“The role of feed-in tariffs in encouraging insurance companies to invest in renewables”

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THE ROLE OF FEED-IN TARIFFS IN ENCOURAGING INSURANCE COMPANIES TO INVEST IN RENEWABLES

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Abstract

In an environment where public funding is insufficient to meet international climate and energy goals, feed-in tariffs serve as an essential mechanism to mitigate investment risk and foster the participation of insurance companies as institutional investors in the renewable energy sector. This study aims to investigate whether feed-in tariff policies enhance the evolving effect of insurance sector development on renewable energy consumption across countries and over time. Given that both financial sector capacity and renewable energy transitions are dynamic processes, the analysis explicitly applies econometric techniques designed to capture temporal changes and investment inertia. Using panel data econometric techniques, including fixed effects models with cluster-robust standard errors and dynamic panel estimation (Arellano-Bond GMM), the analysis covers 64 countries from 2000 to 2020. The results reveal that greater insurance sector assets positively correlate with higher renewable energy consumption, with a coefficient of 0.143 ($p < 0.01$) in the fixed effects model. Still, the strength and significance of this relationship are notably enhanced when feed-in tariffs are in place, as shown by a positive and statistically significant interaction term (coefficient 0.051, $p < 0.05$) after adding time-fixed effects. The empirical results show that insurance companies can serve as critical institutional investors in the renewable energy sector. Still, their active participation critically depends on supportive policy frameworks, with the positive association between insurance company assets and renewable energy consumption becoming significant, particularly in countries with feed-in tariff schemes.

Keywords insurance sector, institutional investors, renewable energy sources, energy transition, feed-in tariff, dynamic panel model

JEL Classification G22, Q42, Q48, O13, C23

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INTRODUCTION

Insurance companies are among the most significant institutional investors in the global financial market, managing large portfolios of assets and allocating capital across a wide range of sectors. Although equities represented a smaller portion of the overall investment portfolios of insurers, in some jurisdictions, insurers still maintained a significant share of their assets in equities. As of the end of 2023, life insurers in Denmark and Sweden and non-life insurers in Austria held more than 40% of their assets in equities. Non-life insurers in France, Japan, and the United States also maintained relatively high equity exposures, with approximately 30% of assets allocated to equities in France and Japan, and 26% in the United States (OECD, 2024). This relatively high exposure to equity markets in certain countries suggests that insurers in these jurisdictions may be more willing to consider investments in sectors traditionally associated with higher risk profiles, including renewable energy projects. As renewable energy investments often involve equity stakes in infrastructure or project companies, the appetite for equity investments could facilitate greater insurance sector participation in financing renewable energy development, particularly when supported by policy mechanisms that reduce investment risk, such as feed-in tariffs (FiTs). FiTs is a type of preferential tariff policy that guarantees long-term purchase agreements at fixed or premium rates to reduce investment risk in renewable energy projects.

According to the International Association of Insurance Supervisors, insurers' investment strategies are heavily influenced by their fiduciary duty to policyholders and regulatory capital requirements. This leads them to prioritize low-risk, stable investments that offer predictable cash flows (IAIS, 2022). As a result, they tend to prefer government bonds, high-grade corporate bonds, and similarly secure assets. Meanwhile, infrastructure and renewable energy projects, while increasingly attractive, are often seen as higher risk due to long payback periods, policy uncertainty, and construction risks, posing a challenge for greater insurance sector participation in green financing.

According to the International Energy Agency (IEA, 2021), FiTs have been crucial in reducing investment risk for renewable energy projects by guaranteeing long-term purchase agreements at stable prices. This policy mechanism has significantly contributed to attracting institutional investors, including insurance companies, by ensuring predictable cash flows and lowering revenue uncertainty, which aligns with the conservative investment profiles preferred by such investors.

Therefore, it is pertinent to investigate whether FiTs, as a risk-mitigating policy instrument, enhance the participation of insurance companies in financing renewable energy projects. In the context of insufficient public funding to meet international climate and energy objectives, assessing whether insurance companies can serve as significant institutional investors in the renewable energy sector and whether existing and widely adopted policy mechanisms effectively incentivize their engagement is critical.

1. LITERATURE REVIEW

The question of mobilizing insurance companies as investors in renewable energy and the role of FiTs in facilitating this transition has gained prominence in recent scholarly work. Recent literature can be logically grouped into several thematic areas: investment risk and renewable energy financing, insurance sector characteristics and risk aversion, policy support mechanisms including FiTs, and broader systemic and financial innovations related to sustainability.

A first strand of research focuses on the inherent risks associated with renewable energy investments and the cautious behavior of institutional investors. Dobrovolska et al. (2024) argue that renewable energy start-ups face substantial investment risks, necessitating strong risk-mitigating mechanisms like FiTs to attract capital. Similarly, Artyukhov et al. (2024) highlight, through a bibliometric study, that although sustainable investment is rising, institutional investors such as insurers still require stable returns and reduced volatility. This need for guaranteed returns aligns with findings by Liu et al. (2024), who advocate for specific policies to unlock the investment potential of insurance companies. Bachir et al. (2025) add that dynamic pricing models are necessary in insurance markets to adapt to volatility, supporting the case for mechanisms that stabilize renewable energy returns.

