Predicting country-specific financing capacity for renewable energy project

Mohd Suhaimi Mohamed-Ariffin[1*], *Mazlifa* Md Daud[2], *Haslinah* Muhammad[3], *Abdul Rahim* Abdul Samad[3], and *Mazlan* Hassan[3]

[1]Universiti Kuala Lumpur, UniKL Business School, 1018 Jalan Sultan Ismail, 50250 Kuala Lumpur, Malaysia
[2]Faculty of Accountancy, Universiti Teknologi MARA, Merbok, Kedah, 08400 Malaysia
[3]School of Business and Economics, Universiti Putra Malaysia, Seri Kembangan, 43400 Serdang, Malaysia

Abstract. This study aims to scrutinize the various determinants that influence a nation's ability to fund and support renewable energy ventures, encompassing factors such as economic stability, regulatory environment, energy demand, and access to capital markets. By drawing on a range of empirical data, financial indicators, and statistical models, this study seeks to determine which factor most potent when predicting financing capacity of a specific country towards renewable. A secondary research using published data by government publications and non-governmental databases is the research method for the present study. The data derived from these databases organized into tables to allow for regression analysis to be conducted to achieve the research objectives. The results from the regression analysis indicate that stock market and inflation rate are significant variables should be included in the predictive model of financing capacity for renewable energy.

1 Introduction

The global pursuit of sustainable and clean energy solutions has brought the financing of renewable energy ventures to the forefront of discussions on energy policy, economic development, and environmental sustainability. As nations grapple with the dual challenges of mitigating climate change and securing their energy futures, the ability to accurately predict and assess the financing capability of renewable energy projects within a country assumes paramount significance. According to IEA, the use of renewable energies in the electricity, heating and transport sectors is one of the most important prerequisites for keeping the rise in average global temperatures below 1.5°C.

Renewable energy has emerged as a linchpin in the transition toward a low-carbon economy [1]. It promises not only to reduce greenhouse gas emissions but also to catalyse economic growth, enhance energy security, and create employment opportunities [2]. However, the successful deployment of renewable energy technologies relies heavily on the availability of financial resources, investor confidence, and supportive policy frameworks [3]. Understanding and predicting a country's capacity to finance its renewable energy ventures is thus pivotal for harnessing the full potential of clean energy and achieving international climate goals [4].

This paper embarks on an exploratory journey into the multifaceted landscape of predicting a country's financing capability for renewable energy projects. It aims to scrutinize the various determinants that influence a nation's ability to fund and support renewable energy ventures, encompassing factors such as economic stability, regulatory environment, energy demand, and access to capital markets. By drawing on some selected economic indicators, this study seeks to determine which factor most potent when predicting financing capacity of a specific country towards renewable.

Moreover, the paper delves into the vital role of financial institutions, both domestic and international, in catalysing or constraining the financing of renewable energy projects within a given nation [5]. It also assesses the implications of financial risks and market dynamics, exploring how these factors influence investor behaviour and project viability in the renewable energy sector [6]. By addressing these critical aspects of predicting a country's financing capability for renewable energy ventures, this paper aspires to offer valuable insights for policymakers, financiers, and energy stakeholders. The ability to forecast a nation's renewable energy financing capacity not only aids in strategic planning but also informs decisions related to the allocation of resources, risk management, and the design of policies that support sustainable energy transitions. In essence, this study seeks to contribute to the broader discourse on clean energy financing, facilitating informed and evidence-based decisions that can accelerate the transition to a more sustainable energy future.

* Corresponding author: msuhaimi@unikl.edu.my

2 Literature Review

The financing of renewable energy ventures within a country's borders is a complex endeavour influenced by a myriad of factors, including economic conditions, regulatory frameworks, investor sentiment, and the broader energy landscape. This section reviews the existing literature on the determinants and predictive factors related to a country's financing capability for renewable energy projects.

2.1 Economic Factors

Economic stability and growth have long been identified as fundamental factors affecting the financing capability of renewable energy ventures. Persakis and Emmanuel (2023) indicate that forecasts by analysts are more accurate during period of high investor sentiment and in the presence of higher levels of earning quality [7]. A stable economic environment provides investors with confidence in the long-term viability of projects. The gross domestic product (GDP), national income, employment rate, foreign direct investment (FDI), and inflation and technological advancement on energy production have been recognized as the key economic factors in creating this stable environment [8]. In another study, a strong correlation between a nation's GDP per capita and its capacity to attract renewable energy investments [9].

