks avoid failure? analysis of the distance to default of banks. *Journal of the Japanese and International Economies*, 25(1):1–22.

Hassan, Q., Viktor, P., Al-Musawi, T. J., Ali, B. M., Algburi, S., Alzoubi, H. M., Al-Jiboory, A. K., Sameen, A. Z., Salman, H. M., and Jaszczur, M. (2024). The renewable energy role in the global energy transformations. *Renewable Energy Focus*, 48:100545.

Hulshof, D. and Mulder, M. (2020). The impact of renewable energy use on firm profit. *Energy economics*, 92:104957.

Ji, G., Kim, D. S., and Ahn, K. (2019). Financial structure and systemic risk of banks: Evidence from chinese reform. *Sustainability*, 11(13):3721.

Jiang, J., Ye, B., Sun, Z., Zeng, Z., and Yang, X. (2023). Low-carbon energy policies benefit climate change mitigation and air pollutant reduction in megacities: An empirical examination of shenzhen, china. *Science of The Total Environment*, 892:164644.

Kabir, M. N. and Worthington, A. C. (2017). The 'competition–stability/fragility'nexus: A comparative analysis of islamic and conventional banks. *International Review of Financial Analysis*, 50:111–128.

Khan, M. A. and Ahmad, W. (2022). Fresh evidence on the relationship between market power and default risk of indian banks. *Finance Research Letters*, 46:102360.

Li, K. and Lin, B. (2015). Impacts of urbanization and industrialization on energy consumption/co2 emissions: does the level of development matter? *Renewable and Sustainable Energy Reviews*, 52:1107–1122.

Mazzucato, M. and Semieniuk, G. (2018). Financing renewable energy: Who is financing what and why it matters. *Technological Forecasting and Social Change*, 127:8–22.

Merton, R. C. (1974). On the pricing of corporate debt: The risk structure of interest rates. *The Journal of finance*, 29(2):449–470.

Miles, M. P. and Covin, J. G. (2000). Environmental marketing: A source of reputational, competitive, and financial advantage. *Journal of business ethics*, 23:299–311.

Milne, A. (2014). Distance to default and the financial crisis. *Journal of financial stability*, 12:26–36.

Nadeem, M., Zaman, R., and Saleem, I. (2017). Boardroom gender diversity and corporate sustainability practices: Evidence from australian securities exchange listed firms. *Journal of Cleaner Production*, 149:874–885.

Omri, A. and Nguyen, D. K. (2014). On the determinants of renewable energy consumption: International evidence. *Energy*, 72:554–560.

Philip, L. D., Emir, F., and Udemba, E. N. (2022). Investigating possibility of achieving sustainable development goals through renewable energy, technological innovation, and entrepreneur: a study of global best practice policies. *Environmental Science and Pollution Research*, 29(40):60302–60313.

Roodman, D. (2009). A note on the theme of too many instruments. *Oxford Bulletin of Economics and statistics*, 71(1):135–158.

Safarzyńska, K. and van den Bergh, J. C. (2017a). Financial stability at risk due to investing rapidly in renewable energy. *Energy Policy*, 108:12–20.

Safarzyńska, K. and van den Bergh, J. C. (2017b). Integrated crisis-energy policy: Macro-evolutionary modelling of technology, finance and energy interactions. *Technological Forecasting and Social Change*, 114:119–137.

Stiroh, K. J. (2006). New evidence on the determinants of bank risk. *Journal of Financial Services Research*, 30:237–263.

Studenmund, A. and Cassidy, H. (1997). Multicollinearity. In *Using Econometrics: A Practical Guide*, pages 274–277. Addison-Wesley, Boston, Mass.

Switzer, L. N., Tu, Q., and Wang, J. (2018). Corporate governance and default risk in financial firms over the post-financial crisis period: International evidence. *Journal of International Financial Markets, Institutions and Money*, 52:196–210.

Taghizadeh-Hesary, F. and Yoshino, N. (2020). Sustainable solutions for green financing and investment in renewable energy projects. *Energies*, 13(4):788.

Trad, N., Trabelsi, M. A., and Goux, J. F. (2017). Risk and profitability of islamic banks: a religious deception or an alternative solution? *European Research on Management and Business Economics*, 23(1):40–45.