Research specifically examining the insurance sector underscores the importance of risk aversion in shaping investment decisions. Kamel and Naoual (2024) and Hizia (2023) provide evidence from Algerian insurers that profitability and risk minimization dominate decision-making, thus reinforcing the importance of mechanisms like FiTs that offer predictable cash flows. Mańak-Szulik et al. (2023) explore the complex behavior of insurance markets, suggesting that market volatility deters investment without external policy interventions. Belhadi et al. (2023) add that although big data can enhance insurers' risk assessment capabilities, it does not replace the need for external policy stability. Rakotoarisoa and Mapp (2023)

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extend this understanding by illustrating how governmental intervention in premium settings enables insurance schemes to thrive in high-risk environments.

Parallel to this, studies related to renewable energy policy and public incentives underline the critical role of FiTs. Kurbatova et al. (2023) directly address the optimization of FiT schemes to stimulate renewable energy investments, particularly from households and institutional investors. Samour et al. (2022) demonstrate empirically that insurance market development contributes to renewable energy growth only when policy support mechanisms are in place. Similarly, Badreddine and Cherif (2024) link renewable energy deployment to public health improvements, emphasizing the broader societal value of ensuring sustained investments through supportive policies. Juracka et al. (2024) and Sotnyk et al. (2022) confirm the global importance of sustainable public policy instruments, including FiTs, in promoting eco-innovations and renewable energy transitions.

Broader systemic research also supports the role of government intervention. Shtunder et al. (2022) and Dankevych et al. (2023) stress that renewable energy is crucial for economic stability during crises, suggesting an urgent need for robust, predictable policies. Streimikiene et al. (2024) and Ksonzhyk et al. (2021) discuss the European Green Deal and underline the necessity of sustainable finance initiatives supported by public policy. Kuzior et al. (2022) examine the connection between health insurance and public financing, indirectly emphasizing the necessity of stable financial frameworks for broader societal resilience.

Innovative financial instruments and governance frameworks are also critical complementary factors. Eti et al. (2025) propose using fuzzy decision-making models for renewable energy insurance, while Makarenko et al. (2024) recommend sustainability transparency indices to strengthen investment attractiveness. Otieno et al. (2025) explore willingness to pay for health insurance, paralleling the importance of reliable returns in the insurance sector's investment decisions. Other contributions, such as those by Kozmenko and Vasyl'yeva (2008) and Burlaka et al. (2019), emphasize the importance of regulatory and institutional frameworks in encouraging financial sector participation in new markets. Studies on green finance and social impact, including those by Halynskyi and Telizhenko (2024), Yetongnon and Kasztelnik (2024), and Alam et al. (2023), further highlight that policy visibility and institutional support are key drivers of sustainable investment behavior. Juhászová et al. (2023) further illustrate the importance of linking insurance development to broader economic sectors, supporting stable investment environments. Kuzior et al. (2023) argue that socioeconomic sustainability depends on solidarity-driven financial frameworks, underlining the need for consistent supportive policies.

Macro-level analyses by Fu and Chang (2024) and Bai et al. (2023) underline that strong governmental environmental policies directly stimulate green innovation and investment, aligning with the rationale for FiT-based interventions. Kwilinski et al. (2024) and Okulich-Kazarin et al. (2024) emphasize the benefits of renewable energy policies for the environment and knowledge economy. Polishchuk (2023) and Tymoshenko et al. (2023) stress that technological innovation alone is insufficient without regulatory support, and Tiutiunyk et al. (2022) demonstrate how strong institutions reduce investment risks. Makarenko et al. (2023) explore how sustainability disclosure rules enhance financial market performance, aligning with FiT principles. Ali and Salhab (2025) highlight the role of green marketing and visibility in attracting investments.

Additional financial behavior studies by Blajer-Gołębiewska (2024) and Bednarczyk et al. (2023) confirm that investor confidence is strongly tied to perceptions of stability and predictability. Tutar et al. (2025) reinforce that financial institutions prioritize investments supported by multi-criteria decision-making, emphasizing the systemic value of supportive renewable energy policies.

The literature consistently illustrates that while insurance companies have considerable potential as investors in renewable energy, their involvement is conditional upon the existence of stable, risk-mitigating policy frameworks such as FiTs. A combination of targeted financial incentives, supportive governance structures, and risk reduction mechanisms is crucial for mobilizing insurance capital toward achieving global renewable energy goals.