One of the key factors influencing the adoption of renewable energy generation projects is the access to financing [10]. Renewable energy generation projects are typically financed through project financing, and investors generally consider two aspects before funding a project: investment returns and investment risks [11]. The project finance is a popular financing method because it can accommodate requirements typically associated with large and expensive project costs and long-term contracts. These sort of economic activities require rational allocation of risks between public and private parties [12]. The required high initial investment in building renewable energy facilities has been evidenced to prevent adoption of renewable energy from spreading into the reach of small business operators [13]. Even venture capitalists seem to be giving less attention to the start-ups involved in green energy initiative [14].

The good news is, based on the study by Abbas et al. (2023) shows that green finance has been proven able to play a role in promoting renewable energy investment and achieving sustainability [15]. Using data derived from fifty (50) energy firms in China, the researchers found that green finance can significantly increase the electricity output.

2.2 Regulatory Environment

The regulatory landscape plays a pivotal role in shaping the financing capability of renewable energy projects. Research indicates that clear and supportive policies, such as feed-in tariffs, tax incentives, and renewable portfolio standards, can stimulate investments in clean energy [3, 15]. Conversely, policy instability and frequent changes in regulations can deter investors and undermine the financing of renewable energy ventures [16]. The role of stable, predictable, and transparent regulatory frameworks in attracting investment cannot be overstated.

Lyu et al. (2023) listed three impacts of regulatory intervention on green technology and innovation investment [17]. First, green innovation subsidies are more effective than product subsidies at boosting innovation investment when the direct subsidy to the consumer is minimal. Additionally, with a high emission-reducing subsidy rate, this subsidy outperforms cap-and-trade systems in promoting green technology investment. Second, a moderate subsidy to manufacturers allows the green innovation subsidy to balance economic gains, consumer benefits, environmental advantages, and societal welfare. Lastly, in terms of environmental benefits, emission-reduction subsidies consistently outshine cap-and-trade. However, for economic prosperity and societal welfare, cap-and-trade often emerges as the preferable option.

On research with respect to the varying impacts of environmental policy stringency (EPS) on renewable energy investment utilizing the nonlinear panel QARDL (quantile autoregressive distributed lag) approach, the findings indicate there are short and long-term positive shifts in EPS. In the study, data of BRICS nations were used and it indicates there is a long-term negative EPS shifts affecting the investments in the lower and medium quantiles, while short-term declines have a marked impact across most quantiles. The Wald test which was conducted over short and long durations, confirms the distinct impacts of EPS on renewable energy investments for all quantiles. Thus, it's crucial for policymakers to differentiate between the positive and negative fluctuations in EPS when assessing its influence on renewable energy investment [18].

Equally important lessons from the above mentioned study, investors and policy makers must pay attention to the asset allocation optimization and market risk management [19].

2.3 Access to Capital Markets

Access to capital markets, both domestically and internationally, is another crucial determinant. Financial institutions, including banks, venture capitalists, and multilateral development banks, are essential sources of funding for renewable energy projects [5]. Based on the study by Tian et al. (2022) regarding connectedness mechanisms in the carbon finance system in the emerging economies, it found that the stock market is the main conduit for shock transmission within the system, while green bonds absorb the most significant shocks [19]. The same study also found that the carbon market has diverse connections with both commodity and financial markets. It absorbs shocks from the stock, silver, and copper markets and passes them on to the gold market. Additionally, it interacts with other carbon markets either directly or via channels like energy markets, foreign exchange rates, and green bonds.

