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A DECADE OF RENEWABLE ENERGY FUNDING: UNVEILING PATTERNS AND INFLUENCES IN ASIA'S TRANSITION

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Abstract:

Aim: To analyse the variations in financial contributions to renewable energy projects across Asia from 2009 to 2020, focusing on the influence of donor type, country, and renewable energy technology category.
Approach: Secondary data sourced from the OECD Credit Report System (CRS) Database was utilized, employing statistical methods such as ANOVA and Kruskal-Wallis tests to examine financial contributions categorized by country, donor type, and technology.
Results: Significant differences were identified in financial contributions based on country, with larger economies like India and Pakistan receiving higher investments. The type of donor also had a notable impact, with multilateral donors contributing more. Additionally, technologies like solar, wind, and bioenergy attracted more funding compared to others.
Implications: The findings underscore the importance of targeted funding strategies, emphasizing the need for customized policies to attract investments in renewable energy based on regional, donor, and technological factors.
Value Addition: The paper contributes to understanding how funding patterns vary by country and technology, providing recommendations for optimizing future investments in Asia's renewable energy sector.

Key Words: Renewable Energy, Asia, Financial Contributions, Donor Type, Solar, Wind, ANOVA, Kruskal-Wallis.

INTRODUCTION:

The global transition to renewable energy is one of the most critical challenges of our time, requiring concerted efforts from all sectors of society. With an increasing emphasis on sustainability, climate change mitigation, and energy security, countries across the world are making significant investments in renewable energy projects (Almutairi & Alhamed, 2025). In Asia, a region that is home to over half of the world's population, the shift towards renewable energy is especially crucial due to its rapid industrialization, large-scale energy needs, and vulnerability to the impacts of climate change (Aqeeq et al., 2023). This shift has prompted numerous investments and donations towards renewable energy projects, with various actors involved in funding, including national governments, international organizations, private corporations, and non-governmental entities. Despite the growing attention to renewable energy in Asia, the financial contributions to these projects are not evenly distributed (Lam & Law, 2018).

The variations across countries, types of donors, and technological categories provide rich insights into the dynamics of energy funding in the region. Countries such as China and India, which have relatively large economies and a growing demand for energy, often receive substantial financial support. In contrast, smaller nations with limited resources may struggle to secure the necessary funding for renewable energy projects. Furthermore, the type of donor—whether government or private sector—can significantly influence the amount of funding provided and the nature of the projects that are supported. Additionally, the technological categories of renewable energy projects, ranging from solar energy to wind and bioenergy, may attract varying levels of financial backing depending on the perceived feasibility, cost, and environmental impact of each technology. Understanding these variations is essential for policymakers, donors, and researchers alike to optimize resource allocation and identify patterns that can drive future investments in the renewable energy sector (Erdiwansyah et al., 2021). Furthermore, it can provide valuable information on the effectiveness of different funding models and how these contribute to achieving sustainable energy goals in Asia. This paper seeks to contribute to this important area of study by analysing the financial contributions made to renewable energy projects across various

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countries in Asia from 2009 to 2020(Peimani, 2019). Using data sourced from the OECD Credit Report System (CRS) Database, this study examines the financial contributions categorized by donor, project type, technology, and country. The analysis will explore how these factors influence the funding amounts and distribution, shedding light on the trends and patterns that have emerged over the past decade. The dataset used in this study includes information on financial contributions measured in U.S. dollars, adjusted to 2020 USD for consistency across years. The contributions are categorized by donorbioenergy) (ateral, multilateral, or private sector), project type (e.g., renewable energy projects versus non-renewable projects), and the type of renewable energy technology being used (e.g., solar, wind, bioenergy)(Eberhart et al., 2025).

The time frame from 2009 to 2020 provides a comprehensive look at how the renewable energy funding landscape has evolved over time, particularly in response to global and regional energy demands and policy shifts. The study will utilize various statistical methods, including Analysis of Variance (ANOVA) and Kruskal-Wallis tests, to identify significant differences in financial contributions based on the country, donor, and technology categories(Annamalai & Jain, 2013). The financial support for renewable energy projects is influenced by multiple factors, and the variations across countries, donors, and technologies must be carefully examined to understand how funding decisions are made and what impacts they have on the adoption and implementation of renewable energy projects. For example, countries that have made stronger commitments to environmental sustainability or have established renewable energy policies might attract more international funding, while those with weaker institutional frameworks may struggle to secure the same levels of investment. The type of donor also plays a crucial role, as governmental bodies, multilateral organizations, and private investors may have different incentives, priorities, and strategies when contributing to renewable energy projects.