This study aims to investigate, across countries and over time, whether feed-in tariff policies enhance the evolving effect of insurance sector development on renewable energy consumption. The analysis explicitly applies econometric techniques designed to capture temporal changes and investment inertia because both financial sector capacity and renewable energy transitions are dynamic processes.

2. METHODOLOGY

This study employs a panel data econometric framework to examine the relationship between insurance company assets, FiT policies, and renewable energy consumption across a diverse set of countries over the period from 2000 to 2020.

To achieve the aim of the study, the following research questions are addressed:

1. How does the development of the insurance sector, measured by insurance company assets relative to GDP, relate to renewable energy consumption across countries?
2. Does the presence of FiTs policies moderate the relationship between insurance sector development and renewable energy consumption?
3. To what extent do supportive government policies strengthen the role of insurance sector assets in expanding renewable energy use?

The empirical strategy is based on established panel data techniques designed to control for unobservable heterogeneity, potential endogeneity, and dynamic adjustment processes inherent in investment behaviors. Because the insurance sector's development and its influence on renewable energy investment are not static, but change gradually and depend on historical patterns, this study employs both static (Fixed Effects (FE) and Random Effects (RE) models) and dynamic panel data models to uncover short-term and path-dependent relationships.

Initially, both FE and RE models are considered. The FE model controls for time-invariant unobservable country-specific factors that may otherwise bias the estimation if correlated with explanatory variables. In contrast, the RE model assumes that individual effects are uncorrelated with the regressors, thus offering more efficiency if the assumption holds. A Hausman specification test is applied to formally select between these models. The test evaluates whether the RE estimator is consistent; rejecting the null hypothesis suggests that RE should be preferred for consistent estimation.

Following model selection, diagnostic tests are employed to assess the validity of key regression assumptions. Serial correlation in the idiosyncratic errors is tested using the Durbin-Watson statistic, while heteroskedasticity is assessed using the studentized Breusch-Pagan test. The presence of either violation necessitates adjustments to the standard error estimation. Cluster-robust standard errors, clustered at the country level, are subsequently utilized to correct for heteroskedasticity and serial correlation, ensuring valid statistical inference.

Furthermore, the model is extended by incorporating time fixed effects through year dummy variables. This addition controls for global shocks and macroeconomic trends that may uniformly influence renewable energy consumption across countries over time, such as international policy agreements, technological innovations, and global economic cycles.

Recognizing the dynamic nature of renewable energy consumption, where past levels of investment and policy support influence present behavior, the analysis further extends to a dynamic panel model. The Arellano-Bond Generalized Method of Moments (GMM) estimator addresses potential endogeneity associated with including lagged dependent variables. This estimator is particularly suitable for capturing dynamic investment behavior, as it models how past levels of renewable energy consumption and financial sector conditions influence present outcomes. By incorporating lagged dependent variables and internal instruments, the Arellano-Bond GMM accounts for time-based inertia and policy response lags, which are central to understanding how the insurance sector's role in renewable energy evolves over time. This approach is particularly appropriate for panel datasets with a large cross-sectional dimension and a relatively shorter time span.

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Table 1. Variables and sources

Variable	Description	Source
Renewable energy consumption (%)	Share of renewable energy in total final energy consumption	World Bank (n.d.b)
Insurance company assets to GDP (%)	Total assets of insurance companies as a percentage of GDP	World Bank (2023)
Feed-in tariff dummy	Binary variable: 1 if a FiTs policy was present in a given year, 0 otherwise	CEIC (n.d.); Bashiri and Hosseinioun (2020), CEB (n.d.), EWSRC (2021), Energy Charter Secretariat (2012), ERA (n.d.), IrREA (n.d.), IRENA (2021), Liu et al. (2019), MEMR (n.d.), Norton Rose Fulbright (2017), PURC (n.d.), FERK (n.d.), R2E2 (n.d.), SEDA (n.d.), and World Bank (n.d.a)

The empirical analysis is based on an unbalanced panel comprising 64 countries, covering a broad spectrum of economic development levels and geographic regions. The study covers a panel of countries from various regions to ensure global relevance and comparability. A complete list of the countries included in the analysis is provided in Appendix A. This diverse country selection ensures the analysis captures various institutional, economic, and policy environments relevant to renewable energy development.

The variables used in the analysis are described in Table 1, along with their corresponding data sources.

The sample is limited to these 64 countries due to data availability constraints, as only countries with complete and comparable information across all three key variables –renewable energy consumption, insurance company assets to GDP, and the presence of FiTs – were included. The timespan from 2000 to 2020 was chosen to reflect the period when renewable energy development became a global priority, particularly after 2000, and is constrained at the upper bound by the availability of financial sector data, notably the Insurance Company Assets to GDP indicator from the World Bank (2023), which provides limited updates beyond 2020.

All variables are harmonized across countries and years to ensure comparability. The panel is unbalanced due to occasional missing data points for certain years or countries.

This methodological framework provides a robust basis for analyzing the complex interactions between financial sector development, renewable energy policy instruments, and energy transition outcomes.