The extent literature indicates that the ability to secure loans and investments at competitive rates is

contingent on a country's creditworthiness and financial infrastructure [20]. There are several components making up the country's creditworthiness. Credit rating is one of them. In this instance, credit rating agencies such as Moody's, Standard & Poor's, and Fitch Ratings, assess and assign credit ratings to countries based on their ability and willingness to repay debt. A higher rating often signifies lower risk, leading to more favourable borrowing terms. Another is economic stability which often times characterized by factors like low inflation, steady growth, and manageable levels of public debt, tend to attract investments at better terms. Political stability plays an equal important role because frequent policy changes and political turmoil can deter investors given the uncertainty they bring. Stable governance and predictable policy-making can enhance a country's creditworthiness. The high external debt level of a country can pose a repayment concerns should the country wishes to tap the international bond or sukuk (Islamic bond) markets [21].

Researchers have emphasized the importance of developing domestic financial markets and fostering international cooperation to facilitate access to capital [22].

2.4 Energy Demand and Resource Potential

The demand for energy and the availability of renewable energy resources are vital factors influencing financing capability. Countries with a substantial domestic energy demand, coupled with abundant renewable energy resources, are better positioned to attract investments [14]. Moreover, the diversification of energy sources and reduced dependence on fossil fuels contribute to energy security, which, in turn, can bolster the financing of renewable energy ventures [1].

In Europe for instance, the crisis caused by Russia's incursion into Ukraine has expedited the adoption of renewable energy in the European Union (EU), pushing the region to quickly lessen its reliance on Russian natural gas imports [23]. This is possible given the accelerated expansion of distributed solar PV primarily accounts for the optimistic outlook, making up nearly three-quarters of the EU's forecast adjustments. Elevated electricity prices, which enhance the financial appeal of solar PV, along with amplified policy backing in crucial EU markets like Germany, Italy, and the Netherlands, drive this growth. In other words, demand is there. Presented below is the net renewable electricity capacity additions by technology in EU.

As for Malaysia, currently, only 25% of Malaysia's total energy consumption comes from renewable and alternative sources. As a developing nation, Malaysia's swift economic growth requires more energy than many developed countries. This intense energy demand threatens long-term sustainability and contributes to significant carbon emissions. Malaysia mainly relies on fossil fuels for electricity generation in its power sector. However, these fossil fuels are unsustainable in the foreseeable future because of their environmental impact and eventual depletion. With Malaysia's booming population and economy, there's an urgent need to look into alternative energy sources to fulfil its growing energy requirements [24]. In order for Malaysia to achieve its target of 70 percent energy requirement through renewable sources by 2050, as a resource rich country must ensure sufficient usage of natural resources, reallocating funding at regional governmental levels, and transitioning toward sustainable technology [25]. If not addressed, she might fall prey to the outcomes predicted by the resource curse theory.

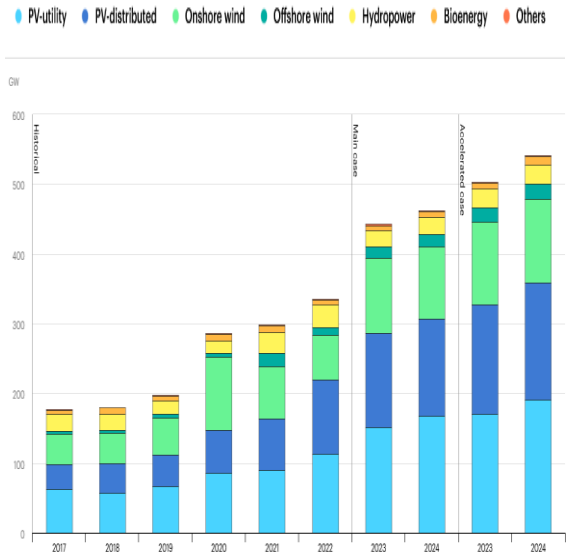

Fig. 1. Net renewable electricity capacity additions by technology, 2017-2024

2.5 Financial Risks and Market Dynamics

Renewable energy investments are not without financial risks. Researchers have examined various risk factors, including technology risk, market price volatility, and policy risk [6]. The understanding and mitigation of these risks are crucial for attracting financing. Financial markets' dynamics, including the availability of green bonds and impact investing, have also gained attention as potential mechanisms for mitigating risks and mobilizing capital for renewable energy [26]. The World Bank is the champion for green bonds and recognized as an innovative product from the "Strategic Framework for Development and Climate Change" launched back in 2008.