Unep, E. p. (2004). Financial risk management instruments for renewable energy projects. https://energy-base.org/app/uploads/2020/03/1.SEFI-Financial-Risk-Management-Instruments-for-Renewable-Energy-Projects-2004.pdf. Accessed: 2024-03-15.

Unep, E. p. (2007). Global trends in sustainable energy investment 2007: analysis of trends and issues in the financing of renewable energy and energy efficiency in oecd and developing countries. https://wedocs.unep.org/handle/20.500.11822/7958. Accessed: 2024-03-15.

Wang, S., Wang, X., and Chen, S. (2022). Global value chains and carbon emission reduction in developing countries: does industrial upgrading matter? *Environmental Impact Assessment Review*, 97:106895.

Zeng, S., Liu, Y., Liu, C., and Nan, X. (2017). A review of renewable energy investment in the brics countries: History, models, problems and solutions. *Renewable and Sustainable Energy Reviews*, 74:860–872.

Zhou, S. and Yang, P. (2020). Risk management in distributed wind energy implementing analytic hierarchy process. *Renewable Energy*, 150:616–623.

A Figures and Tables

Table 1: List of countries and banks in the final sample.

Country	Number of banks	Number of observations
Argentina	6	41
Australia	35	282
Austria	8	81
Brazil	20	236
Canada	29	279
Chile	8	92
China	96	660
Denmark	15	176
Finland	6	57
France	19	218
Germany	13	132
Greece	5	52
India	186	1664
Indonesia	59	534
Italy	20	203
Japan	103	1129
Korea	29	265
Mexico	9	99
Netherlands	4	34
New Zealand	5	39
Norway	40	353
Spain	6	66
Sweden	12	92
Switzerland	18	212
Thailand	37	112
Turkey	18	199
United States of America	567	5410
Total	1,373	12,717

Table 2: Summary statistics.

Variable	Obs	Mean	Std. Dev.	Min	Max
Dependent variables					
DD	12717	79.65	52.27	-7.19	196.92
DC	12717	26.73	31.74	-2.9	108.51
Independent variables					
REN	12717	0.13	0.13	0.01	0.72
LCEN	12717	0.19	0.14	0.04	0.74
PIREN	8383	0.39	0.27	0	1
Control variables					
Bank size	12717	21.79	2.72	15.12	26.27
Bank leverage	12717	1.52	1.67	0.01	6.21
Bank profitability	12717	0.08	0.08	-0.14	0.26
Market value	12717	1.4	1.32	0.1	6.09
Revenue growth	12717	0.85	2.12	-4.96	3.43
GDP growth	12717	2.62	3.09	-11.17	11.74
Population	12717	0.62	0.46	-1.85	2.25
CO_2 emission	12448	3493.01	2852.87	27.92	11969.25
Gov. effectiveness	12717	53.53	23.34	0.59	99.52

Figure 1: Bias reduction due to Propensity Score Matching.