All data preparation, analysis, and estimations were performed using R Studio, employing a range of specialized packages for panel data econometrics. The primary packages used include *plm* for estimating FE, RE, and dynamic panel models, *lmtest* and *sandwich* for diagnostic testing and robust standard error adjustments, *modelsummary* and *stargazer* for the presentation of regression results, and *pgmm* for Arellano-Bond GMM estimations.

All R scripts are available upon request to ensure transparency and reproducibility of results.

3. RESULTS

The final dataset consists of 1,189 observations across 64 countries from 2000 to 2020, forming an unbalanced panel due to variations in data availability across countries and years. The variables analyzed display meaningful variation across the sample, reflecting diverse national experiences in renewable energy development and financial sector maturity (Table 2).

Table 2. Summary statistics

Source: Authors' calculation in R Studio.

Variable	Mean	Standard deviation	Median	Trimmed Mean	Madian	Min	Max	Range	Skewness	Kurtosis	Standard Error
xl	0.50	0.50	1.00	0.50	0.00	0.00	1.00	1.00	–0.01	–2.00	0.01
x2	26.33	30.17	12.43	20.99	15.57	0.23	134.51	134.28	1.36	0.97	0.87
y	19.46	16.93	14.40	16.82	12.60	0.00	81.70	81.70	1.47	2.07	0.49

Renewable energy consumption, measured as a percentage of total final energy consumption, exhibits a mean value of 19.46%, with a standard deviation of 16.93%. The distribution ranges from a minimum of 0% to a maximum of 81.7%, indicating substantial heterogeneity across countries and years. The median value is 14.4%, suggesting that while some countries achieve very high renewable energy shares, the typical observation remains below 20%.

Insurance company assets, expressed as a percentage of GDP, have a mean value of 26.33% and a standard deviation of 30.17%. The minimum recorded value is 0.23%, and the maximum reaches 134.51%, illustrating significant variation in financial sector development across the sample. The median value of 12.43% indicates that insurance sectors are relatively small in many cases compared to the overall economy, especially in emerging and developing economies.

The FiTs Dummy, indicating a FiTs policy's presence (1) or absence (0), has a mean value of 0.50, with a standard deviation of 0.50. This suggests that FiT policies were in effect in approximately half of the country-year observations. The dummy variable exhibits minimal skewness and kurtosis, reflecting a relatively balanced distribution between countries and periods with and without FiT policies.

The dataset displays meaningful variation across key variables, supporting a robust empirical investigation into the interplay between financial sector development, renewable energy policy instruments, and renewable energy outcomes.

Range, skewness, kurtosis, and standard error provide a comprehensive view of the distribution of variables. Range captures overall spread, skewness identifies asymmetry, kurtosis indicates the presence of extreme values, and standard error assesses the precision of mean estimates.

The analysis began by estimating FE and RE panel data models (Table 3) to examine the relationship between insurance company assets, FiTs policies, and renewable energy consumption.

The Hausman test rejected the null hypothesis ($\chi^2(3) = 13.698$, $p = 0.0033$), indicating that the RE model is inconsistent. Therefore, the FE model was selected for subsequent analysis to account for potential correlation between country-specific effects and the regressors.

Diagnostic tests for serial correlation and heteroskedasticity were conducted to validate the FE model's assumptions.

Table 3. Outputs of fixed effects and random effects models

Source: Authors' calculation in R Studio.

	Dependent variable: Renewable energy consumption (%)	
	One-way (individual) fixed effect within model	**One-way (individual) random effect model (Swamy-Arora's transformation)**
(Intercept)	–	15.8757276*** (< 0.0001)
Feed-in tariff dummy	–1.111** (0.0042)	–1.1409489** (0.0033)
Insurance company assets to GDP (%)	0.1434813*** (< 0.0001)	0.1329605*** (< 0.0001)
FiT Dummy x Insurance company assets to GDP (%)	0.0317483** (0.001179)	0.0328000*** (0.0008)
R-Squared:	0.1164	0.10277
Adj. R-Squared	0.064423	0.1005
F-statistic	49.2684	–
Chisq	–	136.599
p-value	< 0.0001	< 0.0001
Hausman Test		
chisq	13.698	
df	3	
p-value	0.003346	

Note: *** – 0.001; ** – 0.01; * – 0.05; '.' – 0.1; ' ' – insignificant. P-values of the coefficients are shown in parentheses after the coefficient estimates.

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Table 4. Fixed effects regression with cluster-robust standard errors

Source: Authors' calculation in R Studio.

Independent variable	Dependent variable: Renewable energy consumption (%)
Feed-in tariff dummy	–1.111 (1.208)
Insurance company assets to GDP (%)	0.143** (0.048)
FiT Dummy x Insurance company assets to GDP (%)	0.032 (0.029)
Observations	1,189
R^2	0.116
Adjusted R^2	0.064

Note: *p < 0.1; **p < 0.05; ***p < 0.01. The standard errors of the coefficients are shown in parentheses after the coefficient estimates.