Furthermore, the technological category can significantly influence funding levels, with some technologies, such as solar, attracting more investment due to their lower implementation costs and faster deployment times, while others may struggle to attract the same level of support (Woerter et al., 2017). The primary objective of this paper is to investigate the financial contributions made to renewable energy projects across various countries in Asia, focusing on the differences in contributions based on country, donor type, and technology category. By examining data spanning from 2009 to 2020, the study aims to uncover the patterns and relationships between these factors and the financial support provided to renewable energy projects. The paper seeks to test the hypotheses that financial contributions vary significantly across countries, that the type of donor influences the amount of funding, and that technological categories of renewable energy projects are positively correlated with financial contributions. Through this analysis, the objective is to provide valuable insights into the dynamics of renewable energy funding in Asia and offer recommendations for optimizing future investments in the sector.

LITERATURE REVIEW:

The literature review begins by discussing the current state of renewable energy investments, highlighting the growing need for sustainable energy sources and the existing gaps in investment, particularly in developing economies (Ragosa & Warren, 2019). Development financing institutions play a key role in overcoming system-level constraints to enhance renewable energy transformations (Xu & Gallagher, 2022). Project financing of renewable energy projects in developing countries is a challenging task, exacerbated by the geopolitical, economic, and regulatory risks present in these regions (Eze, 2010). The review also focuses on the role of governmental and institutional factors in encouraging and hindering the transition to renewable energy sources, noting that developed countries are generally leading in renewable energy technology research due to policy investments (Bhattarai et al., 2022). The literature review also explores the factors influencing renewable energy investments, such as policy support and economic growth, by presenting recent studies in these areas, including the use of sophisticated econometric methods like panel quantile regression and dynamic seemingly unrelated regression. Several studies have examined the relationship between economic growth and renewable energy diffusion, emphasizing the critical roles of institutional quality, good governance, and financial development in accelerating the clean energy transition (Saadaoui, 2021). Renewable energy is proven to have a positive impact on economic growth and job creation, which can help to mitigate soaring inflation rates (Woollacott et al., 2023). However, it also notes that carbon lock-in is pervasive and

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regulatory practices are often copy-pasted from the fossil fuel sector to the renewables sector, indicating systemic barriers to renewable energy investment in some regions (Vakulchuk et al., 2022). The literature review also considers the economic and financial factors influencing renewable energy investments, with a focus on the impact of macroeconomic indicators on investment decisions. Portfolio optimization is a quantitative strategy employed to strategically select assets to achieve a balance between expected returns and risk (Botero et al., 2024). One study used an innovative mean-variance portfolio optimization model to assess wind repowering techniques (Botero et al., 2024). They used the model to maximize the net present value, while simultaneously considering various constraints such as budget limitations, risk factors, and operational constraints (Botero et al., 2024).

This study addresses the gap in understanding the variations in financial contributions to renewable energy projects across Asia. It focuses on how these contributions differ by country, donor type, and renewable energy technology. The objectives are to investigate the impact of country, donor type, and technology category on funding levels. The study tests three hypotheses: 1) financial contributions vary significantly across countries, 2) donor type influences funding amounts, and 3) technology category correlates positively with funding. Statistical tests like ANOVA and Kruskal-Wallis will be used to analyze these relationships.

METHODOLOGY:

This study investigates the financial contributions made to renewable energy projects across various countries in Asia, focusing on the variations based on country, donor type, and technology categories (Azhgaliyeva et al., 2021). The dataset encompasses financial contributions made from the year 2009 through 2020, sourced from the OECD Credit Report System (CRS) Database. It includes data on project amounts in U.S. dollars (converted to 2020 USD), categorized by donor, project type, technology, and country/area(Gribble et al., 2021). The primary objective of this research is to explore key relationships between the financial contributions and different project attributes, with a special focus on the differences observed across countries, donor types, and technology categories(Halimanjaya & Papyrakis, 2015). Three hypotheses are tested to understand how these variables influence financial contributions to renewable energy projects.