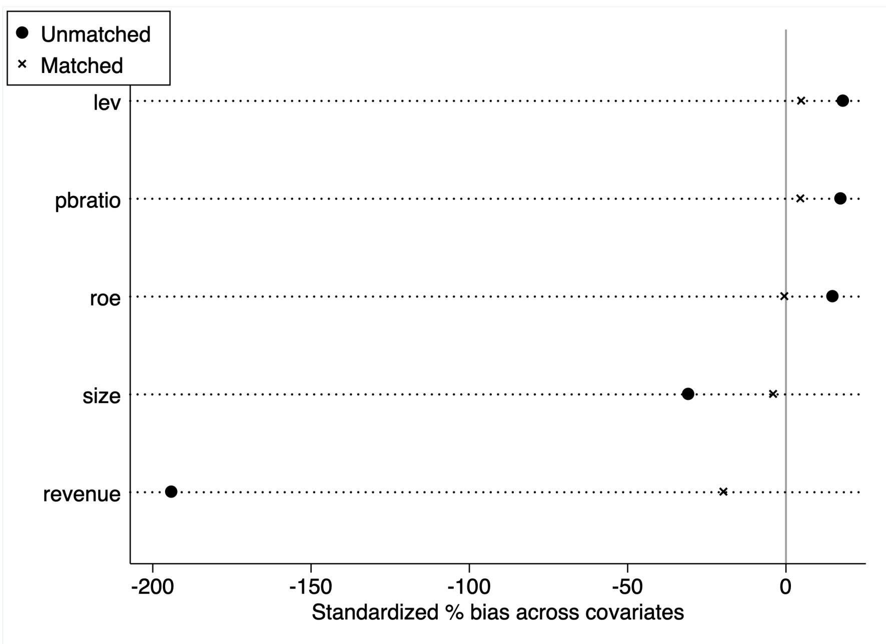

Table 3: Cross-correlation table.

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.
1. DD													
2. DC	0.352												
3. REN	0.112	0.030											
4. LCREN	0.149	-0.059	0.893										
5. PIREN	-0.077	0.151	0.016	-0.084									
6. Bank size	0.364	0.022	0.091	0.120	-0.072								
7. Bank leverage	0.006	0.050	0.219	0.159	0.088	0.260							
8. Bank profitability	0.154	0.157	0.049	0.044	-0.048	0.228	0.123						
9. Market value	-0.125	0.010	-0.106	-0.102	-0.043	-0.195	0.011	0.183					
10. Revenue	0.286	-0.186	0.091	0.280	-0.184	0.422	0.063	0.183	-0.126				
11. GDP growth	-0.079	0.250	-0.114	-0.186	0.139	-0.123	0.015	0.084	0.049	-0.324			
12. Population	-0.148	0.193	0.102	0.057	0.132	-0.269	0.098	0.089	0.178	-0.309	0.158		
13. CO_2 emission	0.137	-0.094	-0.322	-0.235	-0.075	0.010	-0.164	0.071	-0.006	0.104	0.157	-0.103	
14. Gov. effectiveness	0.258	-0.382	0.329	0.425	-0.214	0.231	0.065	-0.057	-0.114	0.542	-0.395	-0.320	-0.170

Table 4: Results of estimation main model.

	DD	DC
REN	25.87***	54.48***
	(4.458)	(13.24)
Bank size	0.937***	0.0431
	(0.215)	(0.593)
Bank leverage	0.290***	1.087***
	(0.0750)	(0.246)
Bank profitability	5.549***	20.75***
	(0.932)	(2.793)
Market value	-0.0400	0.233
	(0.0715)	(0.194)
Revenue growth	0.553***	2.184***
	(0.130)	(0.418)
GDP growth	0.369***	1.225***
	(0.0181)	(0.0591)
Population	-0.320	-0.508
	(0.328)	(1.031)
Gov. effectiveness	-0.194***	-0.665***
	(0.0222)	(0.0646)
DD_{t-1}	0.235***	
	(0.0459)	
DC_{t-1}		0.167***
		(0.0348)
Constant	43.37***	40.96**
	(6.262)	(15.05)
Observations	12717	12717
R^2	0.185	0.139
Bank FE	Yes	Yes

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 5: Results of estimation: divide sample in developed and emerging countries.

	DD		DC	
	Emergent	Developed	Emergent	Developed
REN	-62.96***	45.36***	-313.7***	151.2***
	(11.81)	(5.209)	(26.18)	(18.13)
Bank size	-0.935*	1.081**	-4.032***	-0.135
	(0.471)	(0.335)	(0.969)	(0.861)
Bank leverage	0.520***	0.333***	1.145***	1.426***
	(0.130)	(0.0984)	(0.332)	(0.326)
Bank profitability	3.941*	4.597***	15.26***	15.90***
	(1.771)	(1.078)	(3.663)	(3.653)
Market value	-0.418***	0.250*	-0.514*	0.782**
	(0.113)	(0.0973)	(0.216)	(0.281)
Revenue growth	0.0799	1.185***	0.0626	4.709***
	(0.192)	(0.184)	(0.532)	(0.582)
GDP growth	0.230***	0.372***	0.691***	1.274***
	(0.0262)	(0.0306)	(0.0563)	(0.119)
Population	-3.257**	-0.350	-11.69***	-1.504
	(1.227)	(0.390)	(2.767)	(1.316)
Gov. effectiveness	0.0186	-0.187***	-0.282***	-0.554***
	(0.0472)	(0.0252)	(0.0520)	(0.0742)
DD_{t-1}	0.169**	0.239***		
	(0.0611)	(0.0266)		
DC_{t-1}			0.0861*	0.204***
			(0.0339)	(0.0218)
Constant	76.18***	43.32***	175.0***	19.68
	(11.55)	(8.812)	(22.69)	(21.92)
Observations	3637	9080	3637	9080
R^2	0.144	0.241	0.343	0.151
Bank FE	Yes	Yes	Yes	Yes