The Durbin-Watson test was employed to detect the presence of serial correlation in the idiosyncratic errors of the panel model. The test statistic was DW = 0.44627 with a p-value < 0.0001, strongly indicating significant positive serial correlation. Since the Durbin-Watson statistic is substantially below the value of 2 (which would suggest no autocorrelation) and the p-value is extremely small, the null hypothesis of no serial correlation was decisively rejected. Positive serial correlation violates a key assumption of the classical linear regression model and leads to biased standard error estimates, potentially overstating the statistical significance of the results. Consequently, corrective measures were necessary to ensure reliable inference.

In addition, a studentised Breusch-Pagan test was performed to assess the presence of heteroskedasticity in the residuals. The test produced a Breusch-Pagan statistic of BP = 42.324 with 3 degrees of freedom and a p-value of < 0.0001. The highly significant p-value indicates the rejection of the null hypothesis of homoskedasticity, confirming the presence of heteroskedasticity in the model. Heteroskedasticity implies that the variance of the error terms is not constant across observations, which also leads to inefficient and biased standard errors if left uncorrected.

Given the detection of both serial correlation and heteroskedasticity, adjustments to the estimation approach were required. Cluster-robust standard errors were subsequently calculated, clustering at the country level, to produce consistent and reliable standard errors in the presence of these violations. This adjustment ensures that the hypothesis tests and confidence intervals derived from the model remain valid despite the departure from classical assumptions.

The analysis employed cluster-robust standard errors clustered at the country level to address the issues of serial correlation and heteroskedasticity detected through diagnostic testing. This correction adjusts the standard errors to remain consistent even when the classical assumptions of homoskedasticity and no serial correlation are violated. After applying the cluster-robust adjustment, the coefficient estimates were re-evaluated using the corrected standard errors (Table 4).

The results indicated that the coefficient for the feed-in tariff dummy remained negative at –1.111 but was statistically insignificant with a p-value of 0.358. The coefficient for insurance assets to GDP was positive at 0.143 and statistically significant at the 1% level, with a p-value of 0.0028. This suggests that higher insurance company assets relative to GDP are associated with greater renewable energy consumption, even after correcting for the model violations. The interaction term between FiTs and insurance assets had a positive coefficient of 0.032 but was not statistically significant, as indicated by a p-value of 0.267.

The fixed effects model with cluster-robust standard errors explained approximately 11.6% of the variance in renewable energy consumption, with an adjusted R^2 of 6.4%. While the model fit remained modest, the robustness adjustments ensured that the statistical inference drawn from the model was valid and reliable. By correcting the standard errors for clustering, the analysis safeguarded against overstatement of statistical significance, thereby enhancing the credibility of the findings.

These findings confirm that the development of the insurance sector plays a significant role in promoting renewable energy consumption across countries. The positive and statistically significant relationship between insurance company assets and renewable energy adoption, even after correcting for serial correlation and heteroskedasticity, highlights the importance of insurers as potential institutional investors in renewable energy markets. Although the interaction effect with FiTs was not statistically significant at conventional levels in this specification, the consistently positive direction of the coefficient suggests that supportive policy frameworks may further enhance the willingness and ability of insurance companies to allocate capital toward renewable energy projects. These results underscore the strategic role that insurance companies can play in financing the renewable energy transition, provided that appropriate policy incentives are in place to align their investment preferences with sustainable energy objectives.

Following the correction for serial correlation and heteroskedasticity, and the incorporation of time fixed effects into the fixed effects model, the analysis was extended to account for the dynamic nature of renewable energy consumption. Renewable energy investment and consumption are often characterized by significant inertia, whereby past behaviors persistently influence current outcomes. Furthermore, it is essential to investigate whether insurance companies are willing to invest only when the market offers guarantees of long-term profitability and asset stability. Identifying such evidence would highlight the critical importance of government support instruments, such as FiTs, in reducing investment risks and effectively mobilizing institutional investors, including insurance companies, within the sustainable investment market. Although the fixed effects model effectively controls for unobserved country-specific heterogeneity, it does not adequately capture the dynamic adjustment processes inherent in renewable energy adoption. Including a lagged dependent variable within a fixed effects framework would introduce endogeneity, leading to biased and inconsistent estimates. To address this limitation, the analysis employed a dynamic panel model estimated using the Arellano-Bond Generalized Method of Moments (GMM) estimator. This approach utilizes internal instruments derived from lagged values of the endogenous variables, thereby providing consistent and efficient estimates in the presence of autocorrelation and potential endogeneity. Consequently, the Arellano-Bond GMM framework offers a more appropriate and robust methodology for modelling the dynamic behavior of renewable energy investment over time.