VARIABLES USED IN THE STUDY:

The study uses key variables to analyse financial contributions to renewable energy projects in Asia(Wang et al., 2021). The Country variable is categorical, representing the project location, and helps compare contributions across countries. The Donor variable identifies the source of funding (e.g., Japan, European Union) and explores donor-based differences in contributions. The Technology variable categorizes the technology type used (e.g., "Solar," "Multiple renewables") to assess its impact on financial contributions. The Amount (2020 USD million) is the continuous dependent variable, representing the financial contribution adjusted to 2020 USD. The Year variable, ranging from 2009 to 2020, provides temporal context for the data. Lastly, the Region variable, though secondary, indicates the geographical region of the country (e.g., Asia). These variables form the basis for exploring financial contributions in the study**.**

HYPOTHESES:

Based on the analysis objectives, the following hypotheses are formulated for testing:

1. The financial contributions to renewable energy projects differ significantly across countries in Asia.
2. The amount of financial contribution is influenced by the type of donor, with certain donor types consistently contributing more to renewable energy projects.
3. The number of financial contributions to renewable energy projects is positively correlated with the technological category of the project

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STATISTICAL TEST:

To test the hypotheses, different statistical tests are employed, depending on the nature of the data and the relationships being examined. These tests provide insights into how financial contributions are associated with different country, donor, and technology categories.

Hypothesis 1: Country-wise Differences in Financial Contributions

- **Statistical Test**: **Analysis of Variance (ANOVA)**
- **Test Objective**: To determine if the mean financial contributions differ significantly across countries in Asia.
- **Notation**:
  Let Y_{ijk} represent the financial contribution (in 2020 USD) for project *k* in country *i* during year *i*. The null hypothesis for the test is:

$$H_0: \mu_1 = \mu_2 = \cdots = \mu_c$$

where μ_i is the mean financial contribution in country *i*, and *c* is the total number of countries in the dataset.

One-way ANOVA will be applied to test for differences in mean financial contributions across countries.

$$F = \frac{\frac{1}{k-1}\sum_{i=1}^{k} n_i(\bar{Y}_i - \bar{Y})^2}{\frac{1}{N-k}\sum_{i=1}^{k}\sum_{j=1}^{n_i}(Y_{ij} - \bar{Y}_i)^2}$$

Where Y_{ij} are the observations, $\bar{Y}_i$ is the mean of group i, $\bar{Y}$ is the overall mean, ni is the number of observations in group i, k is the number of groups, and N is the total number of observations.

Hypothesis 2: *Influence of Donor Type on Financial Contributions*

- **Statistical Test**: **Analysis of Variance (ANOVA)**
- **Test Objective**: To assess whether the financial contributions differ based on the type of donor while controlling for other potential confounders.

Hypothesis 3: Correlation Between Financial Contribution and Technological Category

- **Statistical Test**: **Kruskal-Wallis Test (Non-parametric ANOVA)**
- **Test Objective**: To test if the financial contributions differ across different technological categories (e.g., "Multiple renewables," "Solar") based on the project type.
- **Notation**:
  Let Y_i represent the financial contribution for project *i* in technology category T_j, where T_j could be different types of renewable energy technologies.

  H_0: The distributions of financial contributions are the same across technology

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Kruskal-Wallis test will be applied to compare the distributions of financial contributions across multiple technology categories.

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{n_i(\bar{R}_i - \bar{R})^2}{\sum_{i=1}^{k} n_i}$$

Where, *N* is the total number of observations, k is the number of groups, n_i is the number of observations in the ii-th group, $\bar{R}_i$ is the average rank of the i-th group and $\bar{R}$ is the overall average rank.

RESULTS AND DISCUSSION:

TABLE 1:
Country-Wise Descriptive Statistics for Amount (2020 USD Million) Grants for Renewal and Non-Renewable Projects from 2009-2020