Discussion regarding the dynamics of market associated with renewable energy is connected to a larger topic which is the carbon market. As in addressing the environmental dilemmas caused by the high carbon emission, generating renewable energy is one of the solutions in tackling the climate change issue. When it comes to minimizing financial (i.e., investment) risk through portfolio diversification across different markets as a hedging tool, most methods have been proven successful. However, green bonds are the exception, as they produce suboptimal results [19].

In conclusion, the financing capability of a country's renewable energy ventures is a multifaceted issue influenced by economic, regulatory, financial, and environmental factors. A robust understanding of these determinants and their interplay is essential for predicting a nation's readiness to embrace renewable

energy investments and for crafting policies and strategies to catalyse sustainable energy transitions.

3 Research Methodology

The methodology for the study is designed based on the findings from other studies with respect to the renewable energy. From the study by Ozorhon et al. (2018) and similar studies in the past, they found that economic and technical factors are the most significant when deciding for investments in the renewable energy [27]. This is based on the assumption that to fully meet domestic renewable energy target, investors (government or private) alone would not be able to wholly finance the renewable energy projects without the assistance of debt providers from external sources. The concept of entirely financing such projects with equity is rarely considered and doesn't seem logical either. Therefore, investments should be financially viable, and investors somehow rely on certain predictive indicator for a given country if they wish to invest especially in the world where highly probable and unpredictable events underlie almost everything today [28]. This research collects data on different categories but only for a single time period; in other words, it utilizes cross-sectional data to understand how selected variables individually affect the dependent variable. Each variable which represents the financing capability of renewable energy projects would be tested individually against the dependent variable of achieving the desired level of renewable energy generation.

Building on the findings from the study by Ozorhon et al. (2018) where various factors within the economic and technical clusters weigh the most importance far higher than the others, this research takes a distinct approach [27]. First, this research distinguishes some factors and reassign them under financial cluster. Second, this research dropped some factors given the difficulty of tracing relevant data with respect to some factors. Third, this research introduces new factors not investigated in the previous relevant studies given their theoretical importance for consideration with regard to the topic under study. In the end, the factors investigated in this research are mostly from economic and financial clusters namely GDP per capita, debt to GDP, inflation rate, bond rating, with two factors from technical cluster namely technology index and renewable energy generation level. The differed approach is caused by the purpose that each study is pursuing. In the study by Ozorhon et al. (2018), the goal was to identify factors influencing stakeholders' investment decisions in renewable energy. In contrast, the current research aims to pinpoint the most pertinent factors that can serve as indicators for predicting a country's capability to meet its renewable energy targets.

The idea behind this goal is based on the literature with respect to the phenomenon of success where a small number of events can account for the majority of outcomes. Several best-seller authors [29-31] have written about this phenomenon called long tails where the farthest ends of a distribution of outcomes have tremendous influence in finance as well as other things in life. In connection to this research methodology, the author believes that instead of having a sizable number of factors to make a decision which can be troublesome in gathering the data needed and requires expert from various fields as indicated in other relevant studies with respect to decision making in the field of renewable energy, having less factors have been proven in many instances to be sufficient to predict success. Such approach is also compatible with the less is more principle as widely practiced in many areas in life.

3.1 Data Sources

This study utilizes selected data sources to identify the most pertinent factors when predicting a country's ability to meet its target of renewable energy generation. The primary data sources include:

3.1.1 Economic Data

Data on a country's GDP per capita, inflation rate, and overall economic stability are sourced from various databases. These economic indicators provide a foundation for assessing a country's economic environment and its impact on renewable energy financing.

3.1.2 Financial Market Data

Data related to the availability of domestic and international capital markets, interest rates, and credit ratings are sourced from various databases.

3.1.3 Technology Data

Data related to the information regarding a country's technological readiness includes spending on R&D, creativity of its scientific community, personal computer and internet penetration rates are sourced from various databases.