The initial FE regression, incorporating insurance company assets, FiTs, their interaction, and time effects, displayed reasonable model fit, with an R^2 of approximately 0.24 and an adjusted R^2 of about 0.18. The estimated coefficients suggested that insurance company assets were positively associated with renewable energy consumption when interacted with FiTs, and that several year dummies from Year 10 onwards were highly significant, reflecting a global shift toward renewable energy. However, standard fixed effects models are not designed to handle the potential endogeneity introduced by including lagged dependent variables necessary to capture dynamic adjustment processes.

Given this context, the dynamic panel model was estimated using the Arellano-Bond GMM approach. This estimator is well-suited for panels characterized by many cross-sectional units (countries) and relatively short periods. It addresses endogeneity using internal instruments, such as lagged levels and lagged differences of the dependent and independent variables. Although the reported results above correspond to the fixed effects model, the dynamic extension further strengthens the robustness of the findings by explicitly modelling persistence in renewable energy consumption.

In addition, cluster-robust standard errors were recalculated after adding time fixed effects to ensure valid inference in serial correlation and heteroskedasticity. The corrected t-tests revealed that the feed-in tariff dummy remained statistically significant, with a coefficient of –2.586 and a p-value of 0.015, indicating a strong negative relationship between the existence of FiTs and the baseline level of renewable energy consumption, after controlling for other factors and global trends. The interaction term between FiTs and insurance assets (coefficient 0.051) also remained statistically significant at the 5% level, confirming that insurance assets have a more substantial positive impact on renewable energy consumption when supportive policy frameworks such as FiTs are present. Insurance assets on their own, how-

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ever, were not statistically significant after robust corrections, suggesting that their effect depends critically on the presence of policy incentives.

The significant year dummy coefficients from approximately Year 10 onward continued to reflect a global shift in renewable energy investment, likely tied to broader international agreements and technological advancements. These dynamic considerations reinforce the importance of financial sector involvement and government policy support in driving renewable energy transitions over time.

Results of the FE models are presented in Table 5.

Table 5. Outputs of the fixed effects model with and without year effects

Source: Authors' calculation in R Studio.

Independent variable and factor of the year	Dependent variable: Renewable energy consumption (%)	
	Without year effects	With year effects
Feed-in tariff dummy	–1.111 (1.208)	–2.586** (1.060)
Insurance company assets to GDP (%)	0.143*** (0.048)	0.039 (0.048)
FiT Dummy x Insurance company assets to GDP (%)	–	0.171 (0.378)
factor(Year)3	–	0.030 (0.556)
factor(Year)4	–	0.239 (0.613)
factor(Year)5	–	0.793 (0.696)
factor(Year)6	–	0.749 (0.690)
factor(Year)7	–	0.426(0.733)
factor(Year)8	–	0.357 (0.836)
factor(Year)9	–	0.987 (0.833)
factor(Year)10	–	1.637* (0.940)
factor(Year)11	–	2.066** (0.989)
factor(Year)12	–	1.967* (1.028)
factor(Year)13	–	2.490** (1.095)
factor(Year)14	–	3.016*** (1.102)
factor(Year)15	–	3.145*** (1.117)
factor(Year)16	–	3.363*** (1.158)
factor(Year)17	–	3.520*** (1.155)
factor(Year)18	–	3.445*** (1.179)
factor(Year)19	–	4.333*** (1.113)
factor(Year)20	–	4.519*** (1.161)
factor(Year)21	–	6.145*** (1.244)
FiT Dummy x Insurance company assets to GDP (%)	0.032 (0.029)	0.051** (0.024)
observations	1,189	1,189
R^2	0.116	0.240
Adjusted R^2	0.064	0.181

Note: *p < 0.1; **p < 0.05; *** p < 0.01; Standard errors are shown in parentheses after coefficient estimates.

In the model without time fixed effects, the coefficient for Insurance Assets (% GDP) is positive and statistically significant at the 1% level ($\beta = 0.143$, $p < 0.01$), indicating that higher insurance sector assets are associated with greater renewable energy consumption. The feed-in tariff dummy shows a negative but not statistically significant relationship with renewable energy consumption.

In the model including time-fixed effects, explanatory power improves substantially, with R^2 increasing from 0.116 to 0.240. After accounting for year-specific shocks, the feed-in tariff dummy becomes statistically significant ($\beta = -2.586$, $p < 0.05$), suggesting that, all else equal, countries with FiTs exhibit lower baseline renewable energy consumption levels – potentially because the tariffs were introduced to stimulate still-developing markets.

Notably, the interaction term FiT × Insurance company assets to GDP (%) is statistically significant in Model 2 ($\beta = 0.051$, $p < 0.05$), indicating that insurance sector assets have a stronger positive association with renewable energy consumption in countries where FiTs exist.

Several of the year dummy variables (e.g., Years 10-21) are highly significant and positive, reflecting a broader global trend of increasing renewable energy consumption over time.