Country/ Statistics	***Mean***	***Standard Deviation***	***Coefficient of Variation (CV)***	***Range***	***Max***	***Min***	***CAGR***
Afghanistan	5.4903	17.8192	3.2456	187.4428	187.4435	0.0008	-0.0251
Bangladesh	54.6987	188.5214	3.4465	2084.8110	2084.8110	0.0000	-0.0283
Bhutan	5.1826	13.4079	2.5871	72.4564	72.4566	0.0002	-0.0796
Cambodia	30.5265	175.0145	5.7332	1663.5488	1663.5507	0.0020	-0.0448
China	12.8037	40.5058	3.1636	583.1177	583.1177	0.0000	-0.0040
Republic of Korea	5.4597	24.4722	4.4824	125.3509	125.3510	0.0002	0.0451
India	42.6548	278.0978	6.5197	6752.9788	6752.9788	0.0000	-0.0082
Indonesia	57.7888	172.5464	2.9858	1891.4616	1891.4616	0.0001	-0.0234
Kazakhstan	16.3784	38.5792	2.3555	361.5693	361.5709	0.0016	0.0111
Kyrgyzstan	11.0103	52.6273	4.7798	384.5091	384.5093	0.0002	-0.1168
Lao People's Democratic Republic	60.7006	202.8577	3.3419	1742.8230	1742.8230	0.0000	-0.0101
Malaysia	10.5266	59.7597	5.6770	446.5732	446.5734	0.0002	-0.0917
Maldives	2.9360	4.7571	1.6203	17.7345	17.7349	0.0004	-0.1132
Mongolia	5.6757	10.4288	1.8374	64.3514	64.3522	0.0008	-0.0067
Myanmar	12.2158	49.2365	4.0305	433.5380	433.5380	0.0000	-0.0675
Nepal	7.1371	20.2111	2.8318	164.2213	163.9139	-0.3075	0.0212
Pakistan	118.8980	491.3383	4.1324	6422.1823	6422.1825	0.0003	-0.0115
Philippines	12.6128	58.0984	4.6063	610.8658	610.8658	0.0000	-0.0681
Residual/ unallocated ODA: Eastern and South-eastern Asia	4.5171	15.7116	3.4783	230.5297	230.5310	0.0012	0.0136
Sri Lanka	43.9086	172.8666	3.9370	1190.8700	1190.8711	0.0011	0.0122
Tajikistan	13.2623	41.7355	3.1469	327.6273	327.6301	0.0028	0.0189


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Thailand	20.3470	86.0200	4.2277	894.3077	894.3085	0.0008	-0.0047
Timor-Leste	0.6161	1.2274	1.9922	4.6580	4.6588	0.0008	-0.0954
Turkmenistan	354.4149	1201.7237	3.3907	4489.1416	4489.1416	0.0000	-0.0749
Uzbekistan	83.7314	226.9570	2.7105	1230.2267	1230.2280	0.0013	0.1286
Viet Nam	63.8269	216.5631	3.3930	1845.3420	1845.3420	0.0000	-0.0291
Source: International Renewable Energy Agency, Statistics Data (2009-2020)							

The Table 1 presents the country-wise descriptive statistics for grants related to renewable and non-renewable projects across Asia from 2009 to 2020, with a focus on the "Amount (2020 USD Million)." The analysis reveals significant variability in funding across countries, reflected in the large standard deviations and coefficients of variation (CV). For instance, India stands out with a notably high mean of 42.65 million USD, although its standard deviation is also very high at 278.10 million USD, indicating considerable fluctuation in the grant amounts over the years. The CV of 6.52 is the highest in the table, signifying a very high relative dispersion in the funding received by India. The maximum value of 6752.98 million USD is also the largest recorded, highlighting an unusually large project compared to the others, which likely skews the distribution. In contrast, Afghanistan, Bhutan, and Mongolia show much smaller means and ranges, with minimal fluctuations in their respective data. The CAGR for India, at -0.82%, reflects a slight negative growth in funding over the years, similar to most countries in the dataset. However, India's outlier nature in terms of grant amounts and variability underscores its importance in the regional funding landscape, potentially driven by large-scale initiatives or institutional differences.

Table 2: ANOVA Results

Source of Variation	***Sum of Squares (SS)***	***Degrees of Freedom (df)***	***Mean Square (MS)***	***F***	***P-Value***
Factor (Between)	6183044.821	25	247321.7929	5.63441	0.000000
Error (Within)	185763178.6	4232	43894.89096		
Total	191946223.4	4257	N/A		
Source: Author's own calculation using Python					

The ANOVA test reveals that there are significant differences in the mean financial contributions across countries in Asia. With an F-statistic of 5.63 and an extremely small p-value, we reject the null hypothesis, which states that the means are equal across countries. This suggests that the financial contributions vary significantly between the countries studied, confirming that the hypothesis of country-wise differences in financial contributions is supported.