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6: Results of estimation: Mahalanobis and propensity score matching.

	DD		DC	
	Emergent	Developed	Emergent	Developed
REN	-57.16***	26.41**	-307.7***	113.2***
	(16.60)	(8.549)	(31.85)	(33.62)
Gov. effectiveness	0.0495	-0.275***	-0.319***	-0.742***
	(0.0540)	(0.0379)	(0.0581)	(0.130)
GDP growth	0.235***	0.448***	0.754***	1.670***
	(0.0328)	(0.0603)	(0.0645)	(0.224)
Population	-1.623	2.209***	-7.598*	9.669***
	(1.504)	(0.619)	(3.154)	(2.265)
DD_{t-1}	0.203*	0.300**		
	(0.0879)	(0.0926)		
DC_{t-1}			0.128**	0.385***
			(0.0452)	(0.0692)
Constant	50.46***	59.93***	89.46***	35.10**
	(7.858)	(9.314)	(6.753)	(12.89)
Observations	2562	1472	2562	1472
R^2	0.123	0.178	0.317	0.173
Bank FE	Yes	Yes	Yes	Yes

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7: Results of estimation: Covid period.

	DD	DC
REN	129.2***	498.9***
	(11.10)	(40.11)
POST COVID	-3.508***	-15.82***
	(0.307)	(1.024)
REN * POST COVID	3.752***	9.587***
	(0.849)	(2.470)
Bank size	1.944***	2.366*
	(0.420)	(1.087)
Bank leverage	0.624***	2.939***
	(0.125)	(0.399)
Bank profitability	4.839***	22.58***
	(1.458)	(4.226)
Market value	0.167	0.301
	(0.0911)	(0.283)
Revenue growth	0.575**	1.061
	(0.195)	(0.625)
GDP growth	0.263***	0.820***
	(0.0216)	(0.0790)
Population	-0.312	1.374
	(0.439)	(1.519)
Gov. effectiveness	-0.0232	-0.202**
	(0.0302)	(0.0636)
DD_{t-1}	0.00513	
	(0.0158)	
DC_{t-1}		-0.0659***
		(0.0188)
Constant	19.62*	-85.48***
	(9.169)	(24.71)
Observations	7475	7475
R^2	0.084	0.091
Bank FE	Yes	Yes

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 8: Results of estimation: CO_2 emission.

	DD		DC	
	Q1	Q4	Q1	Q4
REN	6.250	61.01***	-27.48	196.9***
	(5.651)	(17.94)	(15.29)	(40.81)
Bank size	0.350	1.177***	0.542	0.946*
	(0.347)	(0.347)	(0.910)	(0.447)
Bank leverage	0.342*	-0.178	0.700	0.0803
	(0.140)	(0.0979)	(0.382)	(0.257)
Bank profitability	-0.924	3.342**	7.385	3.000
	(2.399)	(1.064)	(5.602)	(1.660)
Market value	-0.488*	0.535***	-0.375	1.028***
	(0.196)	(0.106)	(0.341)	(0.240)
Revenue growth	0.540*	0.172	1.417*	0.674
	(0.257)	(0.275)	(0.707)	(0.392)
GDP growth	0.483***	0.413***	1.714***	0.823***
	(0.0455)	(0.0509)	(0.141)	(0.122)
Population	1.754**	1.395	10.98***	-5.419
	(0.604)	(1.645)	(1.971)	(4.479)
Gov. effectiveness	0.00331	-0.202***	-0.146*	0.0964
	(0.0220)	(0.0544)	(0.0613)	(0.0755)
DD_{t-1}	0.258*	0.901***		
	(0.109)	(0.114)		
DC_{t-1}			0.192**	1.378***
			(0.0668)	(0.0595)
Constant	41.27**	-22.54*	13.32	-49.25***
	(12.49)	(9.082)	(20.75)	(8.755)
Observations	2963	2668	2963	2668
R^2	0.121	0.817	0.186	0.919
Bank FE	Yes	Yes	Yes	Yes

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 9: Results of estimation: GMM dynamic panel estimator.