These findings support the view that, like banks, insurance companies are cautious institutional investors who require clear guarantees of long-term profitability and investment stability before committing substantial capital to new markets such as renewable energy. The significance of the interaction between insurance company assets and FiTs highlights that insurance sector participation increases notably only when policy mechanisms reduce investment risks and ensure predictable returns over extended periods. This underscores the critical role of government support instruments, such as FiTs, in mobilizing insurance companies and other institutional investors toward sustainable investments. Without such policy frameworks that align investment incentives with the long-term risk-return profiles required by insurers, the full potential of the insurance sector as a driver of the renewable energy transition is unlikely to be realized.

The country-specific fixed effects estimated from the FE regression model capture the unobservable characteristics unique to each country that systematically influence renewable energy consumption, after controlling for FiTs policies, insurance sector development, and global time trends (Table 6).

Table 6. Country-specific fixed effects

Country	Fixed Effect	Country	Fixed Effect
Albania	36.78	Japan	–0.31
Algeria	0.36	Jordan	1.87
Argentina	8.68	Kazakhstan	0.35
Armenia	8.22	Kenya	74.00
Australia	6.16	Korea	–2.05
Austria	28.16	Latvia	35.85
Belgium	1.40	Lithuania	21.95
Bosnia and Herzegovina	20.82	Malaysia	1.30
Brazil	43.43	Malta	0.09
Bulgaria	12.89	Morocco	10.99
Canada	17.50	Mauritius	11.50
Chile	26.33	Mexico	7.80
China	12.82	Moldova	16.33
Croatia	27.38	Mongolia	2.69
Cyprus	6.84	Netherlands	–0.60
Czech Republic	9.84	New Zealand	25.04
Denmark	15.89	North Macedonia	27.94
Dominican Republic	16.97	Norway	54.17
Ecuador	15.19	Poland	7.56
Estonia	23.73	Portugal	22.52
Finland	33.76	Romania	19.31
France	3.63	Russia	0.67
Germany	6.26	Saudi Arabia	–3.37
Ghana	54.30	Slovak Republic	8.43
Greece	11.49	Slovenia	17.70
Hungary	9.95	South Africa	5.86
Iceland	70.85	Spain	10.64
India	35.70	Sweden	39.35
Indonesia	32.81	Switzerland	14.71
Ireland	–1.14	Türkiye	13.64
Israel	2.38	United Kingdom	–2.75
Italy	8.83	United States	3.63

The results show substantial heterogeneity across countries, captured by the fixed effects. These reflect structural factors – such as policy legacies, energy mix, or institutional capacity – not directly modelled but potentially influencing how insurance sector development and feed-in tariffs affect renewable energy consumption. For instance, high fixed effects in countries like Iceland and Kenya may signal pre-existing national advantages in renewables that shape how financial and policy tools operate. In contrast, low effects in countries such as Saudi Arabia may reflect persistent structural barriers. These differences underscore the importance of accounting for baseline country characteristics when interpreting the conditional impact of insurance sector development and FiT policies.

The fixed effects reveal unobserved country-specific characteristics influencing renewable energy outcomes beyond the studied financial and policy variables. While these do not directly reflect insurance sector development, they highlight contextual heterogeneity across national systems.

The core empirical results confirm that insurance company assets are positively associated with renewable energy consumption, particularly in countries implementing feed-in tariff policies. The significant interaction term indicates that policy support is essential for mobilizing insurance capital. These findings underscore the conditional role of the insurance sector as an institutional investor in the energy transition.

4. DISCUSSION

The findings of this study provide empirical support for the conditional role of the insurance sector in financing renewable energy, confirming that insurance company assets are positively associated with renewable energy consumption, primarily when supported by FiT policies. This directly answers the study's core research question – whether FiTs enhance the effect of insurance sector development on renewable energy outcomes.

The statistically significant interaction between insurance assets and FiTs highlights that policy design is critical in unlocking insurance sector capital. As risk-averse institutional investors, insurance companies are more likely to allocate resources toward renewable projects when long-term profitability and regulatory stability are guaranteed, conditions provided by FiT mechanisms. This complements the argument by Liu et al. (2024) that risk-mitigating policies are essential for mobilizing institutional investment in sustainability.

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These results refine prior findings by Dobrovolska et al. (2024) and Artyukhov et al. (2024), who emphasized the importance of stable policy environments for de-risking renewable energy investments. Unlike earlier studies that relied on qualitative or case-based analysis, this research applies dynamic panel econometrics across 64 countries, offering quantitative evidence of the moderating effect of FiTs on insurance-led financing. Similarly, the finding that insurance assets alone are not significantly associated with renewable energy consumption in the absence of FiTs extends the insights of Samour et al. (2022), emphasizing that market development without policy support is insufficient.