Table 1. List of Criteria Considered

Cluster	Factor	Sources
Economic	GDP (PPP) per capita	GDP per Capita - Worldometer (worldometers.info)
	Debt to GDP	Debt to GDP Ratio by Country 2023 (worldpopulationreview.com)
	Inflation Rate	Inflation Rate - Countries - List | World (tradingeconomics.com)
Financial	Bond Rating	Credit Rating - Countries - List (tradingeconomics.com)
	Stock Market	Stock market access for smaller firms by country, around the world | TheGlobalEconomy.com
Technical	Technology Index	Countries Compared by Economy > Technology index. International Statistics at NationMaster.com
	Renewable Energy Generation	https://wisevoter.com/country-rankings/renewable-energy-by-country

3.2 Analytical Framework

To predict a country's financing capability for renewable energy ventures with the aim to achieve a set target, a comprehensive analytical framework is developed. This framework integrates quantitative and qualitative data, guided by the following steps:

3.2.1 Data Pre-processing

Data collected from various sources are cleaned, standardized, and converted into a common currency and time frame for analysis

3.2.2 Variable Selection

Relevant variables are selected based on their significance in prior research and their theoretical importance in predicting financing capability.

3.2.3 Statistical Analysis

Statistical techniques of regression analysis are employed to examine the relationships between the selected variables and financing capability.

3.2.4 Model Development

A predictive model is constructed based on the results of the above analyses, with the aim of forecasting a country's financing capability for renewable energy ventures.

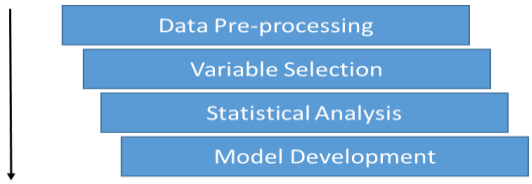

Fig. 2. Analytical framework

3.3 Sample

This study uses 18 countries as sample which mostly made of upper middle income and developed countries as defined by the World Bank. Those countries are United Kingdom, Costa Rica, Brazil, Croatia, Romania, Morocco, Hungary, Uruguay, Germany, United Arab Emirates (UAE), Spain, Russia, United States, New Zealand, China, Hong Kong, Netherlands, and Malaysia. Even though China and Hong Kong are of the same country, but the difference in GDP (PPP) per capita between them along with other statistics worth including them separately in the data.

4 Results and Discussion

4.1 Descriptive statistics

Table 2 presents the descriptive statistics of the dependent and independent variables. The dependent variable is the renewable energy level and the rest are the independent variables that this research is investigating and testing. As illustrated in Table 2, the mean values for GDP (PPP) per capita, debt to GDP ratio, stock market performance, and technology index are lower than their respective median values. In this instance, it suggests that distribution of the data is skewed to the left, or negatively skewed.

As shown in Fig. 1, as an example, it shows that the levels of renewable energy level and GDP (PPP) per capita is not linear which means, the higher the level of GDP (PPP) per capita does not correspond to the level of renewable energy based on the sample made of 18 countries mentioned earlier. This is in contrast with the finding by the previous study by Sarkodie & Strezov (2019) which claimed that a nation's GDP per capita has a strong correlation of attracting investments in renewable energy. To be fair however, in the mentioned study, it measures GDP per capita instead of GDP (PPP) per capita.

This is due to the fact that while GDP per capita provides a straightforward average economic output per person, GDP (PPP) per capita offers a more nuanced view that takes into account the relative buying power of a country's currency and the cost of living. When comparing the economic performance or standard of living between countries, especially between developed and developing nations, GDP (PPP) per capita can offer a more accurate picture. Fig. 3 and Fig. 4 visualize the correlation between respective variables with renewable energy level. In both charts, the trend line is negative.

Table 2. Descriptive statistics of variables.

	GDP (PPP) per Capita	DEBT TO GDP	STOCK MARKET	TECHNOLOGY INDEX	INFLATION RATE	RENEWABLE ENERGY	BOND RATING
Mean	45,276	0.5768	51.62	4.47	4.3806	0.2616	70
Standard Error	5,089	0.0617	3.42	0.16	0.9844	0.0681	6
Median	41,898	0.6055	57.00	4.58	4.3050	0.1622	70

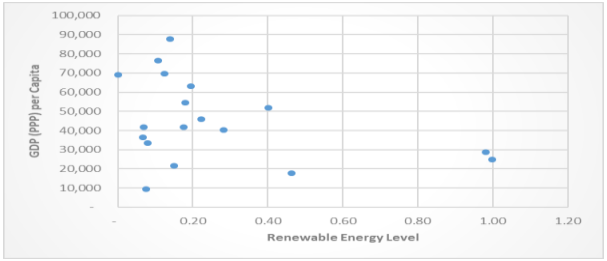

Fig. 3. Correlation between GDP (PPP) per capita and Renewable Energy Level.