	DD	DC
REN	34.79**	34.95***
	(10.70)	(5.441)
Bank size	3.671***	1.259*
	(0.912)	(0.566)
Bank leverage	-4.604***	0.477
	(0.928)	(0.663)
Bank profitability	31.90***	47.36***
	(9.635)	(6.487)
Market value	-1.985**	-0.430
	(0.752)	(0.442)
Revenue growth	2.511**	-0.914
	(0.811)	(0.489)
GDP growth	0.600***	0.969***
	(0.124)	(0.0909)
Population	-1.311	2.972*
	(2.182)	(1.216)
Gov. effectiveness	0.265***	-0.476***
	(0.0652)	(0.0388)
Constant	-19.25	11.09
	(19.23)	(12.19)
Observations	13928	13928
Number of banks	1512	1512
Hansen test p-value	0.127	0.850

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 10: Results of estimation: alternative measure of independent variable.

	DD	DC	DD	DC
Panel A: full sample				
LCREN	14.07***	12.86		
	(3.691)	(11.50)		
PIREN			1.828***	6.772***
			(0.165)	(0.704)
Observations	12717	12717	8383	8383
R^2	0.182	0.137	0.379	0.439
Panel B: emergent countries				
LCREN	-58.99***	-274.8***		
	(9.778)	(23.24)		
PIREN			-0.521*	0.0706
			(0.209)	(0.872)
Observations	3637	3637	2028	2028
R^2	0.144	0.332	0.360	0.445
Panel C: developed countries				
LCREN	31.31***	93.06***		
	(3.990)	(13.34)		
PIREN			2.060***	8.116***
			(0.190)	(0.756)
Observations	9080	9080	6355	6355
R^2	0.233	0.142	0.480	0.558

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 11: Summary of DD and DC results for all panels.

Panel A: DD results								
Table	4	5.1	6.1	5.2	6.2	7	8	9
REN	✓ +	✓ -	✓ -	✓ +	✓ +	✓ +	✓ +	✓ +
Bank size	✓ +	✓ -		✓ +		✓ +	✓ +	✓ +
Bank leverage	✓ +	✓ +		✓ +		✓ +		✓ -
Bank profitability	✓ +	✓ +		✓ +		✓ +	✓ +	✓ +
Market value		✓ -		✓ +			✓ +	✓ -
Rev. growth	✓ +			✓ +		✓ +		✓ +
GDP growth	✓ +	✓ +	✓ +	✓ +	✓ +	✓ +	✓ +	✓ +
Population		✓ -			✓ +			
Gov. effect.	✓ -			✓ -	✓ -		✓ -	✓ +
Panel B: DC results								
Table	4	5.1	6.1	5.2	6.2	7	8	9
REN	✓ +	✓ -	✓ -	✓ +	✓ +	✓ +	✓ +	✓ +
Bank size		✓ -				✓ +	✓ +	✓ +
Bank leverage	✓ +	✓ +		✓ +		✓ +		
Bank profitability	✓ +	✓ +		✓ +		✓ +		✓ +
Market value		✓ -		✓ +			✓ +	
Rev. growth	✓ +			✓ +				
GDP growth	✓ +	✓ +	✓ +	✓ +	✓ +	✓ +	✓ +	✓ +
Population		✓ -	✓ -		✓ +			✓ +
Gov. effect.	✓ -	✓ -	✓ -	✓ -	✓ -	✓ -		✓ -

✓ Denotes statistical significance. $(-)/(+)$ denotes the sign (negative or positive) of the effect of potential determinants on the renewable energy generation.