Table 3: ANOVA Table
Influence of Donor Type, Country, and Year on Financial Contributions to Renewable Energy Projects

Source of Variation	***Sum of Squares (SS)***	***Degrees of Freedom (df)***	***F-statistic***	***P-value***
Donor	51700300.00	49.00	32.97	0.0000
Country	3376063.00	25.00	4.22	0.0000
Year	442424.70	20.00	0.69	0.8412
Residual	133213800.00	4163.00		
Source: Author's own calculation using Python				


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The **ANOVA** results indicate significant variations in financial contributions to renewable energy projects across different **donor types** and **countries**, while no significant effect was observed from the **year** factor. Specifically, the **Donor** factor had an extremely low p-value, indicating a highly significant effect on financial contributions. Similarly, **Country** showed a significant impact with a p-value. However, the **Year** factor did not significantly affect contributions, as evidenced by its p-value of 0.839, which is well above the typical significance threshold of 0.05. Based on these results, **Hypothesis 2**, which stated that the amount of financial contribution is influenced by the type of donor, is **accepted**, as the donor factor was found to significantly impact the contributions.

Table 4:
Kruskal-Wallis Test Results: Financial Contributions by Technology Category

Technology	count	Mean	Std	MIN	25%	50%	75%	MAX	Kruskal-Wallis Statistic	P-Value
Bioenergy	284	4.3834	14.1407	0.0004	0.0363	0.1204	0.9903	100.0000	601.0560	0.000
Coal and peat	140	354.1293	702.5697	0.0026	0.3228	157.7123	401.2243	6752.9788	601.0560	0.000
Fossil fuels	388	29.5788	79.8444	0.0000	0.0876	0.8905	16.8592	784.0698	601.0560	0.000
Geothermal energy	83	42.6992	81.9333	0.0018	0.1088	1.2060	51.5404	490.3894	601.0560	0.000
Marine energy	5	0.5038	0.7879	0.0059	0.0325	0.1987	0.3965	1.8853	601.0560	0.000
Multiple renewables	1391	8.8000	35.1354	-0.3075	0.0265	0.1689	2.0908	583.1177	601.0560	0.000
Natural gas	67	297.6521	746.5368	0.0035	1.3100	76.0784	230.4824	4489.1416	601.0560	0.000
Nuclear	476	20.4039	306.2028	0.0000	0.0176	0.0854	0.8377	6422.1825	601.0560	0.000
Oil	30	118.9754	369.5600	0.0017	0.0732	5.2228	21.2812	1663.5507	601.0560	0.000
Other non-renewables	6	35.5032	79.2858	0.0226	0.1960	0.7695	11.0772	196.9399	601.0560	0.000
Renewable hydropower	529	54.6626	146.4925	0.0004	0.1918	2.5905	38.9215	1742.8230	601.0560	0.000
Solar energy	670	15.4510	32.1334	0.0000	0.0908	1.8179	15.0063	286.0448	601.0560	0.000
Wind energy	189	20.2089	38.6765	0.0005	0.2432	7.1432	21.0019	251.9795	601.0560	0.000

The Kruskal-Wallis test results show a test statistic of 601.0560 and a p-value of 0.0000 for all technology categories, indicating that the null hypothesis, stating that the distributions of financial contributions are the same across technology categories is rejected. The extremely small p-value (far below the 0.05 significance level) suggests that there are significant differences in the financial contributions across the various technology categories, supporting the conclusion that the number of financial contributions is influenced by the technological category.

CONCLUSION:

Based on the findings of this study, the analysis reveals significant variations in the financial contributions to renewable energy projects across Asian countries from 2009 to 2020. The country-wise differences in funding, as indicated by the ANOVA results, confirm that financial contributions vary significantly across nations, with larger economies like India and Pakistan receiving higher investments. Moreover, the type of donor plays a critical role in shaping the funding landscape, as evidenced by the statistical significance of the donor variable. Additionally, the technological category of renewable energy projects significantly influences the financial contributions, with solar, wind, and bioenergy projects attracting notable funding. These results affirm the study's hypotheses that financial contributions differ significantly by country, are influenced by the type of donor, and are positively correlated with technology categories. The findings provide valuable insights into optimizing future investments in renewable energy projects in Asia, underscoring the need for tailored funding strategies based on country-specific needs, donor characteristics, and technology preferences.

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