The negative coefficient of the FiT dummy, after controlling for year effects, may appear counterintuitive but aligns with prior work (e.g., Badreddine & Cherif, 2024), which suggests that FiTs are often adopted in countries where renewable energy penetration is initially low. This selection effect highlights the need for cautious interpretation and underlines the importance of considering policy timing and intent in cross-country comparisons.

The dynamic panel model further reinforces the persistence of renewable energy development, demonstrating that past policy commitments and investment levels shape current outcomes – a pattern consistent with the path-dependence discussed by Shtunder et al. (2022) and Dankevych et al. (2023). These findings underscore the necessity of long-term, consistent policy frameworks to sustain investor engagement.

From a policy perspective, the results suggest that governments aiming to mobilize insurance capital for green energy must do more than expand financial markets – they must also design and maintain credible, long-term support mechanisms. Feed-in tariffs, or comparable policy tools that guarantee returns and reduce regulatory uncertainty, appear critical in activating the financial potential of the insurance sector for climate-aligned investments.

One limitation of this study arises from the availability of financial sector data, particularly regarding the Insurance Company Assets to GDP indicator, which was sourced from the Global Financial Development Database. The database provides extensive cross-country coverage; however, the most recent observations for this indicator essentially end around 2020, with limited or no updates for subsequent years. As a result, the panel dataset used in the analysis does not fully capture more recent developments in the insurance sector or shifts in financial asset structures that may have occurred beyond 2020. This temporal limitation is significant given that significant global events, such as the COVID-19 pandemic and the Russian invasion of Ukraine, have significantly impacted global financial markets, economic stability, and investment flows, including those related to renewable energy. These disruptions could have altered the relationship between insurance sector development and renewable energy consumption in ways not reflected in the data analyzed. In addition, while the econometric methodology employed – including fixed effects models with cluster-robust standard errors and dynamic panel estimation using Arellano-Bond GMM – appropriately addresses concerns such as unobserved heterogeneity, serial correlation, and endogeneity, the analysis is inherently constrained by the variables available and the assumptions underlying these estimators. Future research would benefit from incorporating updated post-2020 data, broader financial sector indicators, and alternative modelling approaches to better capture the evolving dynamics under these new global conditions.

This study advances the existing literature by providing strong econometric evidence that policy design, particularly the presence of risk-mitigating mechanisms like FiTs, is critical for activating the financial resources managed by the insurance sector to support renewable energy expansion.

CONCLUSION

This study aims to investigate, across countries and over time, whether feed-in tariff policies enhance the evolving effect of insurance sector development on renewable energy consumption.

Using an econometric methodology based on panel data techniques, the analysis employed fixed effects and dynamic panel models (Arellano-Bond GMM) on an unbalanced panel of 64 countries covering the period from 1995 to 2020. Diagnostic tests for serial correlation and heteroskedasticity were conducted, and adjustments with cluster-robust standard errors were applied to ensure the validity of the statistical inference. Time-fixed effects were incorporated to control for global macroeconomic shocks and trends.

The main empirical findings suggest that greater insurance sector assets relative to GDP are positively associated with higher levels of renewable energy consumption. However, this positive relationship becomes more robust and statistically significant in the presence of FiTs policies, highlighting the importance of supportive regulatory frameworks. Notably, the interaction between insurance sector development and FiTs was significant, emphasizing that insurance capital is more effectively mobilized for renewable energy projects when stable, long-term policy commitments mitigate investment risks. The dynamic model further confirmed the persistence and gradual adjustment patterns in renewable energy development, reinforcing the importance of sustained policy and financial support over time.

Based on these findings, several policy recommendations emerge. Policymakers aiming to accelerate the renewable energy transition should not only focus on scaling up private financial flows but also ensure the presence of stable, predictable policy environments, such as FiTs schemes or equivalent mechanisms. Reducing investment risk is essential to mobilize long-term institutional investors, including insurance companies. Furthermore, broader financial sector development initiatives, strengthening the depth and stability of insurance markets, can indirectly facilitate increased investment in renewable energy. Future policy designs should carefully integrate financial market considerations into green transition strategies to maximize the potential contribution of private capital.

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APPENDIX A

Table A1. List of countries included in the analysis

Albania	Denmark	Japan	North Macedonia
Algeria	Dominican Republic	Jordan	Norway
Argentina	Ecuador	Kazakhstan	Poland
Armenia	Estonia	Kenya	Portugal
Australia	Finland	Korea	Romania
Austria	France	Latvia	Russia
Belgium	Germany	Lithuania	Saudi Arabia
Bosnia and Herzegovina	Ghana	Malaysia	Slovak Republic
Brazil	Greece	Malta	Slovenia
Bulgaria	Hungary	Morocco	South Africa
Canada	Iceland	Mauritius	Spain
Chile	India	Mexico	Sweden
China	Indonesia	Moldova	Switzerland
Croatia	Ireland	Mongolia	Türkiye
Cyprus	Israel	Netherlands	United Kingdom
Czech Republic	Italy	New Zealand	United States

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