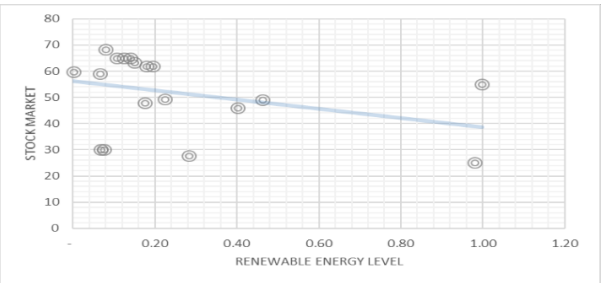

Fig. 4. Correlation between Stock Market and Renewable Energy Level

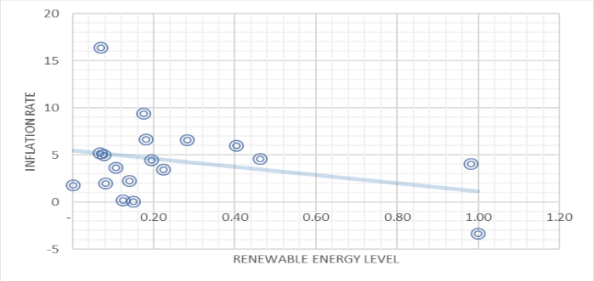

Fig. 5. Correlation between Inflation rate and Renewable Energy Level

4.2 Regression analysis

The authors tested the independent variables to determine each variable's significance towards the level of renewable energy, the dependent variable, by using multiple regression analysis to arrive at the research's statistical inference. By applying the p-value rule of 0.15 as the threshold value for not rejecting the respective variable, the research finally is left with two variables which are technology index and inflation rate as variables to be included in the predictive model. The results are presented in Table 3. The predictive model formulated is as follow:

$$\hat{Y} = 1.1939 - 0.01409X3 - 0.04676X5$$

From the regression statistics, it can be gleaned that the model is able to explain 45% (R^2) of the results. X3 represents the inflation rate while X5 represents technology index. From the ANOVA table in Table 3, the model is good given the "significance F" value smaller than 0.01. In term of the relationship between the independent variables and the dependent variable, it indicates a negative relationship as represented by the negative coefficients of both independent variables. The result of "P-value" is smaller than 0.01 hence it supports that the model has good variables.

Table 3. Regression statistics

Regression Statistics	
Multiple R	0.671450602
R Square	0.450845911
Adjusted R Square	0.377625366
Standard Error	0.227979869
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.640056292	0.320028146	6.157368955	0.011161091
Residual	15	0.779622308	0.051974821		
Total	17	1.4196786			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	1.193931096	0.279653112	4.269328832	0.000672039	0.597864596	1.789997595
X3	-0.01409254	0.004496134	-3.13436798	0.006820944	-0.02367582	-0.00450926
X5	-0.04676856	0.015601941	-2.99761185	0.009016474	-0.08002331	-0.01351381

5 Conclusion and Outlook

Energy plays a pivotal role in the contemporary economic and social landscape. Given the growing environmental issues, investments in renewable energy have become essential worldwide. The purpose of this research is to narrow down few factors related to the financing of renewable energy and organize them into a predictive model. This predictive model then can be used to predict specific country's ability to achieve the target level of renewable energy generation.

As shown in the formulated predictive model presented in subsection 5.2, inflation rate and technology index are the good variables with negative relationship with the renewable energy level. Putting it differently, financial and technical clusters are found to be significant as opposed to the economic cluster where it was proven to be the most significant cluster in other study mentioned previously.

Considering the predictive capacity of the developed model, subsequent research might benefit from integrating both quantitative and qualitative factors related to energy demand, resource potential, financial risks, and market dynamics to enhance and fortify the model.

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